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Reimagining communication in a post-pandemic world: The intersection of information, media technology, and psychology

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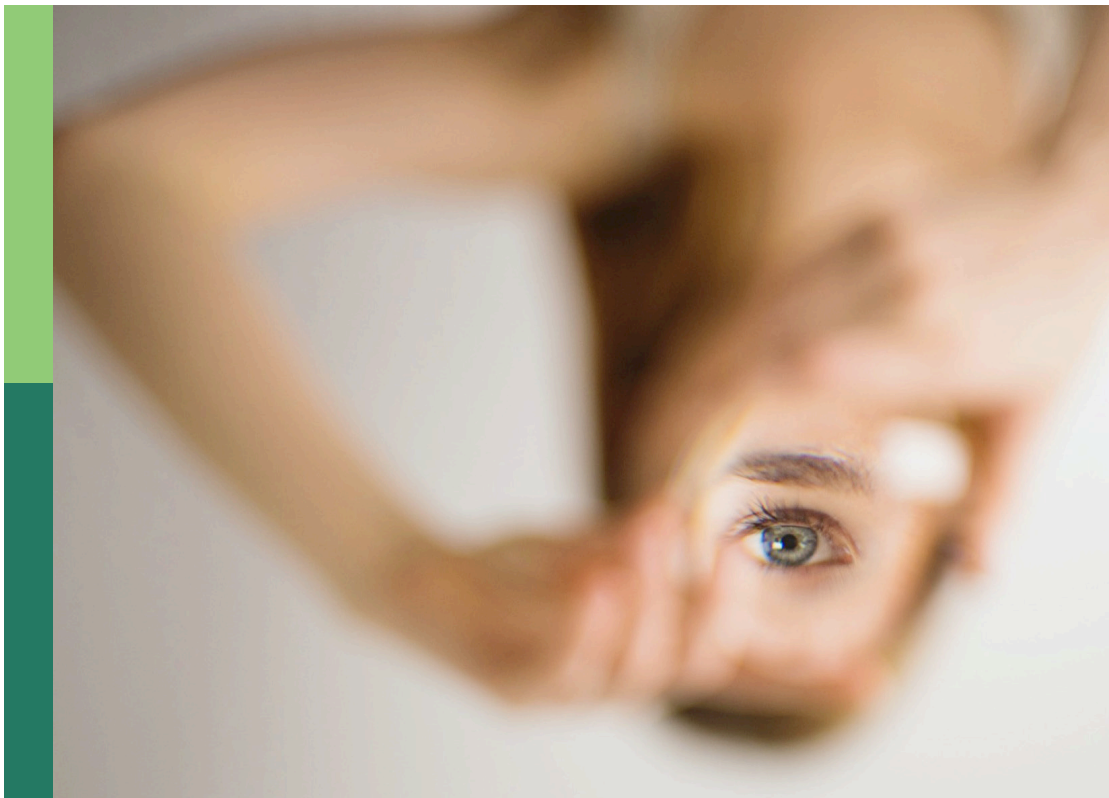

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Reimagining communication in a post-pandemic world: The intersection of information, media technology, and psychology

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Editorial: Reimagining communication in a post-pandemic world: The intersection of information, media technology, and psychology

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Editorial on the Research Topic
Reimagining communication in a post-pandemic world: The intersection of information, media technology, and psychology

The COVID-19 pandemic dramatically changed the nature of social interaction, creating negative impacts and challenges, but also opportunities for progressing how we communicate, as humans. Social distancing policies, lockdown measures, and mandatory quarantines accelerated technological communication. For example, Artificial Intelligence (AI) mediated communication grew at an unprecedented rate, willingly or otherwise. As part of pandemic control efforts, many activities, such as workplace meetings, education, and conferences, moved online, using social media platforms, the metaverse, and specialized programs accessed through mobile devices or laptops. As a result, digitally mediated channels became critical for information acquisition and communication across a wide spectrum of human activities in our personal and professional lives. As the scientific understanding of COVID-19 improved, pandemic restrictions loosened. However, it remains to be seen whether the pandemic communication paradigm, characterized by heavy technological mediation and reliance on non-human agents, will gradually decline, or whether the paradigm shift will become deeply entrenched with further acceleration of the dependency on technological mediation and non-human agents.

Such unprecedented reliance on technological mediation and non-human agents for information and communication is akin to a social-psychological experiment on a global scale. Much remains unknown, however, since this communication paradigm shift began almost 3 years ago. There are two main problems that require attention. First, the psychological impact of and underlying mechanisms behind the extended and extensive reliance on technological mediation and non-human agents is not yet well understood, especially regarding the influence of AI technologies. Second, the extent to which the impact of this reliance is likely to persist and influence future communication is also not well understood, especially in different national and cultural contexts. Research involving new approaches to data collection, such as big data techniques, together with more traditional data techniques, can help in providing greater insights into these two problems.

In this Research Topic, we sought to extend current understanding about how the COVID-19 pandemic has reshaped human communication, especially cognitive, psychological, and behavioral shifts in social interactions. We focused on research that explored new possibilities for interpersonal communication practices in the post-pandemic era. Eighteen manuscripts were selected for inclusion and draw intensive attention with more than 26,000 views.

Social media use during the COVID-19 pandemic

Information technologies, such as social media platforms, offer individuals various functionality to support the maintenance, development, and sustainability of individuals and organizations. For instance, when COVID-19 emerged, the provision of resources and social support became a major concern for many.

In the article titled "*The Importance of Project Description to Charitable Crowdfunding Success: The Mediating Role of Forwarding Times,*" Lu et al. considered 205 COVID-19 charitable projects and 11,177,249 donors to assess the process by which nonprofit organizations raise funds through information descriptions about project descriptions. The results of the study indicated that understandability and a negative tone for descriptions help to improve the amounts raised. A question remains: might quarantines and economic disadvantages exacerbate social anxiety among impoverished individuals?

In the article titled "*Social Media as Online Shelter: Psychological Relief in COVID-19 Pandemic Diaries,*" Feng et al. explored how individual narratives on social media affect people's psychological health during a state of emergency using data collected from 19 interviews with Chinese diary writers. The study found that a pandemic diary could promote self-relief, public communication, emotional drive, meaning connection, and identity construction in public spaces, thus helping shape a sense of unity and belonging and facilitating the psychological reconstruction of people who are vulnerable to potential mental health crises.

In the article titled "*Online Collaborative Documents as Media Logic: The Mediatization of Risk Response in the Post-pandemic Era,*" Jiang et al. used a mixed-method design approach to examine treating online collaborative documents as a special approach to risk response in public health and natural disaster situations. The study found that the editability, accessibility, activability, and normality of technological affordances connected the functional features of a digital platform with users' potential actions.

Benefits and drawbacks of information technology adoption

In this Research Topic, the authors also explored the drawbacks of information technology adoption. As the COVID-19 pandemic progressed, human reliance on information technology increased. For example, social media and the metaverse are now routinely being used for entertainment, learning, daily communication, and work.

In the article titled "*Personal network protects, social media harms: Evidence from two surveys during the COVID-19 pandemic,*" Ren and Yan demonstrated the increasingly critical and multifaceted role of communication technologies in affecting mental health conditions, indicating the destructive outcomes of the overuse of social media.

In the article titled "*How do Internet moms raise children? The reshaping of Chinese urban women's parenting psychology by COVID-19 online practices,*" Zhao and Ju, focusing on a special group of internet mothers, examined how they raised their children using the internet during the pandemic. The study found that social media created a new platform for information empowerment, mutual action, and ideation of motherhood for urban women formerly bound to family and parenting matters.

In the article titled "*Metaverse as a possible tool for reshaping schema modes in treating personality disorders,*" Yin et al. showed the potential role of the metaverse and virtual worlds in reshaping schema modes for treating personality disorders by reconstructing a new object world for a patient with the prescription of a psychotherapist.

In the article titled "*Psychological distance and user engagement in online exhibitions: Visualization of moiré patterns based on electroencephalography signals,*" Li J. et al. followed an Electroencephalography (EEG) signaling approach to highlight the possibility of EEG-visualization media devices in reducing the psychological distance and promotion of interpersonal communication between two participants experiencing an online exhibition.

Social media use in the post-pandemic contexts

Social media also provides new opportunities for many as we enter a post-pandemic era, including the public, institutions, media, and governments.

In the articles titled "*The application of network agenda setting model during the COVID-19 pandemic based on latent Dirichlet allocation topic modeling*" and "*Event history analysis of the duration of online public opinions regarding major health emergencies,*" Liu K. et al. and Liu X. et al. explored the public opinion landscape of the pandemic, as well as the dynamics of public opinion evolution.

In the articles titled "*Social media interactions between government and the public: A Chinese case study of government WeChat official accounts on information related to COVID-19*" and "*Government crisis communication innovation and its psychological intervention coupling: Based on an analysis of China's provincial COVID-19 outbreak updates,*" Shao et al. and Zhou et al. drew on the perspective of government-public relationships to focus on issues pertaining to government-public interactions and government crisis communication in an attempt to provide practical implications for crisis communication systems and public administrations during a public health crisis.

In the article titled "*Relationship Between Hardiness and Social Anxiety in Chinese Impoverished College Students During the COVID-19 Pandemic: Moderation by Perceived Social Support and Gender,*" Cheng et al. studied 673 impoverished Chinese college

students and found that perceived social support moderated the effect of hardiness on social anxiety.

In the article titled "*Self-Efficacy, Proxy Efficacy, Media Literacy, and Official Media Use in COVID-19 Pandemic in China: A Moderated Mediation Model,*" Li Q. et al. explored the determinants of self-efficacy for fighting against the COVID-19 pandemic under social cognitive theory. The authors found that official media use was a negative moderator of the association between media literacy and proxy efficacy.

In the article titled "*Unpacking the effects of personality traits on algorithmic awareness: The mediating role of previous knowledge and moderating role of internet use,*" Fang and Jin revealed that previous knowledge of algorithms and internet use are mediators and moderators between personality and algorithm awareness.

In the article titled "*The mediating role of personal values between COVID-19-related posttraumatic growth and life satisfaction among Chinese college students: A two-wave longitudinal study,*" Xie et al. established that COVID-19-related posttraumatic growth is positively associated with life satisfaction, while self-transcendence and self-enhancement values partially mediate this association.

In the article titled "*Personal space increases during the COVID-19 pandemic in response to real and virtual humans,*" Holt et al. suggested that personal space boundaries were expanded during the pandemic. The authors provided an index of recovery from the psychological effects of the crisis.

In the article titled "*Exploring factors that influence COVID-19 vaccination intention in China: Media use preference, knowledge level and risk perception,*" Chen et al. examined the role of media use preference, knowledge level, and risk perception in predicting people's intentions to take a COVID-19 vaccine in the Chinese context.

Finally, in the article titled "*Influence of personality traits on online self-disclosure: Considering perceived value and degree of authenticity separately as mediator and moderator,*" Lv et al. revealed the role of personality traits in online selfdisclosure, while separately assessing the perceived value and degree of authenticity as mediator and moderator.

In summary, this Research Topic aimed to unite efforts to explore various aspects of communicative practices during and after a major crisis, although most of the studies were situated in the Chinese context. While we cannot say that this Research Topic provides a comprehensive knowledge map of post-pandemic communication practices, we hope that it will contribute to broadening the scope of conventional theoretical versions of information, media technology, and psychology.

Author contributions

All authors listed have made a substantial, direct, and intellectual contribution to the work and approved it for publication.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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The Importance of Project Description to Charitable Crowdfunding Success: The Mediating Role of Forwarding Times

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The COVID-19 outbreak has been a public health crisis of international concern, causing huge impact on people's lives. As an important part of social public crisis management, how to quickly and effectively raise resources to participate in emergency relief in the era of self-media is a common challenge faced by global charitable organizations. This article attempts to use empirical evidence from Tencent charitable crowdfunding platform, the largest charitable crowdfunding platform in China, to answer this question. We consider 205 COVID-19 charitable projects and 11,177,249 donors to assess the process by which non-profit organizations raise funds through the information about project descriptions. Based on the effects of information and emotional framing, we explore the effects of the readability (i.e., complexity and understandability) and negative tone of the project description on fundraising amount. We then investigate the mediating role of forwarding times, as affective response to the text might explain forwarding times, which in turn affects money raised by increasing the visibility of the campaign. On this basis, the moderating role of recipient's crisis involvement is tested during this process. The empirical results indicate that the complexity of the description will reduce the fundraising amount, while understandability and negative tone help to improve it. Furthermore, we found that forwarding times played an important mediating role in this process. Then the buffer effect of crisis involvement on the negative effect of complexity was validated, and its amplification on the positive effects of understandability was also verified.

Keywords: charitable crowdfunding, content analysis, crisis involvement, framing effect, information processing

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INTRODUCTION

Since the outbreak of the novel coronavirus disease (COVID-19), charitable organizations, an important part of social crisis management, have launched a variety of fundraising projects to rapidly raise resources for crisis relief. These projects are primarily transmitted to the public through social media, thereby obtaining financial assistance from a distributed online audience

(Gerber and Hui, 2013; Li et al., 2018). Information from Tencent[1], the largest charitable crowdfunding platform in China, shows that since the Hubei Red Cross launched the first COVID-19 fundraising project on January 23, 2020, almost the entire platform has been dedicated to COVID-19 charity projects within 10 days of the outbreak of the pandemic (see **Figure 1**). The sponsors of these fundraising projects are nearly 200 charitable organizations throughout China. Hence, how to quickly and effectively raise resources to participate in crisis relief through the charitable crowdfunding platform (hereafter referred to as Tencent) has been a common challenge faced by these charitable organizations. This study uses empirical evidence from Tencent, based on the framing effect, to determine how the content of the project description and the donor's forwarding times, moderated by the crisis involvement, affects the amount of the fundraising effort.

Before initiating a project on Tencent, initiators must register and provide valid information about their qualifications. The application is reviewed by Tencent and, if approved, an independent project page is established, which includes the project title; a description of the project and photos, the initiator, and executor; an authenticity label; and project metrics, such as status, target, raised money, and deadline. In this model, the basic problem faced by both fundraisers and donors is information asymmetry. The information to support the donor's decision-making process mainly comes from the project description on the page; therefore, the description provides a forum for fundraisers to persuade potential donors to contribute. Hence, it is crucial to improve the effectiveness of fundraising messages through information framing (Das et al., 2008).

Previous research on financial crowdfunding shows that project attributes, such as the target, duration, and the number of Facebook friends of the initiator, affect the success of the project (Greenberg et al., 2013; Li and Duan, 2014; Mollick, 2014; Xu et al., 2014; Kuppuswamy and Bayus, 2015). Meanwhile, in the humanitarian communication side, based on Text-analytical approaches scholars explored the role of mission statement, donation appeals and humanitarian advertising for charitable organizations. The findings revealed the important effect of textual strategies. Based on this, we will focus on the text description of charity crowdfunding in crisis scenarios, in order to find out how to achieve the fundraising goal effectively through the text strategy. Upon the outbreak of a significant public crisis, the risk perception of the public fluctuates substantially due to uncertainty and information asymmetry, and individuals' information searching and processing methods change accordingly (Lindell and Perry, 2012). Social media can be used by non-profit organizations to rapidly reach a large audience (Li et al., 2018) and provide information about their charitable crisis-relief projects. However, the factors that affect an individual's decision to donate are complex and influenced by word of mouth of previous fundraisers, the experience of the executor, and the degree to which they are affected by the crisis events (Wan et al., 2017; Ki and Oh, 2018; Jin et al., 2016). However, once an individual has access to project information, the direct reference for their judgment is the project description. Previous research has highlighted the direct role that the textual information of project descriptions can play. For example, Majumdar and Bose (2018) found that the presence of rational and credible appeals in a message increases the likelihood of receiving a donation. And Some entrepreneurial research has proven that new entrepreneurs persuade private investors by manipulating the language (e.g., the tone and style) of business plans to increase their probability of being selected for further consideration or access to funds (Parhankangas and Ehrlich, 2014; Chan and Park, 2015). Therefore, in the context of a significant crisis event, where the public may not have access to additional trustworthy cues, we attempt to determine whether the quality of the project description can persuade the audience to donate through the forwarding times and whether the crisis involvement can moderate the framing effect of the textual information in the project description. Based on a large sample of data from Tencent, this research aims to further expand the research on text communication in the field of charitable crowdfunding.

THEORETICAL FRAMEWORK AND HYPOTHESES DEVELOPMENT

Fundraising is a persuasive activity that convinces potential donors to contribute to a worthy cause (Goering et al., 2011). Previous research attempted to understand why individuals donate from the perspectives of economics, psychology, sociology, marketing, and so on (Hibbert et al., 2007; Das et al., 2008; Majumdar and Bose, 2018). From the economic and psychological angle, people derive utility when they donate, and charity has been described as the consumption of "warm glow" (Andreoni, 1989) or the purchase of moral satisfaction (Kahneman and Knetsch, 1992). In the past, there are amount of research that focused on the donor's demographic characteristics and their motivation to donate (Bretschneider et al., 2014). However, with the rise of Tencent and other crowdfunding platforms, such as GoFundMe, which are different from the traditional charity channels, the academic community began to pay attention to how persuasive text of charity request can improve the chance of receiving a donation. Take the Tencent platform as an example, strangers come forward to donate on the basis of the unknown seeker's narration. Hence, the description of the project description (positive or negative framing, readability) is crucial.

We propose that non-profit organizations raise funds from online donors using persuasion through the project description. The research framework, shown in **Figure 2**, is constructed based on the cognitive theories of framing and information processing, to define the process of soliciting donations from supporters through the project description as a type of framing effect. Based on this framework, we explore whether textual information quality (i.e., the readability and the tone) is a prerequisite for fundraising amount by considering the

[1]http://gongyi.qq.com

mediating role of forwarding times and moderating role of crisis involvement.

Readability and Fundraising Success

Readability serves as the cornerstone of text communication (Leong et al., 2002). This role has been discovered and validated in the field of financial accounting (e.g., Li, 2008; Loughran and McDonald, 2014; Asay et al., 2017) and marketing (e.g., Sawyer et al., 2008; Archak et al., 2011; Ludwig et al., 2013), finding that text readability can significantly affect the stock market value and product sales of listed firms.

We infer that the readability of a charitable project description affects fundraising success for the following two reasons. First, the readability of the project description can affect the donor's reading time. Readable text improves the speed and ease in which the information receiver can browse and understand the meaning and purpose of the project (McKeown et al., 1992). Conversely, message receivers may not persevere with a poorly written project description. Tversky and Kahneman (1973) proposed that human information-processing capacity is limited in a specific environment; when individuals are faced with a large amount of information, they will selectively filter the information. Several scholars have begun to consider the phenomenon of social media information overload (e.g., Miritello et al., 2013; Bright et al., 2015). In the case of COVID-19, social media information about similar fundraising projects and the epidemic evolution is growing rapidly. As shown in **Figure 1**, since January 2020, COVID-19 has been a trending topic on networks and social media, and related charitable projects are launched continuously every day. Therefore, individuals' tolerance for reading charitable project descriptions are limited and based on the premise that the project description can be easily understood.

Second, the readability of the project description reflects the qualifications of the fundraiser. Previous research on loan-based crowdfunding has examined the relationship between the readability of listed firms' annual reports and their performance. Based on the Fog index of annual reports of listed firms, Li (2008) found that firms that provide more readable annual reports show stronger profitability. Furthermore, the obfuscation hypothesis proposes that underperforming firms will deliberately mask the true content of reports by reducing the readability of the text and by using unnecessarily complex vocabulary (Abu Bakar and Ameer, 2011). Similarly, research by Li (2008); Loughran and McDonald (2014), and Tan et al. (2015) on the annual reports of listed firms found that in the event of poor corporate performance, managers will increase the length of the annual report and add irrelevant information to confuse investors. Conversely, when the firm is performing well, annual reports provide simple explanations. We can, therefore, infer that the textual readability of a project description reflects the capabilities of the project sponsor. Tausczik and Pennebaker (2010) noted that the readability of text reflects the education, social status, and social class of information publishers. Therefore, initiators with rich experience in project execution and high credibility will use simple and understandable expressions. We posit that:

Hypothesis 1: The better the readability of the charity project description, the greater the likelihood of fundraising success.

Negative Tone and Fundraising Success

Emotional framing has a significant influence on decision-making behavior, and its role in persuasion has long been a focus of researchers (e.g., Briñol et al., 2007; Sinclair et al., 2010). The emotional framework refers to the emotional implications of the arguments within the information presented. Scholars of narratology state that narration can affect human emotion and influence individuals to obtain and spread information (Rimmon-Kenan, 2003). This theory can be extended to the study of narrative text; that is, text can influence an individual's cognition and emotional response to generate appeal while conveying information. Psychology scholars have also found the importance of tone to charity request (Smith and Petty, 1996; Marchand and Filiatrault, 2002; Hibbert et al., 2007; Das et al., 2008). Almost all requests are marked with a negative word highlighting the seeker's distress, anxiety, or anger (Majumdar and Bose, 2018). Some of the negative appeals that have been studied in the charitable setting and that induce an empathetic reaction from the prospective donors include sadness, anger, fear, and guilt, and these serve as a motivational force to donate (Bagozzi and Moore, 1994; Marchand and Filiatrault, 2002; Vitaglione and Barnett, 2003; Hibbert et al., 2007). In fact, past research has shown that donations are higher when victims display sad facial expressions in charity advertisements (Small and Verrochi, 2009).

Research investigating the effects of persuasion from the perspective of individual emotional state and information emotional frame, states that an individual in an unhappy state is more likely to be persuaded by a negative tone of information. That is, an alignment between an individual's emotional state and the emotional framework of the information can increase the persuasion effect (DeSteno et al., 2004). Therefore, as the tone of the project description can have a direct emotional impact on readers (Demers, 2011) and capture the general attitude that project owners use to describe their products or services (Larcker and Zakolyukina, 2012), we believe that a negative tone in the charitable project description in a crisis scenario has the potential to mobilize the empathy of individuals to donate. Hence, we posit that:

Hypothesis 2: The more negative the project description, the greater the likelihood of charity fundraising success.

The Mediating Role of Forwarding Times

The public's forwarding behavior on social media has become one of the important focuses of research in recent years. Forwarding can be seen as the establishment of a conversational process, with social media spreading the conversation across an open, interconnected network of participants, breaking down the confines of space and groups. The public charitable crowdfunding

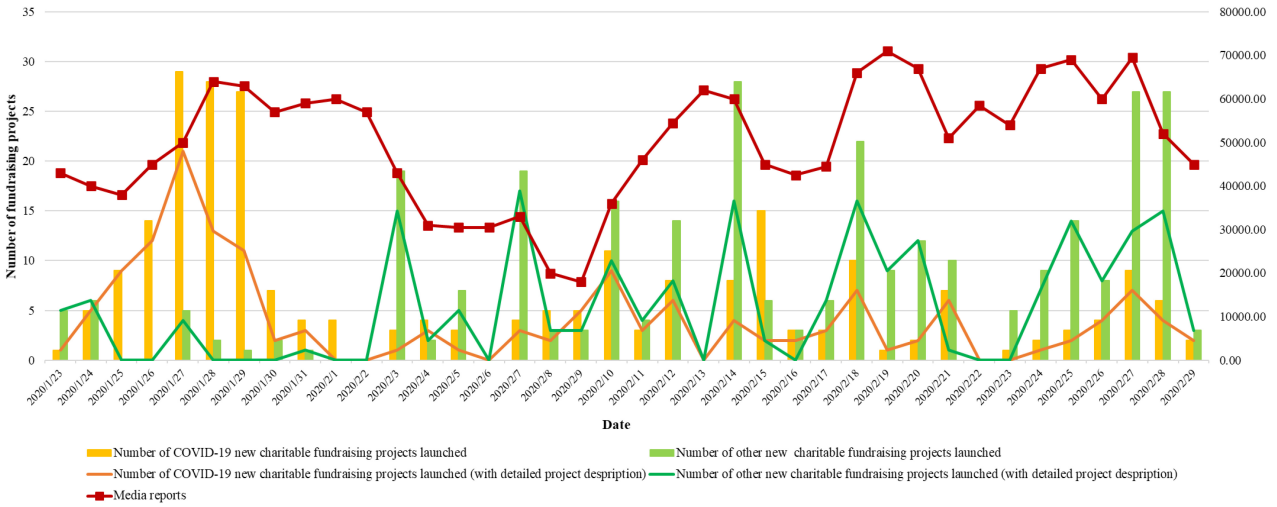

FIGURE 1 | Statistical information of charitable fundraising projects on Tencent and Media reports on web and social media.

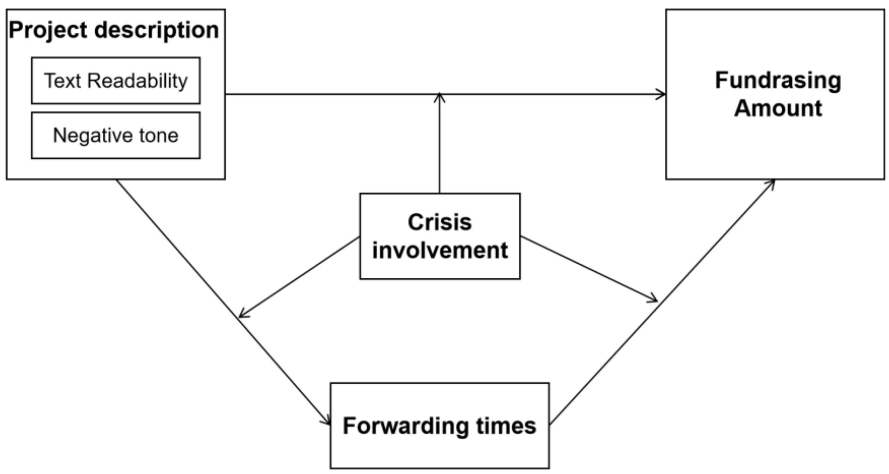

FIGURE 2 | Conceptual framework.

platform installed on social media also provides users with a forwarding function so that the fundraising information can be widely shared. Research on social media forwarding behavior focuses more on influencing factors, incentives of forwarding, forwarding content and other angles. For example, Suh et al. (2010) found that the more followers a blogger has, the easier it is to forward tweets posted by other users. In addition, the user's social networks also play a very important role, as people are more inclined to retweet tweets from users they've ever forwarded (Himelboim and Golan, 2019). Boyd et al. (2010) pointed out that users usually retweet for some purpose, such as hoping to expand the scope of tweet dissemination, expressing their support and recognition of a certain point of view, and expecting to receive more attention, and they found that users will consider whether their fans are the target audience of the tweet content before deciding to retweet, aiming to enhance their own image. Botha and Reyneke (2013) found that users have preferences for forwarded content, and it is easy to forward content that is interesting or has emotional resonance. However, in the context of disaster, research on the role of public forwarding behavior on the chartable crowdfunding platform is relatively lacking. The information directly generated by the forwarding user is more real-time, which can more directly reflect the emotional changes and psychological conditions of the forwarder, and may have an impact on the emotions and cognition of other users in the process of dissemination, thereby promoting the fundraising of public welfare projects. Digging deeper into the role of such behaviors can help decision makers make the right judgments in emergency management. Hence, we posit that:

Hypothesis 3: Forwarding times play the mediating role in the relationship between textual information (i.e., readability and negative tone) and fundraising amount.

The Moderating Role of Crisis Involvement

The moderating role of individual involvement is stressed in the literature on the process of persuasion (e.g., Coombs and Holladay, 2005; Choi and Lin, 2009; Claeys and Cauberghe, 2014). In the field of crisis communication, McDonald and Härtel (2000) defined the concept of perceived crisis involvement, which refers to the degree to which individuals comprehensively feel personal relevance. That is, the perception of the personal relevance of an issue determines the degree of an individual's involvement with the issue. Scholars believe that involvement is related to situational and endogenous factors. Once the internal clues, such as knowledge and information, are extracted by individuals, involvement in a certain topic will be activated, and this level of involvement influences the amount and direction of their attention (Celsi and Olson, 1988), cognition, and information processing (McDonald and Härtel, 2000). Although most of the existing findings on crisis involvement are based on organizations, their theoretical basis and reasoning logic can provide us with an important reference to study the effect of individual involvement on information processing during a social crisis.

Similarly, we speculate that the degree of personal involvement in a social crisis affects the way individuals interpret information about a charitable project, which further affects the donation decision. According to the elaboration likelihood model, the degree of involvement will interact with specific information; individuals with high involvement will interpret the relevant information in depth, while an individual with low involvement will interpret the information formally. That is, crisis involvement can influence the value of crisis-related information (Claeys and Cauberghe, 2014). Moreover, crisis involvement can lead to greater attention to related information; for example, charitable projects for COVID-19 social assistance are more likely to attract the attention of those who are personally affected by the crisis. The information will have a greater impact on those personally affected due to their systematic information processing of the project description, thereby amplifying the effect of the project description on their donation behaviors. Hence, we posit that:

Hypothesis 4: Crisis involvement plays a moderating role in the relationship between textual information (i.e., readability and negative tone) and fundraising amount.

Hypothesis 5: Crisis involvement furtherly moderates the mediating path of fundraising amount through the forwarding times.

MATERIALS AND METHODS

Sample and Data Collection

Tencent is the most influential social media tool in China, with 1.1 billion active users. As a platform that integrates and standardizes distributed public welfare information, Tencent charitable platform has great advantage. First, in WeChat's payment function, "Tencent Philanthropy" is built-in, that is, users can participate in public welfare activities without going through the website or official account. Second, the same link for participating in public welfare can be obtained in different ways. Decentralizing the entrance to participating in public welfare can attract more people. Despite this, the influence of its official account should not be underestimated. Almost every time it publishes, there will be more than 100,000 readings, and the spread is extremely wide.

We collected all the charitable fundraising projects published on the platform between January 23 and February 29, 2020[2]. Each project has a fixed id number, and we checked the continuity of the id number to make sure we have collected all projects data. Then we manually read the project title and project description to find out all the projects about COVID-19. After eliminating three test projects and 45 projects without a clear fundraising target[3], our final sample consisted of 205 charitable projects for COVID-19 relief launched on Tencent. By March 31, 2020, a total of 11,177,249 donors contributed CN¥1,575,096,774 to these projects, achieving 35.46% of the target amount of all projects. Based on the threshold value of the donation target, we determined the proportion of projects that achieved the project fundraising target. As shown in **Table 1**, even during a significant crisis that endangers each individual, few charitable projects achieved their goal. In addition, considering a charitable organization may use the same formats and patterns to write their descriptions for different projects: they may, for example, only replace a small part of the data and pictures in one description for one project to formulate a new one for another project. It follows that project descriptions from the same organization may not vary much in terms of readability and tone management. We counted the initiators of these 205 projects and found them from 198 charitable organizations, during which one institution initiated up to three fundraising projects, indicating that our sample is representative.

[2]The first project on COVID-19 assistance launched on Tencent was on January 23, 2020. Hence, we chose January 23, 2020 as the starting time of our sample.

[3]The main reason for excluding the projects with no clear goal from the sample was to remove the bias from charities that are less likely to succeed or have a different focus. For example, many of the excluded charity projects are part of the guardian of the angels of war, which was launched in late February and aims to help health workers in the aftermath of the crisis.

TABLE 1 | Statistics of charitable fundraising projects.

Fundraising goal (10 thousand yuan)	Number of projects	Completion rate (%)
No clear goal	43	–
[1–10)	9	30.47
[10–50)	39	23.77
[50–100)	20	20.53
[100–500)	83	40.65
[500–1000)	27	64.78
[1000–3000]	25	66.80
11000	1	100.00
75000	1	0.02

A web crawler created in Python 8.0 was adopted to automatically capture project information, donor information, and media reports on the Internet and social media platforms (i.e., WeChat and Sina Weibo). Then, the readability (similarity and understandability) and keywords frequency were calculated, respectively, through Python's language analysis module. COVID-19 statistics are from the official website of the National Health Commission of the People's Republic of China.

Measurement

Dependent Variable

The dependent variable is *fundraising amount* (FA), measured by the total donation amount of the project.

Independent Variables

Readability

Attention capacity in specific environments is limited (Tversky and Kahneman, 1973). According to the "7 ± 2 principle" proposed by Miller (1956), the human brain blocks complex information and can generally remember only 5–9 things in the short term. Complex text information produces information noise and increases the cost of information processing for the audience (Miller, 2010). Previous measurement of readability, such as the fog index (Fog Index), is represented by the average length of each sentence (ASL). What's more, the punctuation mark can work to split the text (Shriberg et al., 2000) and the number of punctuation marks significantly affects the text content and sentence length (Roux, 2008). Therefore, we use the number of words in each pause[4] to measure the complexity. The specific formula of complexity is as follows:

$$\text{Readability}_{-\text{complexity}}(\text{RC}) = \frac{\text{Number of words}}{\text{Number of punctuation marks}}$$

Second, we use the corpus word list, published by the Ministry of Education of the People's Republic of China, as an integral part of understandability in text readability. The corpus word list contains 20 million Chinese characters, including 14,629 common words according to the number of occurrences. Following the research of Chen et al. (2018), understandability is measured by the proportion of the number of words included in the corpus word list in the project description. The specific formula of understandability is as follows:

$$\text{Readability}_{-\text{understandability}}(\text{RU}) = \frac{\text{Number of common words}}{\text{Total words}}$$

Negative Tone

For each project description, the sentiment analysis extracts Chinese characters (excluding numbers, English characters, punctuations, URL, hashtags, and mentions), construct Chinese word segmentations, and obtain the sentiment scores of these word segments from the Chinese emotional vocabulary ontology. Chinese emotional vocabulary ontology (CEVO) is a Chinese ontology resource organized and labeled by the Information Retrieval Research Office of Dalian University of Technology. This resource describes a Chinese word or phrase from different perspectives, including word type, emotion type, emotion intensity and polarity. The emotion classification system of CEVO is built on the basis of Ekman. There are seven parts of word categories in the dictionary. These are Noun, Verb, Adjective, Adb, NW, IDIOM, and Prepositional Phrase. Each word corresponds to one of three polarities: neutral (5,376), positive (11,230), and negative (10,784). With the help of natural semantics processing tool, we identified the number of positive/negative words in project description based on CEVO. Then, we measure negative tone as the percentage the difference of negative and positive words in the project description. Specifically, it is calculated as follows:

$$\text{Negative tone (NT)} = \frac{\text{Number of negative words} - \text{Number of positive words}}{\text{Total words}}$$

Mediating Variable

The mediating variable, *forwarding times* (FT), is measured by the number of donors who started "donate together." As shown in **Figure 3**, "donate together" is a special function set up by Tencent public welfare platform. When the user decided to donate the project, they can choose whether to launch "donate together." If the function was chosen, the user can spread this fundraising project to their social media friends, so as to expand the spread of project information.

Moderating Variable

Personal involvement/relevance pertains to how publics perceive importance of an object or their mental distance from a topic (Petty and Cacioppo, 1986; Jin et al., 2016). It can be found that the extent of involvement is closely related to the perceived crisis severity, and that the description of the severity of the epidemic needs to take into account comprehensively the number of confirmed cases as well as the total local population size. Hence, the moderating variable, *crisis involvement* (CI), is measured by the per cumulative number of confirmed COVID-19 cases from the previous day in the province where the donor target is located.

$$\text{Crisis involvement (CI)} = \sum_{\text{i=1}}^{\text{n}} \frac{\text{M}_\text{i}}{local\_population\ \_size}/n$$

where M_I is the cumulative number of confirmed COVID-19 cases from the previous day in the province where the donor target *i* located and *n* is the total number of donors of a project.

Control Variables

We include variables that have been used in prior studies to control for individual prosocial behaviors (e.g., Hannah et al., 2011; Bolino and Grant, 2016; Gotowiec and van Mastrigt, 2019). The variables are *fundraising target, clear deadline, description length, images, plan length, initiator experience, executive expertise, recommended times*, *total confirmed cases nationwide, total recovered cases nationwide, total death cases nationwide, and media reports.*

[4]The paused punctuation marks include the full stop, question mark, exclamation mark, comma, colon, and semicolon.

FIGURE 3 | The function of "donate together".

The detailed measurements and sources of each variable are shown in **Table 2**.

Model and Analysis

Mediation Effect Model

According to the analysis of the impact mechanism, the mediation effect model is introduced, and the impact of text information on the fundraising amount (FA) through the forwarding times (FT) is analyzed. In order to effectively eliminate heteroscedasticity, this paper uses the form of a double logarithmic function for estimation. The mediation effect model as follows:

$$\ln\mathrm{FA_i} = \alpha_0 + \alpha_{11}\ln RC_i + \alpha_{12}\ln RU_i + \alpha_{13}\ln NT_i + \alpha_2\ln CV_i + \varepsilon_{1i} \quad (1)$$

$$\ln\mathrm{FT_i} = \beta_0 + \beta_{11}\ln RC_i + \beta_{12}\ln RU_i + \beta_{13}\ln NT_i + \beta_2\ln CV_i + \varepsilon_{2i} \quad (2)$$

$$\ln\mathrm{FA_i} = \gamma_0 + \beta_{11}\ln RC_i + \gamma_{12}\ln RU_i + \gamma_{13}\ln NT_i + \gamma_2\ln\mathrm{FT_i} + \gamma_3\ln CV_i + \varepsilon_{3i} \quad (3)$$

where i represents the charitable fundraising project; FA represents the amount raised; RC and RU represent two indicators of readability that is complexity and understandability, respectively; NT indicates the negative tone in the project description; CV are the control variables; ε represents the random error; $_{11}$, $_{12}$, $_{13}$ indicate the total effect of complexity, understandability and negative tone on the amount of fundraising, respectively; $_{11}$, $_{12}$, $_{13}$ indicate the direct effect of them, respectively; $_{11\times2}$, $_{12\times2}$, $_{13\times2}$ represent the mediating effect that represents text complexity, understandability, and negative tone transmitted through the forwarding times.

Moderated Mediation Model

In order to further test the regulatory effect of crisis involvement on the mediation effect, a regulated mediation effect estimation model is constructed as follows:

$$\ln FA_i = c_0 + c_{11}\ln RC_i + c_{12}\ln RU_i + c_{13}\ln NT_i + c_2\ln CI_i + c_{31}(\ln RC_i \times \ln CI_i) + c_{32}(\ln RU_i \times \ln CI_i) + c_{33}(\ln NT_i \times \ln CI_i) + c_4\ln CV_i + \varepsilon_{1i} \quad (4)$$

$$\ln FT_i = a_0 + a_{11}\ln RC_i + a_{12}\ln RU_i + a_{13}\ln NT_i + a_2\ln CI_i + a_{31}(\ln RC_i \times \ln CI_i) + a_{32}(\ln RU_i \times \ln CI_i) + a_{33}(\ln NT_i \times \ln CI_i) + a_4\ln CV_i + \varepsilon_{2i} \quad (5)$$

$$\ln FA_i = c_0' + c_{11}'\ln RC_i + c_{12}'\ln RU_i + c_{13}'\ln NT_i + c_2'\ln CI_i + c_{31}'(\ln RC_i \times \ln CI_i) + c_{32}'(\ln RU_i \times \ln CI_i) + c_{33}'(\ln NT_i \times \ln CI_i) + b_1\ln FT_i + b_2(\ln FT_i \times \ln CI_i) + b_3\ln CV_i + \varepsilon_{3i} \quad (6)$$

TABLE 2 | Measurement of variables.

Variable name	Measurement
1. Fundraising amount (FA)	The total fundraising amount of the project by March 31, 2020.
2. Readability	$\text{Readability}_{-\text{complexity}}\ (\text{RC}) = \frac{\text{Number of words}}{\text{Number of punctuation marks}}$ $\text{Readability}_{-\text{understandability}}(\text{RU}) = \frac{\text{Number of common words}}{\text{Total words}}$
3. Negative tone	$\text{Negative tone} = \frac{\text{Number of negative words} - \text{Number of positive words}}{\text{Total words}}$
4. Forwarding times	Log 10 (the number of donors who initiated "donate together"+1)
5. Crisis involvement	$\text{Crisis involvement (CI)} = \sum_{i=1}^{n} \frac{M_i}{local\_population\_size} / n$ Where M_i is the cumulative number of confirmed COVID-19 cases from the previous day in the province when the donor target *i* located; *n* is the total number of donors of a project.
6. Fundraising target	Log 10 (the amount initiator seeks to raise)
7. Clear deadline	1 = Deadline is marked on the page; 0 = Deadline is not marked on the page
8. Description length	Log10 (the number of words contained in project description)
9. Images	Log 10 (the number of images embedded in the project description+1)
10. Plan length	Log 10 (the number of words contained in project plan+1)
11. Initiator experience	Log 10 (the number of projects created by the initiator in the last year+1)
12. Executive expertise	Log 10 (the number of projects successfully executed by the executive in the last year+1)
13. Recommended times	The number of times it was set to "Recommend Items Today" by the platform
14. Other projects	Log 10 (the number of other projects initiated that day+1)
15. Total confirmed cases nationwide	$\log 10\left(\frac{\sum_{i=1}^{n} W_i}{n}\right)$ Where W_i is the cumulative number of confirmed COVID-19 cases from the previous day nationwide when the donor *i* donated; *n* is the total number of donors of a project.
16. Total recovered cases nationwide	$\log 10\left(\frac{\sum_{i=1}^{n} R_i}{n}\right)$ Where R_i is the cumulative number of recovered COVID-19 cases from the previous day nationwide when the donor *i* donated; *n* is the total number of donors of a project.
17. Total death cases nationwide	$\log 10\left(\frac{\sum_{i=1}^{n} D_i}{n}\right)$ Where D_i is the cumulative number of death COVID-19 cases from the previous day nationwide when the donor *i* donated; *n* is the total number of donors of a project.
18. Media reports	$\log 10\left(\frac{\sum_{i=1}^{n} \text{Media}_i}{n}\right)$ Where Media_i is the cumulative number of reports online (including the Web and Social media — Sina Blog and Weichat) from the previous day nationwide when the donor *i* donated; *n* is the total number of donors of a project.

where CI represents crisis involvement; the coefficients of $\left(\ln RC_i \times \ln I\right)$, $\left(\ln RU_i \times \ln CI_i\right)$, $\left(\ln NT_i \times \ln CI_i\right)$, and $\left(\ln FT_i \times \ln CI_i\right)$ Ire used to measure the moderating effects; Under the moderating role of crisis involvement, the total effects of text complexity, understandability and negative tone on the fundraising amount are $c_{11}c_{31}\ln CI_i$, $Ic_{32}\ln CI_i$, and $I_{13}c_{33}\ln CI_i$; Under the moderating role of crisis involvement, the effects of complexity, understandability and negative tone on the forwarding times are $a_{11}a_{31}\ln CI_i$, $a_{12}a_{32}\ln CI_i$, and $a_{13}a_{33}\ln CI_i$, respectively; Under the moderating role of crisis involvement, the intermediary effects of the forwarding times on the amount of fundraising are $(a_{11}a_{31}\ln CI_i)(b_1b_2CI_i)$, $(a_{12}a_{32}\ln CI_i)(b_1b_2CI_i)$, $(a_{13}a_{33}\ln CI_i)(b_1b_2CI_i)$, respectively; $c_{11}{}'c_{31}{}'\ln CI_i$, $c_{12}{}'c_{32}{}'\ln CI_i$, $c_{13}{}'c_{33}{}'\ln CI_i$ indicate the direct effects of text complexity, understandability and negative tone on the amount of fundraising under the moderating role of crisis involvement.

RESULTS

We test our hypotheses through the sample of 205 COVID-19 charitable fundraising projects with a clear fundraising target initiated on Tencent from January 23, 2020, to February 29, 2020. Tables 3, 4 lists the results of the mediation effect model and that with regulation.

According to the **Table 3**, the model 3 indicates the coefficients of complexity, understandability and negative tone are −0.099, 0.068 and 0.402, respectively. It suggests that the textual information has the direct effect on the fundraising amount. The coefficient of complexity ($\beta = 0.099$, $p < 0.001$) is negative and significant, indicating that a complex project description decreases the total amount of charitable fundraising, while the coefficient of understandability ($\beta = 0.068$, $p < 0.01$) is positive and significant, suggesting that using common words to write the project description can increase the fundraising amount. That is, the better the readability of the project description (i.e.,

TABLE 3 | Estimation results of the mediation effect model.

Variables	Model 1 DV: FA	Model 2 DV: FT	Model 3 DV: FA
(Constant)	1.761***	1.627***	1.108***
RC	−0.138***	−0.098**	−0.099***
RU	0.155***	0.221***	0.066**
NT	0.398***	0.407***	0.234***
FT			0.402***
CV	Controlled	Controlled	Controlled
R^2	0.439	0.483	0.528
Adj R^2	0.436	0.479	0.523
F-statistics	112.36	133.97	120.07

*$p < 0.05$, **$p < 0.01$, ***$p < 0.001$.

low complexity and high understandability), the greater the likelihood of raising fundraising, which supports Hypothesis 1. The coefficient of negative tone ($\beta = 0.234, p < 0.001$) is significant, suggesting Hypothesis 2 is supported. In model 2, coefficient for understandability ($\beta = 0.221, p < 0.001$) and negative tone ($\beta = 0.407, p < 0.001$) are positive and significant, and that for complexity ($\beta = 0.098, p < 0.01$) is negative and significant, indicating that forwarding times serves a significant mediating effect between textual information and fundraising amount and Hypothesis 3 is supported. Specifically, the indirect effects of complexity, understandability and negative tone on the amount of donations raised by the forwarding times were −0.039, 0.089, and 0.016, respectively, and the total effects were −0.138, 0.155, and 0.398, with mediating effects accounting for 28.2%, 57.4%, and 4.0%, respectively. Markowitz and Shulman (2021) found the predictive utility of word familiarity for online engagements and funding. Our results on complexity and understandability are consistent with the study. The results of the negative tone acting positively on fundraising amount differ from those found by Majumdar and Bose (2018). In their research on registered charities in online communities, they found that negative emotional appeal does not do the likelihood of receiving a donation. We believe that this may be due to differences study context. Our data were collected from January 23, 2020, to February 29, 2020 during the worst period of COVID-19 in China, The public would have more empathy with negative emotional appeal under a common viral threat.

Table 4 provides the estimation results of the mediating effect model with regulation. The regression results of model 6 show that the coefficient of the interaction term NTCI (i.e., negative tone = crisis involvement) is not significant, and the regression coefficient of the interaction term RCCI (i.e., complexity = crisis involvement) and RUCI (i.e., understandability = crisis involvement) is significantly positive. It shows that the degree of crisis involvement moderates' complexity and understandability to the direct path of the amount of fundraising, suggesting that Hypothesis 4 is partially verified. The interaction plot in **Figure 4A** reports a positive interaction between complexity and crisis involvement ($\beta = 0.046, p < 0.05$) on fundraising amount. It indicates that the negative effect of the complexity of the project description can be weakened when the crisis involvement is high. **Figure 4B** indicates a positive interaction between understandability and crisis involvement ($\beta = 0.050, p < 0.001$) on fundraising amount. It shows that when the crisis involvement is in a high degree, the positive effect of understandability on the amount of donations raised will be further amplified. Further, according to the significance of the interaction term RCCI and RUCI of model 5 and the coefficients of the interaction terms of model 6, it can be seen that the degree of crisis involvement affects the indirect path of the amount of fundraising through the forwarding times, and the moderating effect is significant, in line with hypothesis H5. Specifically, the interaction plots of **Figures 5A,B** report the positive interactions between readability (i.e., complexity and understandability, respectively) and crisis involvement. It is explained that the degree of crisis involvement can reduce the negative effect of text complexity on the forwarding times, and thus reduce the negative effect on the amount of fundraising. In addition, crisis involvement amplifies its positive effect on the forwarding times by amplifying the positive effect of understandability on the forwarding times, which in turn amplifies its positive effect on the amount of donations raised.

DISCUSSION AND CONCLUSION

The success of charitable crowdfunding warrants research, especially during a public crisis, as it can serve as an efficient tool for non-profit organizations to raise resources and participate in crisis relief. By using a large dataset obtained from Tencent after the outbreak of COVID-19, we examine the influence of the project description on fundraising amount. We view

TABLE 4 | Estimated results of the moderated mediation effect model.

Variables	Model 4 DV: FA	Model 5 DV: FT	Model 6 DV: FA
(Constant)	1.531***	3.318***	0.316***
RC	−0.153***	−0.058***	−0.141**
RU	0.125***	0.029***	0.119***
NT	0.601***	0.188***	0.562***
CI	0.111***	0.417***	0.024***
FT			0.208***
RCCI	0.046***	0.012**	0.046**
RUCI	0.051**	0.046**	0.050***
NTCI	−0.070	0.053	−0.097
FTCI			0.019***
CV	Controlled	Controlled	Controlled
R^2	0.456	0.507	0.544
Adj R^2	0.447	0.499	0.534
F-statistics	51.07	62.77	56.31

*$p < 0.05$, **$p < 0.01$, ***$p < 0.001$.

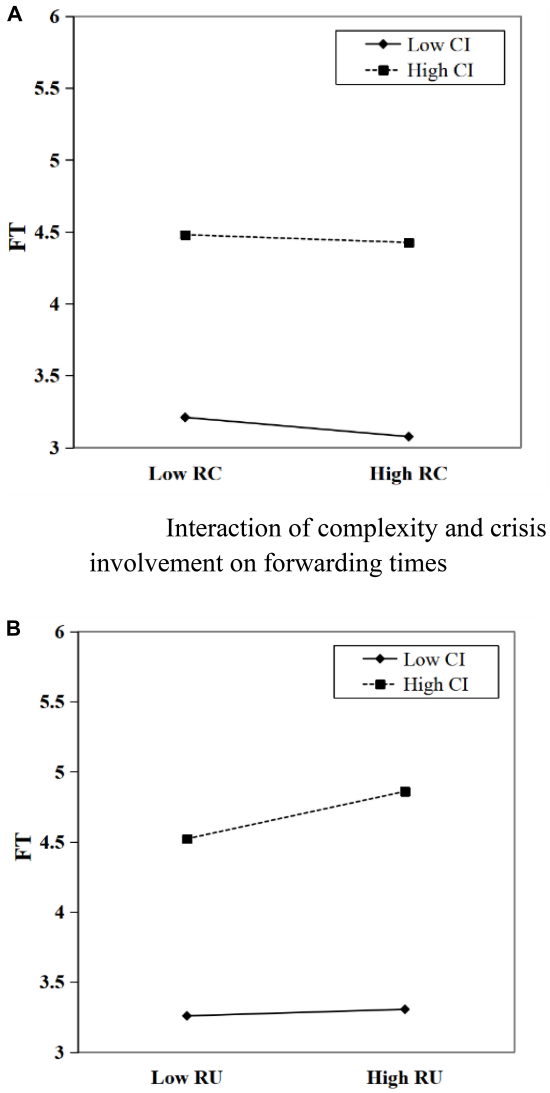

FIGURE 4 | (A) Interaction of complexity and crisis involvement on forwarding times. **(B)** Interaction of understandability and crisis involvement on forwarding times.

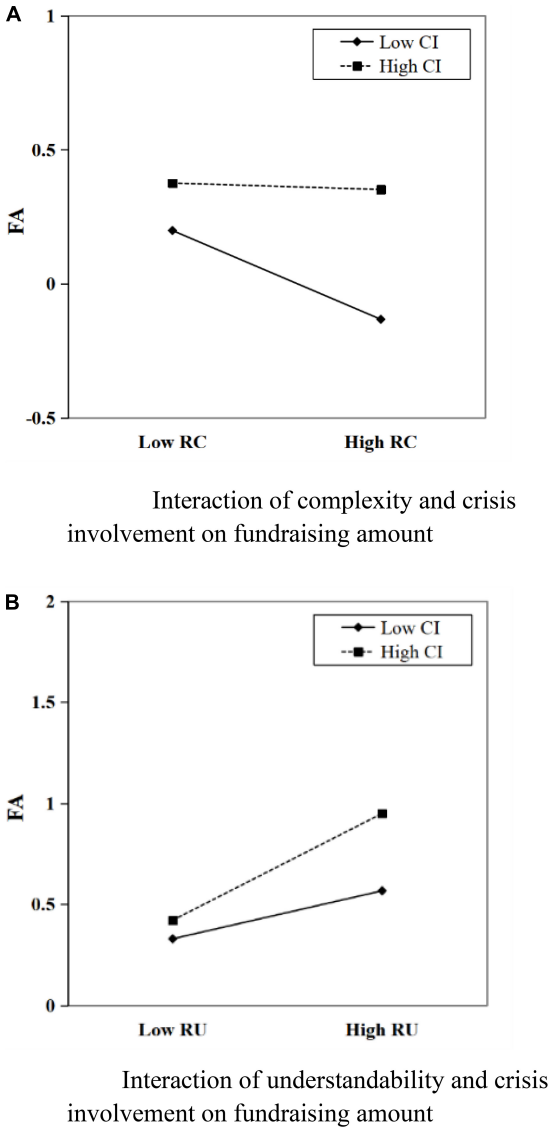

FIGURE 5 | (A) Interaction of complexity and crisis involvement on fundraising amount. **(B)** Interaction of understandability and crisis involvement on fundraising amount.

the process by which non-profit organizations raise funds from online donors as a persuasion process through project descriptions and identify two kinds of exemplary antecedents from project description: text readability and negative tone, which serve as the information framing effect and the emotional framing effect, respectively. We then investigate the mediation role of forwarding times, as affective response to the text might explain forwarding times, which in turn affects money raised by increasing the visibility of the campaign. On this basis, the moderating role of one's crisis involvement is tested during this process, as individuals with a high degree of crisis involvement will systematically process the information and make in-depth interpretations. The empirical results indicate that the complexity of the description will reduce the fundraising amount, while understandability and negative tone help to improve the success. Furthermore, we found that forwarding times played an important mediating role in this process. Then the buffer effect of crisis involvement on the negative effect of complexity was validated, and its amplified effect on the positive effects of understandability was also verified.

This study contributes to the crowdfunding literature in several ways. First, textual information is becoming increasingly important in the field of crowdfunding

(Parhankangas and Renko, 2017). By exploring charitable projects with a focus on the information content of project descriptions in the scenario of a public crisis, we expand the research scenarios of such issues and combine scenario features, such as crisis involvement, to provide new perspectives for such future studies.

Second, most studies on the readability of the text focused on the English language. Due to differences in expression in different languages, the methods used to measure the readability of English text cannot be directly applied to Chinese text analysis (Hu et al., 2017). In the current research, we constructed a text readability index that can extract text information from a large number of Chinese natural languages and provide a new insight for text analysis in the Chinese language context.

Third, we expanded the research scenario of persuasion theory by studying the roles of information and emotional framing effects on the crowdfunding amount. How to effectively persuade the public to make donations is very important (Hibbert et al., 2007). The results highlight the importance of project descriptions and provide insights for non-profit organizations to focus on information and emotional framing of project descriptions when they launch charitable projects on crowdfunding platforms. Moreover, this can be applied to further crowdfunding research to enhance predictive capabilities.

Finally, the moderating effect of donors' crisis involvement on fundraising success is noteworthy. We verified that high crisis involvement will stimulate the systemic information processing of individuals, thereby the framing effects of the project description are amplified. This finding extends the research on individuals' issue involvement. There is currently no theoretical framework that uses individuals' crisis involvement as a moderating variable that regulates the persuasive outcome of information and emotional frames. Therefore, the results of this study indicate the potential use of this variable in current and future theoretical frameworks.

Our study also has practical implications for the effective combination of information and emotional framing effects for individuals of different involvement levels. It provides an important reference for non-profit organizations to better frame information within the project description, to improve the participation of information receivers when seeking donations through online crowdfunding platforms. According to previous research on information framing, the information that can be verified by donors takes up a large weight, such as the experience and ability of initiators and executors, and it is costly for information receivers to verify the credibility of this information. The findings of this study prove that the text can reflect the capabilities of initiators, which is an effective and low-cost supplement to the traditional information framing model. Therefore, non-profit organizations should not only emphasize their credible qualifications and execution experience but also consider the readability and tone of the description, which will significantly improve the success of fundraising. Our research also reminds social media users how to make better decisions based on the textual quality of project descriptions when they are exposed to information about relevant charitable projects. Our results provide meaningful insights to researchers, project initiators (especially non-profit organizations), and online donors to better understand the importance of project descriptions and their influence on funding success during a crisis scenario.

Some limitations of this study offer suggestions for future research. First, we conduct our studies base on a single online crowdfunding platform. However, the charitable crowdfunding market is growing, and several crowdfunding platforms are not bound to social media for disseminating project information. This may limit the generalizability of our findings. Future research may test the framework and results of this study by using other charitable crowdfunding platforms bound to social media, such as Sina Weibo, and conduct comparative research between platforms that are bound to social media and those that are not. Even more, the qualitative analysis through a combined methodology, through meaning analysis, could be interesting in future studies. Furthermore, we suggest comparing the weight differences between the role of project description and the role of social media dissemination breadth. Second, we studied the moderating effect of individual crisis involvement. However, several other factors affect the information processing of individuals in a crisis, such as the attribution of responsibility for the crisis, the emotional state of individuals, and the physical and social connections with the affected areas. Future research may extend the textual analysis to individuals' updates on social media about the crisis, to explore other influencing factors that may be different from traditional research and enrich relevant research on risk communication.

DATA AVAILABILITY STATEMENT

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

AUTHOR CONTRIBUTIONS

LL and WJ contributed to the material preparation, data collection, and analysis. JX wrote the first draft of the manuscript. All authors contributed to the study conception and design, commented on previous versions of the manuscript, and read and approved the final manuscript.

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Self-Efficacy, Proxy Efficacy, Media Literacy, and Official Media Use in COVID-19 Pandemic in China: A Moderated Mediation Model

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Purpose: COVID-19 pandemic is a significant threat toward the public health. However, the discussion of the mechanism of media literacy's effect in fighting against pandemic is limited. Thus, this study aims to explore the mechanism with a sociocognitive perspective.

Methods: A survey was administrated to 420 college students in China. PROCESS macro of SPSS was applied to analyze the data and test the moderated mediation effect.

Results: The moderated mediation model of media literacy, proxy efficacy, self-efficacy, and official media use was tested and supported. Official media use was a negative moderator on the association between media literacy and proxy efficacy.

Conclusion: The study explored the media literacy's role as a determinant of proxy efficacy and self-efficacy, which contributed to the sociocognitive theory.

Keywords: media literacy, proxy efficacy, mediation effect, moderation effect, self-efficacy

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INTRODUCTION

The impact of the COVID-19 pandemic has gone beyond the original prediction of people in both size and time aspects. Cooperation between the public and governments is required. The public's confidence in themselves and governments is necessary to achieve this. In spreading pandemic-related information, both useful and scientific one and misinformation are of large amounts. To distinguish them, media literacy is required (Howell and Brossard, 2021).

Given that people went out less during the pandemic, media became essential information sources (Liu et al., 2021). In China, official media is the authority of pandemic-related information publishing with higher credibility of information. Therefore, the coverage of official medial could play an essential role in public information gaining and confidence improving.

The aim of the study is to explore the determinants of self-efficacy of fighting against the COVID-19 pandemic under the sociocognitive theory. Based on the works of previous researchers, the current study collected data by questionnaires, then established a theoretical model to discuss the association between the public's media literacy, proxy efficacy, self-efficacy, and official media use. The proxy efficacy's mediation effect between media literacy and self-efficacy and the moderation effect of official media use between media literacy and proxy efficacy was verified. Also, the suggestion of improving the confidence of fighting against the pandemic.

LITERATURE REVIEW

Theoretical Framework: Sociocognitive Theory

Media Literacy and Self-Efficacy

Based on previous works, media literacy is defined as individuals' ability to obtain, interpret, critically think about information, and improve daily life and social development (Yu and Zhao, 2017).

According to Bandura (2000), self-efficacy refers to individuals' perceived ability to achieve certain goals. Individuals acquire cognitions about the society and environment by constant learning and practice, then articulate experience, which is an essential source of self-efficacy (Usher and Pajares, 2008). Media literacy could enhance an individual's ability to obtain knowledge and then favor articulating cognition and experience (Austin et al., 2012).

Cakmak (2013) found that individuals' self-efficacy of computer use improved after media literacy intervention. Furthermore, the association between media literacy and the self-efficacy of the public has been verified in health studies (e.g., Cho et al., 2020). In the public health area, self-efficacy is seen as the key role in improving people's wellbeing (Cattell, 2001). Another study showed that for subjects correctly self-diagnosed with H1N1, their media literacy could positively predict self-efficacy (Avery, 2009). With the improvement of media literacy, the self-efficacy of the public for dealing with the pandemic can also be improved. That is, media literacy could be a determinant of self-efficacy.

With the outbreak of the COVID-19 pandemic, an infodemic is also emerged (Mheidly and Fares, 2020). Living with information of different qualities, media literacy of the public can represent their ability to obtain and understand information, then evaluate its credibility, which is a crucial source of self-efficacy (Avery, 2009). Therefore, in COVID-19 pandemic, media literacy can help people in their confidence of fighting against the pandemic by obtaining scientific protections.

The positive association between media literacy and self-efficacy has thus emerged in the studies mentioned above. In the COVID-19 pandemic, media literacy could help deal with the infodemic to obtain more credible information. Then, the confidence in coping with the pandemic could be improved. Therefore, we propose hypothesis 1.

> *H1*: Media literacy can positively predict self-efficacy in protecting herself or others from the pandemic.

Proxy Efficacy as the Mediator

Social cognition theory argues that behaviors are determined by the interaction between social, environmental, and individual factors (Bandura, 1988). The individual factor's role is based on the individual's ability to handle events actively and strong expectancy for particular outcomes (Usher and Pajares, 2009). According to the social cognitive theory, individuals are no longer viewed as passive subjects whose behavior is reinforced by external stimuli alone but as active ones who have agency over their learning and the consequences of their actions (Bandura, 2001). In this regard, individuals' level of trust in their ability to accomplish their goals (i.e., self-efficacy) and their levels of trust in the ability of third parties to assist them in accomplishing their goals (i.e., proxy efficacy) are both important sources of their efficacy (Bandura, 2000).

Media Literacy and Proxy Efficacy

Proxy efficacy refers to an individual's perception of the ability of a third party (i.e., proxy) to help her accomplish a specific goal (Bandura, 2001), and higher proxy efficacy implies a higher level of trust in the proxy. Proxy efficacy in this study refers to the level of trust individuals have in the government's ability to help them through the epidemic.

The vital role of media literacy in promoting citizens' political participation and enhancing their right to information has gradually become a consensus among scholars (Craft et al., 2017; Tully and Vraga, 2018). Also, enhancing the public's media literacy will help strengthen their interest and understanding in joining the discussion of political issues, thus increasing individuals' level of trust in the government's ability to do so (Burroughs, 2009; Kahne et al., 2012). In public health emergencies, increased proxy efficacy helps the public adopt scientific responses; that is, the role of media literacy in enhancing agent efficacy can help the public adopt more scientific strategies when encountering the epidemic (Smith and Rimal, 2009; Li, 2018). Cho et al. have conducted a remote media literacy intervene, which found that participants whose media literacy was enhanced by the intervention had significantly improved proxy efficacy, which reduced their unhealthy tanning behaviors (Cho et al., 2020).

The current study argues that in the context of the COVID-19 pandemic, the increased media literacy of the audience can help them learn more about the government's effective prevention and control measures in the epidemic, thus increasing their sense of agent efficacy regarding the government's ability to prevent the epidemic, leading to research hypothesis 2.

> *H2*: Media literacy can positively predict an individual's proxy efficacy in Chinese government.

Proxy Efficacy and Self-Efficacy

Efficacy is defined as an individual's perceived ability to control aspects of her life (Bandura, 1986). Self-efficacy emphasizes one's perception of herself, while proxy efficacy emphasizes the perceived ability to control a certain proxy (e.g., teachers, churches, and government).

It should be noticed that the relationship between self-efficacy and proxy efficacy is not exclusive but an interactive one. In different situations, different efficacies show different levels' influence (Bandura, 2001). In situations with sufficient social resources and infrastructure, self-efficacy usually plays a stronger role than poxy efficacy; while self-efficacy and proxy efficacy function jointly when resources, especially public health resources, is insufficient (Smith and Rimal, 2009).

The existing literature has demonstrated that proxy efficacy positively predicts self-efficacy (Bray and Cowan, 2004; Bray

et al., 2006), that is, the higher the proxy efficacy, the higher the self-efficacy (Bandura, 1997). In the context of bodybuilding, the proxy efficacy of fitness individuals (fitness instructors as the proxy in this study) significantly and positively predicted their self-efficacy, which in turn increased their participation in fitness classes (Bray et al., 2001). Furthermore, the public's proxy efficacy regarding politics was also significantly and positively related to their self-efficacy for political information seeking (Farman et al., 2018).

The collective perspective provides an idea to explain the operation of proxy efficacy, which helps individuals perceive practical help from third parties in developing their self-efficacy, thus contributing to their self-efficacy (Kim et al., 2021). From the beginning of the pandemic to the present-day normalization of prevention and control, audiences are often confronted with many reports with different qualities from the media. Then, audiences with higher trust in the pandemic prevention policies of the basic level government, that is, higher proxy efficacy, are more likely to perceive the sense of order and stability brought by the proxy, thus enhancing their self-efficacy in the face of the pandemic. In other words, the higher the proxy efficacy, the higher the self-efficacy of individuals in the pandemic prevention and control. Thus, we propose hypothesis 3.

> *H3*: Proxy efficacy can positively predict an individual's self-efficacy in protecting herself or others from the pandemic.

The Mediation Effect of Proxy Efficacy

Studies above identified two pathways through which media literacy affects self-efficacy. More importantly, media literacy can also enhance the public's self-efficacy by increasing proxy efficacy. In the context of public health emergencies, proxy efficacy strengthens the public's confidence in their response to crises by enhancing their perceptions of organizational and institutional competence, which helps them adopt scientific responses (Li, 2018). Previous research has identified the mediation effect of proxy efficacy, where the level of the public's social capital, through their sense of proxy efficacy for community leaders, indirectly influences their HIV prevention behaviors (Smith and Rimal, 2009). Thus, the current study argues that media literacy indirectly enhances individuals' self-efficacy in responding to the pandemic by increasing their proxy efficacy, leading to research question 1.

RQ1: Is there a mediation effect of proxy efficacy between media literacy and self-efficacy?

The Moderation Effect of Official Media Use

Media Mobilization Theory (MMT), as a positive effects view (Norris, 1999), emphasizes the positive effect of media use on public participation in political perceptions, arguing that media can enhance the public's level of political perceptions and thus its perceived trust in government (Shah et al., 1999). There is a positive correlation between media use and public perceptions of agent efficacy regarding government (Avery, 2009), and there is a virtuous cycle between media use, public perceived trust in government, and political participation (Norris, 2000).

Official media is a concept proposed for China's media context in the context of the new media environment (Huang et al., 2017; Sun, 2021) and refers to media majorly sponsored by the Party and government (Ma, 2021) or mass media under official control (Xue et al., 2018). Furthermore, official media use refers to the audience's behavior of using official media. The image of the government or government officials shaped by official media affects the public's perception of the government's image and trust in government agencies (Huang et al., 2017). As official media use increases, the public's level of trust in the government then rises, thereby increasing its sense of proxy efficacy in terms of government competence. In the case of the COVID-19 pandemic, Chinese official media tended to report on the COVID-19 pandemic using positive frames such as "effective control of the epidemic," while negative frames that exaggerated the negative effects were often avoided (Zhang and Fleming, 2005: p. 327). Such positive frames constructed by official media helped increase Internet users' level of political trust in the government (Xue et al., 2018).

The audience's use of official media tends to make them share a consistent ideological outlook (Zhou and Lu, 2008), making China's official media powerfully effective in political mobilization and popular education, which has positive implications for maintaining high levels of public trust in the government (Zhu, 2001). The current study argues that for audiences with low media literacy, if they have a high level of official media use, raising the media literacy of such audiences with the "help" of official media use will more significantly increase their level of confidence in the government's ability to fight the pandemic. For individuals with higher media literacy, their proxy efficacy is higher, and official media use can help them further maintain their high level of proxy efficacy. As a result, we propose research question 2.

RQ2: Is there a moderating effect of official media use between media literacy and proxy efficacy?

Also, based on media mobilization theory and the powerful effects of official media use, this study further infers that when official media use increases to a certain level, audiences are more likely to enhance proxy efficacy due to official media use and less likely to rely on media literacy. That is, official media use negatively moderates the relationship between media literacy and agent efficacy, leading to hypothesis 4 and the theoretical model shown in **Figure 1**.

> *H4*: Official media use negatively moderates the relationship between media literacy and proxy efficacy.

MATERIALS AND METHODS

Sampling

This study used a survey method, using the Wenjuanxing platform[1] to form a questionnaire and through the WeChat Moments, snowball sampling to obtain convenient samples in mainland China and Macao S.A.R., and finally obtained 420

[1]www.wjx.com

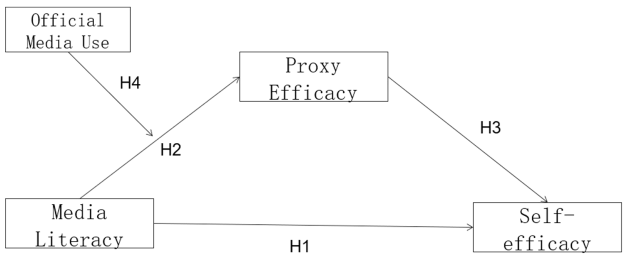

FIGURE 1 | The theoretical model.

TABLE 1 | Descriptive statistics of major variables.

	High	Low	*M*	*SD*
Media literacy	6	1	4.648	0.8506
Self-efficacy	6	1	4.7851	0.8709
Proxy efficacy	6	1	4.7667	1.0132
Official media use	36	1	22.9381	8.5039

samples. The privacy and voluntariness of each participant was ensured in the data collection process. Due to the sample size of this study, the Boots-trapping method was used to draw samples during data analysis repeatedly, and the number of samples drawn was set at 5,000 to assess better the validity of the model constructed by the study.

Measures

Media Literacy

Based on the previous research (Austin et al., 2016), this study measured respondents' agreement with 10 statements such as "I would consider the intentions of the publisher of the article," "I would compare information from different sources for the same event," and "I would search for more relevant information to determine whether the content of an article is credible" (1 = strongly disagree, 6 = strongly agree) to measure respondents' level of media literacy ($M = 4.648$, $SD = 0.8506$, $\alpha = 0.908$).

Self-Efficacy

This used existing scales (Austin et al., 2012, 2021) and uses questions including "I can protect myself from coronavirus," "I know how to protect myself from coronavirus," "I know what to do if I have symptoms of coronavirus," and "I know how not to protect others if I have coronavirus" (1 = very unlikely, 6 = very likely) to measure the self-efficacy of the respondents in the face of coronavirus ($M = 4.7851$, $SD = 0.8709$, $\alpha = 0.839$).

Proxy Efficacy

Based on the literature (Liu et al., 2021), this study measured respondents' proxy efficacy ($M = 4.7667$) through four questions: "I believe the community is confident in controlling the COVID-19 pandemic," "I believe the community is capable of helping people through the COVID-19 pandemic," "I believe the community is I believe that the community is well prepared to respond to the COVID-19 pandemic," and "I believe that the community is skilled in using various methods to respond to the COVID-19 pandemic" were used to measure respondents' proxy efficacy ($M = 4.7667$, $SD = 1.0132$, $\alpha = 0.957$).

Official media use was measured by 2 items with 6-point Likert scale: (1) The frequency of using official media (1 = never, 6 = very frequent); and (2) I believe information offered by official media (1 = strongly disagree, 6 = strongly agree). Answers were multiplied to construct the variable (Ma and Wang, 2015). Higher scores of the variable indicate higher levels of official media use.

Control Variables

This study included demographic variables including gender, grade, and current usual residence in the model as control variables. Among them, males were coded as 1 and females were coded as 0; grades were coded as 1–8, representing freshman to doctoral students, respectively; the current usual residence was partially coded as 1 and 0, representing usual residence in mainland China and usual residence in Hong Kong, Macao, Taiwan, and overseas regions, respectively.

Data Analysis

SPSS and its PROCESS macro were used to analyze data and test moderating and mediating effects (Hayes, 2017). The test answered this study's two research questions, and all four research hypotheses were verified. **Table 1** showed the results of descriptive statistics for the four main variables in this study.

RESULTS

Sample Characteristics and Descriptive Statistics of Key Variables

The total sample size is 420. Among them, most were female (71.43%) and 28.57% were male; 62.85% were undergraduates and 37.15% were graduates.

Table 2 showed results of the media literacy questionnaire among college students, where it was found that the college students were more concerned about the accuracy of media content ($M = 4.81$, 4.91; $SD = 1.084$, 0.985) and the timeliness of articles ($M = 4.83$, $SD = 1.069$), which indicated that the respondents have the higher ability in judging the timeliness and content of information. However, respondents paid less attention to the production process ($M = 4.22$, $SD = 1.304$), a gate-keeping mechanism ($M = 4.52$, $SD = 1.219$), and information source diversity ($M = 4.45$, $SD = 1.234$), and the degree of concern varied more. It meant that respondents' literacy in judging information production is relatively low. That is, when exposed to media information, respondents showed higher media literacy regarding the content of the information itself. However, they were not very alert when thinking about and judging the information production and distribution parties and information production processes.

The Mediation Effect of Proxy Efficacy Between Media Literacy and Self-Efficacy

In this study, proxy efficacy was used to mediate media literacy and self-efficacy. **Tables 3, 4** demonstrated the relationship

TABLE 2 | Media literacy of respondents.

Question	*M*	*SD*
I would consider how this article was produced when reading content related to the COVID-19 pandemic (same below).	4.22	1.304
I would think about the source of this article.	4.72	1.206
I would consider the intent of the article publisher.	4.52	1.219
For the same event, I would compare information from different sources.	4.70	1.167
I would pay attention to the completeness and clarity of the original information.	4.81	1.084
When new developments occur, I decide whether to trust the new information by comparing it to previous information.	4.76	1.078
I would search for more relevant information to determine if the content of an article is credible.	4.45	1.234
I think it is important to think over and over about the message of the article.	4.56	1.116
I will consider whether the information in the article is accurate.	4.91	0.985
I will check the timeliness of the article.	4.83	1.069

TABLE 3 | The mediation effect of proxy efficacy between media literacy and self-efficacy.

Media literacy	Proxy efficacy		Self-efficacy	
	β	Boot SE	*β*	Boot SE
Constant variables	2.4664***	0.4186	2.6261***	0.2212
Media literacy	0.5002***	0.0738	0.3164***	0.0426
Proxy efficacy			0.4607***	0.0410
Sex	0.0067	0.1024	−0.0809	0.0632
Grade	−0.0416*	0.0233	−0.0078	0.0157
Residence	0.1401	0.1733	0.0152	0.0904
R square	0.1884		0.5201	
F	24.0851***		89.7469***	

*$p < 0.05$, ***$p < 0.001$.

TABLE 4 | Direct effects, indirect effects and overall effect.

	Effect	Boot SE	Boot LLCI	Boot ULCI
Overall effect	0.5468	0.0432	0.4351	0.6585
Direct effect	0.3164	0.0390	0.2154	0.4173
Mediation effect: low official media use	0.2339	0.0408	0.1185	0.3376
Mediation effect: medium official media use	0.1760	0.0348	0.0954	0.2752
Mediation effect: high official media use	0.1181	0.0395	0.0325	0.2344

between the variables in the mediating effect. **Table 3** presented the direct effect of media literacy on self-efficacy and the indirect effect of media literacy on self-efficacy through proxy efficacy. **Table 4** presented the specific indexes of the mediating effect's total, direct, and indirect effects.

Data analysis showed that: (1) media literacy significantly and positively predicted proxy efficacy ($\beta = 0.3820$, $p < 0.001$); (2) media literacy significantly and positively predicted self-efficacy ($\beta = 0.3164$, $p < 0.001$); and (3) proxy efficacy significantly and positively predicted self-efficacy ($\beta = 0.4607$, $p < 0.001$); media literacy indirectly and positively predicted self-efficacy through proxy efficacy ($\beta = 0.1953$). Therefore, hypotheses 1, 2, and 3 were verified. **Table 4** showed the total, direct, and indirect effects of the mediated model, and the analysis showed that effects above are within the 95% confidence interval, and the upper and lower bounds of the effects do not include 0, indicating that the model is a mediation model that answers research question 1.

The result suggested that the higher the media literacy of college students, the stronger their self-efficacy in coping with the pandemic when faced with information related to the COVID-19 pandemic. Also, media literacy indirectly affected self-efficacy through proxy efficacy. When media literacy increased, the more the group trusts the ability of the state and government to control the pandemic, thus increasing their confidence in their ability to cope with the pandemic.

The Moderation Effect of Official Media Use Between Media Literacy and Proxy Efficacy

Table 5 showed the changes in the mediation model after the introduction of official media use and the moderation effect of official media use between media literacy and proxy efficacy. It was found that official media use significantly and positively predicted proxy efficacy ($\beta = 0.0279$, $p < 0.001$) and then negatively moderated the association between media literacy and agent efficacy ($\beta = -0.0148$, $p < 0.01$); the mediation model index after adding the moderating variable was −0.0068 [SE = 0.0023, 95% CI = (−0.0105, −0.0014). 0.0014]. Thus, research hypothesis 4 was validated and answered research question 2: there is a statistically significant moderation effect of official media use between media literacy and proxy efficacy.

To further explore the moderation effect of the use of official media, **Figure 2** demonstrated the changes in the influence between media literacy and proxy efficacy moderated by different levels of official media use. As can be seen from the figure, the slope increased from the high (M + 1SD) to low (M − 1SD) official media use group. When the degree of official media use is high, the positive relationship between media literacy and proxy efficacy is significant ($\beta = 0.2563$, $t = 3.7196$, $p < 0.01$). The positive relationship between media literacy and proxy efficacy was significant when official media use was low, and the effect of media literacy on proxy efficacy was more significant ($\beta = 0.5077$, $t = 7.7402$, $p < 0.001$).

This suggested that for respondents who use official media more, their proxy efficacy increased with increased use of official media, while at the same time, the effect of media literacy on their increased proxy efficacy is relatively weaker [SE = 0.0689, 95% CI = (0.1208, 0.3987)]. Whereas for the respondents who use official media less, the increase in media literacy was associated with a more significant increase in proxy efficacy [SE = 0.0656, 95% CI = (0.3788, 0.6367)]. **Figure 3** shows the tested theoretical model and standardized regression coefficients.

DISCUSSION

Theoretical Implications

The current study used a reliable measure of media literacy and enriched the empirical studies related to media literacy. In addition, this study also contributed in different aspects.

First, this study confirmed the critical role of public media literacy in responding to public health emergencies. Major findings of the study were in comply with previous works, which is, media literacy was positively associated with self-efficacy in health aspects (e.g., Avery, 2009; Cakmak, 2013). The theoretical model proposed in the present study confirmed that improving public media literacy will help the public take scientific strategies for pandemic prevention and control. The higher the media literacy of an individual, the greater her self-efficacy to protect herself and others in the pandemic. Also, the increased self-efficacy will help the public adopt scientific health maintenance behaviors (Yeun et al., 2013; Roncoroni et al., 2019; Choi, 2020; Bektas et al., 2021). This study provides empirical support for previous findings through empirical analysis and found a mediation effect of proxy efficacy between media literacy and self-efficacy, thus enriching previous theoretical models.

Another contribution of the current study was the discovery of the mediation effect of proxy efficacy. The results of this study demonstrated that an increase in individual media literacy could directly lead to an increase in self-efficacy. At the same time, media literacy can also indirectly affect self-efficacy through proxy efficacy. It has been suggested that in some specific situations, self-efficacy cannot be formed without the help of proxy (Kim et al., 2021): when individuals believe that what they are facing is beyond their ability to handle or are unwilling to face it alone, they choose to trust the ability of a third party, that is, proxy, and hope to use its power to achieve the desired goal (Bandura, 2001). In China, the "state" and "government" are considered responsible for controlling the pandemic, and the "state" and "government" are seen as a proxy to seek help. In China, where the "state" and "government" are considered responsible for controlling the epidemic, the "state" and "government" are seen as proxies, and help-seeking becomes common in the China context (Liu et al., 2021). Therefore, trust in the state and government's ability to control the pandemic contributes to individuals' confidence in preventing and controlling the pandemic. This study extended the works above in the Chinese context.

Notably, in public health emergencies, increased proxy efficacy helps the public adopt scientific strategies (Smith and Rimal, 2009; Li, 2018). That is, even without considering self-efficacy, the enhancement effect of media literacy on proxy efficacy can also serve to enhance the public's level of scientific strategies when faced with an outbreak. To identify determinants of self-efficacy was an extension of studies mentioned above.

Finally, this study emphasized the importance of official media use in enhancing public efficacy. In China's media system, political logic is the main rule the media industry follows. Traditional official media have also become a digital tool for the Party and

TABLE 5 | The moderation effect of official media use between media literacy and proxy efficacy.

IV	Proxy efficacy	
	β	Boot SE
Constant variables	4.8069***	0.1976
Media literacy	0.3820***	0.0670
Official media use	0.0279***	0.0059
Int: media literacy* official media use	−0.0148**	0.0049
Sex	0.0214	0.0972
Grade	−0.0451*	0.0227
Residence	0.1647	0.1580
R square	0.2565	
F	23.7492***	

*$p<0.05$, **$p<0.01$, ***$p<0.001$.

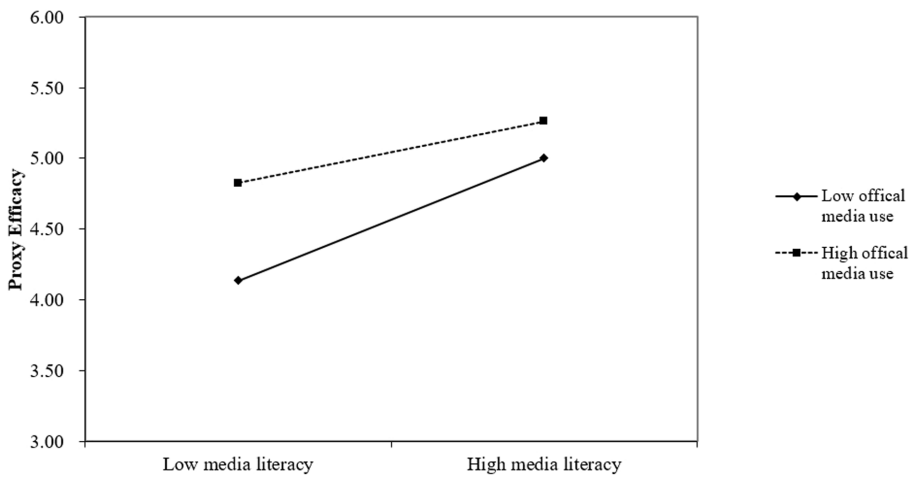

FIGURE 2 | The moderation effect.

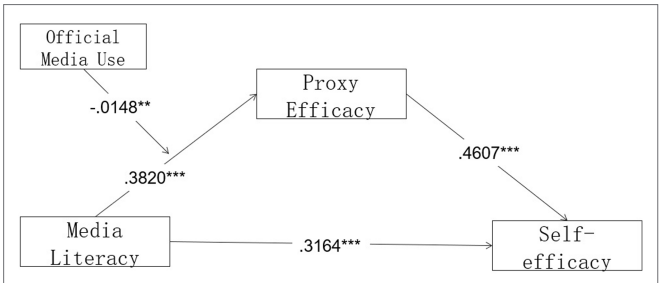

FIGURE 3 | Model with coefficients.

government to enhance their governance capacity in the Internet era of media convergence (Xie and Song, 2021). The theoretical model proposed in the current study illustrated that official media use negatively moderated the relationship between media literacy and proxy efficacy. That is, groups with high levels of official media use have greater trust in government competence, while high or low levels of media literacy do not significantly affect their levels of proxy efficacy. To our knowledge, this study is the first to test the actual effect of official media on efficacy.

Practical Implications

This study provided a new path to increasing individuals' trust with different levels of media literacy in the government and other proxies. For the more media-literate group, whose efficacy is already high, increasing their use of official media can further increase their confidence in the government to help them through difficult times. However, the existing literature suggests that individual differences in the media literacy levels of new citizens in urban China differentiate them (Song, 2019) and that there is more room for improving the media literacy of college students in general (Chen, 2020; Yuan, 2020). The current study found that for individuals with lower levels of media literacy, increasing their official media use can more significantly enhance their trust in the government's competence.

In other words, although improving public media literacy and developing media literacy education is important and long-term work, increasing the coverage of official media, promoting its image, and improving the public's use of official media can be a complementary way to strengthen the public's proxy efficacy. Thus, enhancing the confidence of some public with relatively low media literacy in themselves and the country can be achieved.

This study also has some limitations. First, the sample size is relatively small because the sample is a convenience sample, and the sample size of the female is relatively high; future studies can further improve the sample representativeness on this basis. Second, this study did not distinguish between types of media when measuring official media use; future studies can further refine the media types on this basis. Finally, the theoretical model of this study did not involve measurement of the behavior; future studies can research behavior and develop the theoretical model proposed in this study.

DATA AVAILABILITY STATEMENT

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

AUTHOR CONTRIBUTIONS

QL contributed to the conception, data analysis, and manuscript writing of the study. YZ contributed to parts of the conception, data analysis, and manuscript writing of the study. JZ contributed to the literature obtaining and analysis, manuscript writing, and performed the analysis with constructive discussions of the study. RG contributed to the literature obtaining and analysis, manuscript writing, and performed the analysis with constructive discussions of the study. All authors contributed to the article and approved the submitted version.

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Social Media as Online Shelter: Psychological Relief in COVID-19 Pandemic Diaries

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The pandemic diary on social media is a special form of online communication. Studying individual narratives in social networks during the pandemic and post-pandemic periods can help us generate valuable knowledge about the behaviors of media users and the function of social media in a public health crisis. This research focuses on psychological relief in virtual public spaces and explores how social media individual narratives affect people's psychological health in a state of emergency from the perspective of narrative theory. Based on 19 in-depth interviews with Chinese diary writers, it has been found that the narrative genres of the pandemic diary were mainly Restitution and Quest narrative, while a few were categorized as "Restrained chaos" narrative. The purpose of editing pandemic diaries is to communicate both inwardly and outwardly. The pandemic diary can promote self-relief, public communication, emotional drive, meaning connection, and identity construction in public spaces, thus helping shape a sense of unity and belonging, and facilitating the psychological reconstruction of people who are vulnerable to potential mental health crises.

Keywords: social media, pandemic diary, individual narrative, psychological relief, COVID-19 pandemic

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INTRODUCTION

The COVID-19 pandemic has had a tremendous impact throughout the world since the end of 2019, and one which has been felt in every corner of the internet. Living in the pandemic period, people are responding in various ways, including expressing emotions and creativity (Belli and Alonso, 2021). Millions of users in every country have left a plethora of comments on social media with a variety of intentions and sentiments.

Disasters are often interpreted as a cause of immense physical and psychological pain to a minority but have consequences for the majority as well (Huang, 2016). Although the felt emotions are often private, the way these emotions can be expressed depends on society's power structure. When traditional media reigned supreme, state-oriented narratives suppressed individual communication in the past. However, today's social media have empowered nearly every single member of society to voice their opinion. What used to be hidden now bubbles up to the surface. Social media and digital platforms facilitate information-sharing, user-created content, and collaboration among people (McFarland and Ployhart, 2015). The upward spiral of collective emotional activation has attracted widespread attention (Gerbaudo, 2016).

The narratives in the pandemic provide us with a novel perspective to understand public health practices (Zhao, 2021). By observing the journaling behavior on social media, this research analyzes the content in these posts and the embedded identity interactions through narrative theory. It attempts to discover and summarize the rules of interaction between different subjects (diary writers and readers) in the process of emotional exchange.

LITERATURE REVIEW

Media Narrative Theory

Mass media is a product of collective social participation (Anderson and Curtin, 2002). When it comes to user-generated content in social media, individuals not only present their knowledge of past experiences but also focus on self-cognition and reconciliation (Shao, 2014). During the COVID-19 pandemic, it was widely prevalent for social media users to share their experiences as they related to this predicament. As a representative of historical narrative text, the pandemic diary has the characteristics of originality and authenticity that fictional text does not possess (Aldrich and Eccleston, 2000; Jackson, 2005; Skultans, 2007).

As an effective way to convey symbolic meaning, narrative profoundly affects the process of public understanding and interpretation of meaning (Caldiero, 2004). The individual narrative is a prose in which a witness describes and comments on an event on the basis of their individual presence (Chen, 2020). Scholars attach great importance to the role of social media in studying crisis narrative and the narrative of disease (Moulton, 2016). Social media platforms encourage everyone to participate in the production of individualized narratives, and the public becomes the main narrator in crisis.

This study draws on the theory of narratology as particularly relates to pain and disaster narratives. American sociologist Frank (1995) proposed three types of disease narratives in the western context: Restitution, Chaos, and Quest narrative (see **Table 1**). This classification enables us to study how personal, social, and cultural factors affect individual narratives, as well as help patients' friends and family and health service providers and researchers to better understand the experience of illness (France et al., 2013). Many researchers have applied the theory to the narrative of physiological diseases, such as breast cancer (Nettleton et al., 2004; Thomas-MacLean, 2004; Pinnock et al., 2011), but paid little attention to the narrative of potential psychological disorders. Yet people's state of mind could easily collapse when a serious public health crisis suddenly occurs, leading to major and long-term mental illness. It is necessary to classify and explore narratives related to mental trauma during the COVID pandemic time based on Frank's narrative framework. Moreover, this study tries to find new narrative categories outside of this framework and supplement existing literature. Hence, the first research question could be raised:

> *RQ1*: What are the narrative genres of pandemic diaries in Chinese social media in the context of the COVID-19 pandemic?

TABLE 1 | Frank's narrative genres.

Genres	Defining characteristics
Restitution	Illness is temporary, not a permanent threat to mortality, a transitory interruption, able to construct oneself as good as "new" or recovered, I am or will be fine, expect cure or remedy
Chaos	Despair, depression, futility, hopelessness, vulnerability, impotence, powerlessness, lack of control, no one in control, uselessness, no recognition for pain and suffering, emotional battering, lack of temporal order (unless told retrospectively)
Quest	Seek alternative ways of being ill; accept illness; emphasize gains from illness experience; see illness as an opportunity, opening, or challenge; sense of purpose; includes branch genres of memoir, manifesto, and auto-mythology
Quest memoir	Simply accept illness, incorporate illness into life, trials told stoically, no special insight gained from illness experience
Quest manifesto	Demands for social reform or social action, special insight gained from illness experience
Quest auto-mythology	Change of character, personality, rebirth, self-reinvention

Psychological Pain and Relief During the COVID-19 Pandemic

The COVID-19 pandemic has disrupted the normal order of society and caused tremendous psychological pressure. Had no intervention measures been taken, the psychological shock would have resulted in cataclysmic proportions (Bao et al., 2020). Post-disaster mental disorder has always been a research focus of psychological health communication in China and abroad. Some scholars believe a disaster event is always beyond the ability of ordinary people to cope with, thus causing a series of mental health problems, such as post-traumatic stress disorder, major depression, and even suicide (Zhao et al., 2009). When faced with disasters, individuals experience both personal and collective trauma. Sudden personal trauma attacks an individual's psychological defense mechanisms, while collective trauma wreaks havoc on the relationship between sufferers and others (Zhang and Wang, 2008). Mental disorders caused by pandemics also tend to exist for a prolonged time. Although victims can return to the normality of their pre-trauma everyday life, many suffer from avoidance syndrome and emotional numbness especially in the face of new stressful events in the future (Dyke et al., 1985). Medical professionals often compare COVID-19 with SARS given their similar genetic sequence and dissemination pattern. The dissemination of SARS in 2003 caused widespread panic, anxiety, and other psychological problems in Chinese society (Xie et al., 2005). Individual responses vary depending on multiple individual personality traits, such as self-efficacy and social support (Fan, 2003).

White and Epston (2013) proposed Narrative Therapy, according to which the practice of writing is a key mechanism to help patients rediscover the meaning of life. One positive aspect of today's digital environment is that social media allow people to express themselves with various forms of recording. For example, Knight et al. (2015) stated that during the treatment of chronic and non-communicable diseases, social media has the potential to help design healthy behaviors and improve treatment effects, and enable patients to interact with peers in

a safe and confidential manner. Social media and narrative therapy have also helped African-American adolescents withdraw from drug addiction (Qureshi et al., 2015). Most of these studies, however, explored the psychological relief of social media in Western contexts, and there is a dearth of such research on Chinese media. The current study fills this gap by addressing how individuals seek emotional comfort on social media:

> *RQ2*: What is the purpose of generating individual diaries on social media during the pandemic?

Research on disease narrative has discovered the role of multiple parties in the process of sharing (Ziebland, 2004). As it initiates new forms of network and interactivity, social media is effectively reshaping our cognition of disease (Gonzalez-Polledo and Tarr, 2016). Paton and Irons (2016) found that since the information needs of victims of natural disasters are often left unsatisfied, they rely on social media to obtain more information. The narrative of the disaster would also help to build faith and stimulate civilians to actively participate in post-disaster construction. This study focuses on the emotional release of users on Chinese social media during the COVID-19 pandemic and tries to evaluate the potential of psychological healing from individual narratives. Hence, here comes our third research question:

> *RQ3*: What changes have been brought about by the individual narrative writing on social media in the context of the pandemic?

RESEARCH METHOD

Data Collection

The "pandemic diary" term used in this study refers to content about daily life events, personal thoughts, and emotions social media users post in relatively frequent intervals on the internet during the pandemic. They usually appear in single or mixed types of text, pictures, and short videos on social media, such as Sina Weibo. This research mainly collects text-based diaries, as well as a small number of pictures and video diaries. The number of words in each text diary varied from eight to 2,973 words, and the length of the video ranges from 59 s to 12 min and a half. The whole collection of diaries contains 103 pictures and 131 videos.

In-depth Interviews

The respondents of this study were Chinese social media users who kept on posting pandemic diaries on WeChat, Sina Weibo, Bilibili, etc. Nearly half of them came from Wuhan, where the pandemic initially broke out. Respondents' identities were diverse, and their diaries were relatively continuous and complete. In order to ensure differentiation, researchers mainly looked for typical cases and selected convenient samples as a complement to make a comparison. The researcher sought the help of office staff from the Wuhan Municipal Government to contact respondents. In the meantime, researchers sent invitations on social media to recruit participants. Research participants have been asked to complete a study-specific consent form. The information of respondents is shown in **Table 2**.

The research conducted semi-structured in-depth interviews *via* WeChat with 19 participants who persisted in writing pandemic diaries on social media. These respondents were mainly medical staff, patients' relatives, online and offline volunteers, and college school students. The diaries of some respondents have been reposted by influential online media, and are quite representative. The discussion guide consisted of 10–20 questions, as is detailed in the supplementary materials for interview questions.

Ethnographic Content Analysis

Diary extracts were documented and interview audio files were transcribed, checked for accuracy, and anonymized by the research team. Two researchers inductively identified codes in the data according to the theoretical background of narrative genres and constantly compared the diary extracts and interview transcripts to identify sub-themes.

We have completed an ethnographic content analysis, which is a qualitative-oriented method to code respondents' diaries and interview data. According to Altheide (1987), ethnographic content analysis is designed to examine or supplement prior theoretical works by obtaining categorical and unique data in order to develop analytical constructs appropriate for investigations. This study has referred to previous research (Vickovic et al., 2013; Belli and Alonso, 2021) to make structured qualitative content analysis and triangular validation of the coding schemes.

Data were subsequently coded through open and axial coding methods to explore linkages between the data and systematically indexed into an initial coding scheme. These coding techniques are widely used in qualitative research for developing grounded theory (Strauss and Corbin, 2014). We applied the open coding method to divide documents into smaller sections or paragraphs, mark similarities and differences and give codes to similar contents or categorize them into a higher abstract class. Then, axial coding was conducted to integrate the relationship between concepts and categories developed from the open coding process. Researchers imported the data into the qualitative analysis software NVivo11 to find connections and establish theme s. **Tables 3** and **4** elaborate on specific aspects of the coding process. And next, we visualized the theoretical frame construction on the basis of the coding result. **Figure 1** presents major themes and marks associations emerging in the coding procedure.

FINDINGS

Narrative Genres

The pandemic diaries written by most respondents were not confined to a single genre, and each had one or two dominant narrative genres. A majority of respondents mainly used the Restitution and Quest genre to give positive hints of

TABLE 2 | Basic information of participants.

No.	Name	Age	Gender	Current occupation	Current residence	Marital status
1.	JC	28	Female	Nurse	Shijiazhuang, Hebei, China	Unmarried
2.	ZZW	25	Female	Nurse	Shijiazhuang, Hebei, China	Unmarried
3.	XXW	67	Male	Retired	Wuhan, Hubei, China	Married
4.	LK	26	Female	Real estate consultant	Wuhan, Hubei, China	Unmarried
5.	DYQ	25	Female	Teacher	Wuhan, Hubei, China	Unmarried
6.	XM	21	Female	Student	Wuhan, Hubei, China	Unmarried
7.	ZYC	31	Male	Financial analyst	Wuhan, Hubei, China	Married
8.	DXJ	27	Female	Student	Seoul, Korea	Unmarried
9.	MY	45	Male	Administration staff	Wuhan, Hubei China	Married
10.	XJ	43	Female	Teacher	Wuhan, Hubei, China	Married
11.	ALX	33	Male	Accountant	Sydney, Australia	Married
12.	WJ	21	Male	Student	Xiamen, Fujian, China	Unmarried
13.	CM	41	Male	Photographer	Yangzhou, Jiangsu, China	Married
14.	DCR	20	Female	Student	Wuhan, Hubei, China	Unmarried
15.	JMS	45	Male	Freelancer	Sydney, Australia	Married
16.	XW	20	Female	Student	Yangzhou, Jiangsu, China	Unmarried
17.	MSL	26	Male	Product manager	Xianyou, Fujian, China	Unmarried
18.	DHH	24	Female	Student	Yantai, Shandong, China	Unmarried
19.	XDR	33	Male	Freelancer	Taiyuan, Shanxi, China	Unmarried

TABLE 3 | The axial coding scheme of pandemic diary narrative.

Main category	Sub-category	Supplementary explanation
Quest	Quest memoir	Quest memoir is the basis of Quest narrative
	Quest manifesto	Quest manifesto is the advanced stage of the Quest narrative
	Quest auto-mythology	Quest auto-mythology is the ultimate goal of Quest narrative
Restitution	Positive psychological construction	Positive psychological construction is the premise of the Restitution narrative
Chaos	Normal chaos	Express negative emotions unreservedly
	Restrained chaos	Express negative emotions with reservation

self-healing. Only four respondents posted content resembling the Chaos genre.

The Quest narrative was indeed the most common, as 17 respondents applied it in their diaries, while auto-mythology rarely appeared. The process begins with mere acceptance of the disaster, transitions to a determination to take action, and ends with personality changes, such as undertaking some meaningful action as a diversion from the pandemic. For example, ZYC (aged 31) wrote that he decided to start a new translation job after being a volunteering driver:

> *"I found a new job last night. A large number of medical resources arrived in Wuhan. Volunteering translators were in need. I'm good at professional English in biochemistry, and my wife has passed the Japanese N1 test. Our translation skills are good enough. No hesitation!"* (ZYC, aged 31)

The main function of the Restitution narrative is to build self-confidence and encourage others. Though suffering from physical and psychological pain, positive storytellers firmly believe that society will prevail (Belli and Alonso, 2021). The diaries of five respondents were optimistic as they thought that all the difficulties would soon be overcome. As JC (aged 28), a nurse, wrote: "As long as everyone has a strong faith, we will definitely win"; while XXW (aged 67), retired, noted: "I believe that Wuhan people will surely defeat the pandemic! I want to show my will and confidence to everyone."

CM (aged 41), a photographer, and DCR (aged 20), a college student both explicitly mentioned in their video strong beliefs in their country, the Communist Party of China, and the government. While afraid of the pandemic, they did not believe humans would be defeated by the virus. These users also expressed hope to transmit confidence and determination through their diaries. This sense of hope caused an emotional contagion that protects viewers from personal collapse (Belli and Alonso, 2021).

None of the analyzed diaries had typical characteristics of a Chaos narrative. This genre often fails to express coherent meaning, as authors often lack control over their emotions which are often imbued with negativity. Participants in this study clearly expressed their thoughts and emotions. Negative sentiments were sometimes present but always restrained. We deemed it appropriate to name this genre "Restrained chaos" as evidenced by the following quote.

> *"It's useless to make a phone call for help. Even if you call the emergency number, you can't wait for more than 400 numbers, and there is no car to take the patient to the hospital. One day in the early morning, my friend's family tried many ways to ask for a single bed in the hospital, but they always got stuck. I didn't know what to say, and I didn't know what else I could do, except to say sorry to her. I seemed to be a waste. That was the first time I felt the pandemic was so close to me."* (LK, aged 26)

TABLE 4 | The open coding scheme of in-depth interview content.

Example	Conceptualization	Categorization
I want to say something to myself online about what I usually do not want to say offline.	Satisfying self-talking needs	Inward communication
Although photos do not match texts, they can help me recall many things.	Recording precious memories	
I tried my best to tell myself that it was not my fault for things to become like this, and I tried to ease my negative emotions.	Releasing psychological pressure	
I post information about the country where I am studying in, such as reminding people not to travel to Korea shortly.	Posting anti-pandemic progress	Outward communication
My family members are worried about my physical and mental condition. To reassure them, I post positive and relaxed content on WeChat.	Informing personal condition	
The internet also has a bright side. For example, the number of infected people can be updated every day, and the knowledge of prevention can bring hope to people.	Providing positive information	
To show to others what we have done because volunteers do a lot of work.	Hoping to get attention	
I only write what I see, and it is enough to comfort myself.	Comforting oneself	Self-relief
I told my relatives and friends not to spread rumors and cancel the Spring Festival gathering.	Reminding relatives and friends	Public communication
I share stories about helping stray cats on social media.	Sharing warm feeling	Emotional drive
SOS messages are very close to me, and I can feel their hardship.	Seeking help for empathy	Meaning connection
The fight against the pandemic made me feel concerned for us from all walks of life and made me believe that my career choice is correct.	Identifying with one's mission	Identity construction

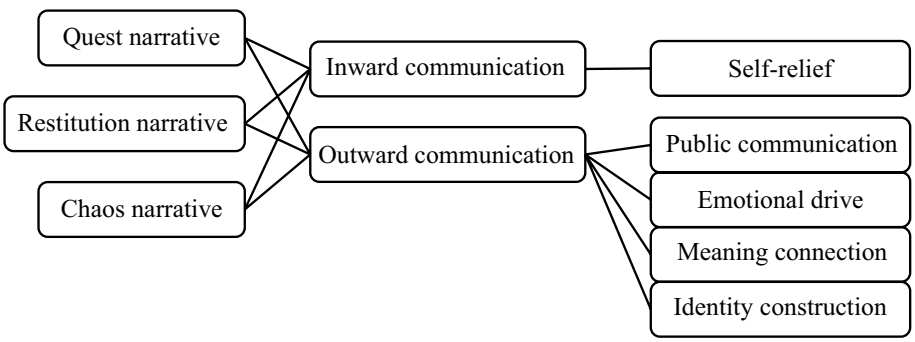

FIGURE 1 | Theoretical frame construction.

This Restrained chaos narrative reflects LK's feeling of powerlessness in a messy situation. It was posted on her Weibo account, which had more than 200 followers. It seems likely she tried to conceal her irritation toward the administrative inefficiency as well as self-blame for her inability to cope. In a follow-up interview, this participant admitted she had better be more careful in controlling her negative emotion due to the "openness" of the Weibo platform.

The Restrained chaos narratives were uncommon in video diaries; the latter were generally less negative than text. As XW (aged 20), a student, noted, "When recording videos, I cannot help expressing a positive attitude, but I am afraid that I would be too optimistic, which will cause no one to pay attention to the severity of the pandemic." The confusion faced by this vlogger demonstrates that the presence of bystanders inhibits the expression of emotions.

The Purpose of Writing: Inward and Outward Communication

The purpose of writing generally falls into two categories. First is "one-way inward communication," a kind of author's self-talk, regardless of whether the diary is read or watched by others. Many participants felt a strong desire to communicate with themselves during the pandemic. The diaries posted on social media are permanent records, and they serve to remind authors of an unforgettable tragedy (XM, aged 21; ZYC, aged 31; XXW, aged 67). Keeping a diary also enables pandemic victims to voice their pain and anxiety and attempt to alleviate their depression. The expression of these emotions varied among participants. Some directly poured out their annoyance or anger (LK, aged 26; DYQ, aged 25); others used sarcastic and self-deprecating rhetoric (MY, aged 45); and one participant said she used the diaries to simply sort out her thoughts and be more rational (LK, aged 26). Yet another said he replayed a video in order to "figure out the psychology trait at the time and estimate the tolerance level" (XDR, aged 33). For authors who applied the Restrained chaos narrative, the public nature of social media prompts them to notice whether their words and deeds are appropriate and whether their statement is objective, rather than go to an extreme.

The second category of purpose is "two-way outward communication" as evident in Quest manifesto, Quest auto-mythology, and Restitution narratives. The individual narrative in the epidemic constructs the interactive relationship between the narrator and the audience, which further strengthens the

transformative role of the individual narrative (Chen, 2020). More than half of the respondents assumed that their diary would be read or watched by others. Supposing that friends and family could be part of this audience, the authors tended to focus on reassurance (JC, aged 28; ZZW, aged 25; XJ, aged 43). Respondents who assumed the diary were followed by strangers expressed the intent of acting as spiritual models by spreading positive beliefs online (ZYC, aged 31; JC, aged 28; ZZW, aged 25). All respondents held the belief that the public nature of diary writing on social media outweighed privacy concerns. Some even saw the pandemic experience as a harbinger of a single collective memory where individual privacy is a thing of the past. The majority of posters believed in sharing the struggle with conquering the virus.

The Result of Writing: Psychological Relief in Social Media

Self-Relief

As in other media, diaries in social media can also promote emotional expression and self-encouragement. Whether subtle encouragement or an unrestrained outpouring of emotion, the individual narrative is an effective way of psychological reconstruction. Respondent LK (aged 26) had come to the following realization:

> *"Most stay-at-home people made a limited effort during the pandemic. As long as I can express my willingness to help, that is enough. Keeping a diary allows me to understand what I am actually able to do and forces me to calm down."* (LK, aged 26)

The self-reflective process of these diaries often leads to the realization of how limited people are in their response to the pandemic. Respondent MY (aged 45) saw his role as one to prevent residents from going outside frequently. He used a sarcastic expression "I was speechless" referring to the frustration he experienced at his office between the different styles of conflict resolution. Because life during the lockdown period was tedious, respondents JMS (aged 45) and WJ (aged 21) both regarded filming video diaries as an indispensable part of their schedule. Apart from expressing one's emotions, the continuous production of the pandemic diary could enhance people's self-discipline and stimulate introspection. As another respondent mentioned, "The pandemic has made me reconsider what life means to us, why we work so hard, and why we are always anxious" (ALX, aged 33). The unforgettable life experience of the pandemic makes them truly value what is important and necessary and what is not. For these participants, the diary is a coping mechanism that helps them co-exist with negative emotions. A kind of cognitive-emotional redefinition of the situation develops and prepares them to face illness and death emotionally (Belli and Alonso, 2021).

Public Communication

In the background of national self-quarantine, social media has offered an opportunity for the public to communicate with family and friends online. Public narratives on social media are often more accessible and readable than professional medical narratives. Individual narratives strike a balance between fact and feeling, and foster awareness and participation (Li, 2020). For instance, two nurse respondents had urged friends and family not to fabricate and disseminate rumors and encouraged them to cancel their gatherings around the Chinese Spring Festival. These two nurses shouldered the responsibility of communication between the medical department and the general public. When offline communication is unavailable, as is often the case with such disasters, diary writing on social media provides a chance to share joy and pain together. Respondent DHH (aged 24) mentioned she was always touched by the friendly comments that were posted below her video, especially many people saying "Welcome home." Another respondent, MSL (aged 26), admitted that his quarantine experience was significantly improved by the comments he regularly read on the screen. Respondent ZYC (aged 31) regarded a diary as a way to boycott abuse and rumors on the internet. In the early days of the epidemic, there were many malicious messages slandering Wuhan people on social media, so he wanted to use his personal experience to tell the audience that people in Wuhan were actively saving themselves, and they were not the so-called "walking virus." In just a few days, he received thousands of likes and hundreds of encouraging messages and comments.

Emotional Drive

During the pandemic, a community of shared destiny has been formed among individuals, families, and society. The pandemic diaries of all participants have attracted varying degrees of attention and praise in social circles. They described the various situations during the pandemic by recording their personal lives. Pandemic diaries are often presented as situational narratives, and a strong emotional connection is established between the diary's author and readers by creating specific situations. DYQ (aged 25), a volunteer working in a small community, often posted stories about helping stray cats and dogs with her colleagues on WeChat. The description of trivial detail displayed a simple but warm emotional experience, which moved a lot of readers. The presentation of the pandemic diary on social media not only contains textual narratives, but also achieves vivid and intuitive audio-visual effects by uploading pictures and videos, creating a real sense of presence for readers. Among all the diaries, whether selfies of medical workers wearing masks, showing volunteers delivering vegetables to the community on a daily basis, or scenery outside the window of a stay-at-home person, all of them represent a positive and persistent individual effort in the pandemic. They have caused deep emotional vibration and brought faith and hope to others. Emotions spread online can be transferred through emotional contagion, which leads people to experience the same emotions, or to form emotional patterns, without awareness (Belli and Alonso, 2021).

Meaning Connection

Pandemic diaries often include concrete descriptions of changes happening to individuals who share similar experiences. Two

nurse respondents recorded their daily work in their diaries. The story fragments demonstrated the significance of national medical assistance. ZZW (aged 25), a nurse providing aid in Wuhan, found the reading of her diary not only relieved her anxiety and fear about the pandemic, but also made her firmly believe in her career choice. Photographer CM (aged 41) imagined himself as an amateur reporter and recorded the real world in the eyes of ordinary Yangzhou citizens who were not quarantined, hoping to convey a different voice, "in order to allow people who are not in this city to understand more about the city's situation." These contents have made the audience of the diary more deeply aware that the pandemic is a reality that everyone is facing. This sense of commonality connects everyone and renders the construction of unity.

Identity Construction

Many respondents stated that they have received unexpected attention and support in journaling. DYQ (aged 25), a volunteer who served in a community, mentioned that voluntary work was difficult to carry out in the early stage and often had to face the unreasonable demands and abuse by rude civilians, which made her desperate to solicit the understanding of friends on the online platform. After she posted the diary, many people comforted her through thumbs-up and comments, which brought her great support. In the interview, she said:

> *"The comments are very reassuring, and they try to evaluate the whole thing objectively, by telling me that what I have done was right. I feel that there is still someone by my side, and I will feel better."* (DYQ, aged 25)

In the narrative of the fight against the pandemic, people are often trapped in thinking about the value conflicts between either self and others, or individualism and collectivism. Therefore, it is necessary to gain recognition of self-worth through communication with others. This also helps to soothe the psychological pain they have suffered during the pandemic, so as to let them find the meaning of life and create a sense of belonging.

DISCUSSION AND CONCLUSION

Catastrophic events can be viewed as opportunities for social transformation, bridging social inequalities, and strengthening individual competencies (Baker, 2009). Since every person could be regarded as an expert in terms of dealing with his or her biographical pandemic situation, it was suggested to shift the focus from the specialists to everyday life "professionals" in order to fully understand the crisis (Boldt, 2021). Journaling in virtual media space is a distinctive form of social media communication. Research on pandemic diaries helps us better understand social media users' behavior and examine social media's function. This research focused on psychological relief in public spaces, specifically analyzing how individual narratives would affect people's psychological status in a health crisis.

Firstly, this article explored the genres of individual narratives in the context of the COVID-19 pandemic. According to the qualitative content analysis of participants' diaries, the narrative genres are mainly Restitution and Quest narrative, among which Quest memoir and manifesto are more common than others. In the diaries collected in this study, no one completely matched the Chaos genre, but we suggest the existence of a "Restrained chaos" genre. This narrative reveals negative emotions, but the authors acknowledge the openness of social media platforms thus posting less harsh content. Frank (1995) found that patients would use different types of narratives at different phases of the disease. Similar to that study, we found that at different stages of the pandemic, the diary authors presented different narrative types. Meanwhile, the interviewees may also apply more than one narrative genre at the same phase. Therefore, the narrative of the pandemic diary is more complicated than we expected. In this research, fewer participants presented Chaos narratives in their diaries, as chaotic narratives are difficult to capture. The most negative narrative genre in public space usually hides in trivial moments of life, as noted by Frank (1995). Regardless of whether the author wanted their diary to be read by others, they would strive toward proper expression. In addition, only a small number of respondents used the Quest auto-mythology narrative. The possible reason is that this genre involves fundamental changes in individual identity and personality. People need to make a comprehensive self-reform after gaining deep insights into the pandemic, which requires a lot of effort. The narrative in individual diaries basically helps participants recognize and discover themselves in the backdrop of the pandemic, and stimulates resilience which is understood as an innate trait of people and systems (Houston and Buzzanell, 2018).

Next, this study discussed the purpose of writing pandemic diaries on social media. We summarized the purposes as inward and outward communication based on in-depth interviews. Not all participants assumed they had an audience. Authors without such expectations just focused on internal dialog, whereas those who presumed an audience expected more interpersonal interactions. All participants tend to believe that social media diaries are more public than private. The findings are in line with a study that revealed marked resilience and a willingness to benefit others as a result of the lockdown (van de Groep et al., 2020). The results demonstrate the need for discovery of oneself and to develop altruistic behavior through inward and outward communication.

Finally, the study focused on the results of diary editing on social media during the pandemic. It was found that pandemic diaries could promote self-relief, public communication, emotional drive, meaning connection, and identity construction in public spaces. Inward communication desire is satisfied by self-relief generated in journaling, while outward communication encourages the other four positive changes. These results may indicate that people's psychological resilience may be higher than it was anticipated by numerous

mental health professionals, at least in the non-clinical populations (Moroń and Biolik-Moroń, 2021). During pandemic times, people may focus more on family and friend relationships, or on creating a sense of solidarity with other people, which may help to alleviate anxiety and enhance confidence, commitment, and social bonding. Previous research found the emotional impacts appeared more pronounced in the narratives of female participants (Scott et al., 2021), our study also echoes this. The mentality of most diary authors changed positively after journaling, as the diaries helped shape a sense of unity and emotional belonging.

Social media is a platform that emphasizes interactivity, often with emotional content. They connect the users' emotions and influence them (Saldias and Picard, 2019). This appears to be certainly the case with the pandemic diary. Exploring the underlying reasons behind it may supplement research on emotional communication in social media. From in-depth interviews with participants, we found most of them believe online diaries are different from private ones. Online posters may hold back their dissatisfaction and anger for personal impression management reasons and for altruistic concern not to flare up panic. Due to the presence of the imagined audience, the communication of emotion in social media also has the characteristics of domestication, which hides the noise that is not conducive to stability and unity and amplifies the harmonious voice (Huang, 2016). Some scholars have stated that emotional expression has social rules, which means the power and class structure of society determine the expression and suppression of emotion (Hochschild, 1979; Kemper, 1980). This research also supports this claim to a certain extent. This conclusion may have some limitations because most participants write diaries on social media with acquaintances. If they are in a completely unfamiliar network environment, perhaps the diary can break through the pressure of face and authority, and convey a voice with more public awareness and objective thoughts.

In the process of transformation into a platform society, diversification and centralization have become important features of network platforms, that is, multilateral relations can be carried out through organizations (Hu, 2018). Examining the public's ritual construction of disasters on social media, we found that the arousal and drive of emotion is a micro but important component. The praise of the heroes, the gratitude to the volunteers, and the tenacious confidence in defeating the pandemic trigger a strong sense of cohesion and solidarity in Chinese society. In the symbolic space constructed by social media, people share certain text symbols to express real emotions, and collective consciousness also emerges (Fan, 2011; Huang, 2016). Therefore, we believe that the public space in the age of social media is conducive to shaping a sense of unity and emotional belonging, and constitutes a space of digital togetherness (Marino, 2015). Commitment to solidarity is invoked when people acknowledge the pandemic as a collective threat and are told by authorities that "standing together" is always effective to mitigate the hazard (Guttman and Lev, 2021). As a special narrative mode, the pandemic diary places personal experiences in a wider scope and conveys individualized experiences to the public. Just as Buzzanell (2010) put forward the process of building resilience after disasters, the healing effect of pandemic diaries is inseparable from the collaborative communication between different groups. Psychological relief is always indispensable from the participation of members of families, workplaces, communities, and organizations. The narrative of the pandemic diary constructs collective memories and emotions in this special period of time (Garro and Mattingly, 2000). The stories in the diary are continuously reproduced, linking people of different classes and interests to encourage a series of social actions (Zhou, 2020), so that individuals suffering from disasters and traumas no longer feel isolated and helpless.

Social media platforms have made pandemic narratives an immediate product. They turn painful and optimistic fighting experiences to be real and sensible and arouse much empathy. Interactivity has established a supportive community through countless personalized expressions. We believe that identifying the ways that pandemic diaries can build resilience related to the psychological burden is important, but we are also aware of a more critical reading of this. Our life experiences are perspectival and can deeply distort reality, truth, and objectivity (Goldie, 2012). The online environment allows a greater sense of freedom in expressing oneself and less concern related to judgment (Saladino et al., 2020). The narratives of the pandemic on the internet are not always true, because diary writers try to weaken negative expression for the sake of impression management (Goffman, 1959), or deliberately spread discrimination, resentment, and false information to attract attention. Therefore, the psychological relief in the pandemic diary is somewhat limited, and it may also cause certain harm to the author. For instance, the hero narrative tends to be potentially problematic for making healthcare workers feel ashamed and embarrassed (Halberg et al., 2021). In order to make individual narratives in social media play a more active and positive role in the context of health crises, we need to create a good online environment and attach more importance to supervision issues, only in this way can diary editors express themselves legally and reasonably.

This study is not without limitations. We collected and analyzed the diaries and interview manuscripts mainly in the Chinese context. Since the COVID-19 pandemic will always be a global issue, it would be better to include more research materials from diverse cultural backgrounds. Due to the unpredictable changes in the pandemic situation, psychological consequences can be long-lasting (Ho et al., 2020). It is necessary to study further the long-term psychological relief in pandemic diary narrative. We suggest that future quantitative studies focus on this perspective, it is important to help future generations of psychologists and patients to collaborate on the potential benefits of keeping the journaling behavior on social media, as a kind of education and training on the benefits and effectiveness of

telepsychology (Maheu et al., 2012). Hopefully, the habit of writing pandemic diaries online would be an effective supplementary intervention of online psychological services in severe public health emergencies.

DATA AVAILABILITY STATEMENT

The original contributions presented in the study are included in the article/supplementary material, further inquiries can be directed to the corresponding author.

ETHICS STATEMENT

The studies involving human participants were reviewed and approved by the Institutional Review Board of Shanghai Jiao Tong University. Written informed consent to participate in this study was provided by the interview participants. Written informed consent was obtained from the individual(s) for the publication of any potentially identifiable images or data included in this article.

AUTHOR CONTRIBUTIONS

RF and YF: study design, data collection, data analysis, and paper writing. AI: study design and manuscript review. All authors contributed to the article and approved the submitted version.

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Online Collaborative Documents as Media Logic: The Mediatization of Risk Response in the Post-pandemic Era

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Online collaborative documents (OCDs) have previously been the focus of office efficiency, but today they can be a special approach to risk response in public health and natural disaster situations. Studying the mediatization of the risk response by OCDs can help us understand the interaction between digital technologies, online users, and emotions in a post-pandemic world. A mixed-method design involving online ethnography and focus groups was employed to discuss OCD performance during the 2021 Henan flood. The empirical results indicate that four dimensions of technological affordances (i.e., editability, accessibility, activability, and normability) connected the functional features of the digital platform with users' potential actions. Risk communication as a contextual element of media exposure and discursive practice provided a participatory and constructive framework for users' gathering. Therefore, affective ties including anxiety, fear, and encouragement supported the affective publics' mass deliberation and social mobilization. These findings provide an institutional lens for mediatization research to view OCD as media logic and reveal some methods that can be referred to for risk management and humanistic concerns globally.

Keywords: online collaborative documents, mediatization, technological affordances, risk communication, affective publics

INTRODUCTION

During the COVID-19 pandemic, people have increasingly relied on various media to search for information about COVID-19, access news stories (Yue and Yang, 2021), maintain social contact (Shearer and Mitchell, 2021), and even seek entertainment to maintain their mental health (Yang and Ma, 2020) due to policy restrictions such as stay-at-home orders, mandatory quarantines, and social distancing. Media was previously merely a supplement to face-to-face communication, but now it is replacing offline interactions (Choi and Choung, 2021). The role of media technology in human society has never been so complex, and it has significantly "mediated" the global publics' daily lives. Thus, reconceptualizing human interactions with media technologies is now a challenge that requires exploration and the discussion of certain forms of digital platforms.

In the wake of disasters, scandals, and other unexpected events, unique forms of social behavior and organization emerge to support information communication, responses, and the construction of meaning. On Mainland China, an online collaborative document (OCD) gained the public's attention for its excellent performance in terms of risk response during the 2021 Henan flood. (To view the original link, please click https://docs.qq.com/sheet/DUG9pRWRsSlRyeHVn) On July 20, 2021, the Henan Provincial Meteorological Department recorded a single-day precipitation level of 449 mm in Zhengzhou, which was 288.74% of the historical average precipitation for this month. Water levels on the surface rose rapidly within hours, destroying power lines, energy, roads, communications, and sanitation facilities and affecting production and service sectors as well as public infrastructure. According to the State Council's investigation report (Disaster Investigation Team of State Council, 2022), the flood disaster caused approximately 40.9 billion yuan in damage, 380 deaths and disappearances, and the evacuation of approximately 100,000 people. However, the government departments' emergency response in the disaster's early stages was not timely enough, so urban people actively self-organized rescue operations among their families and communities. Several agencies also initiated rescue programs, including information exchange, medical advice, alert systems, and evacuation guides. One OCD was converted from an office tool to a collaborative medium by citizens. The content editing, discussion, and sharing of the public issue of mutual aid and disaster relief were widely distributed (19 million views and 250,000 words on the OCD and 300 million views from related topics on social media) and constructively improved the efficiency of the risk communication and disaster relief management.

Online collaborative documents are efficient tools that apply a multi-person collaborative authoring model to text editing. The technology is similar to Wikipedia in terms of stimulating the potential for group intelligence. The existing major products are Microsoft Office for the web, Google Docs, Tencent Docs, etc. Are OCDs a digital media in the universal sense? Obviously, they are constructed with digital technology and have a certain potential as they can be used by humans to store and transmit specific information. A few interesting contributions aiming to discuss OCDs' educational applications have emerged in recent years, such as Khalil (2018) and Woodrich and Fan (2017), who mention Google Docs as a useful tool for collaborative learning that is enjoyed by students. However, the existing research focuses more on the computer science significance of OCDs—such as the algorithmic architectures used for flexible encryption (Lv et al., 2016), content integration, and the implementation of complex functions such as real-time recall and damage identification (Wu et al., 2010). The information-mediating properties of OCDs, including their extensive relationships to social behavior or psychology, have not been sufficiently discussed. The gap in the relevant research is largely due to the lack of empirical cases, making it difficult for researchers to conceptualize the communication phenomenon. The use case in the 2021 Henan flood provides a unique window into events to understand the nature of the OCD medium and the social interactions it supports.

LITERATURE REVIEW

Mediatization and Media Logic

Mediatization is a concept with great potential for constituting a space for an integrated understanding of media-related social practices. In contrast to other research paradigms, mediatization theory invites systematic empirical research on various sub-processes to collectively provide a complex picture of how culture and everyday life evolve in an era of media saturation (Ekström et al., 2016). Through the work of Asp (1990), Hjarvard (2008), and Couldry and Hepp (2013), mediatization is defined as aiming to reveal how the presence of media ensures that interactions between actors take place. In contrast to the "mediated" model, the social interactions explained by mediatization are represented as follows:

> *actors—media as an actor (media logic exerts effects)—actors → the mediatization of social practices*

The consolidation of mediatization theory has supported the activation of empirical studies in recent years—such as the mediatization of culture and society (Al-Zaman, 2022; Shi, 2022), politics (Ragragio, 2021), and journalism (Blassnig and Esser, 2022)—as well as the material dimensions of mediatization processes (Kannengießer and McCurdy, 2021). As Hepp (2012) asserts, media should not be understood in this model of social interaction only as an actor that leads to causality but as a force that supports and molds action. Meanwhile, the ambiguity of this theoretical framework resides in how to clearly define what it claims to be *media logic*. Media logic began with the journalism studies of Altheide and Snow (1979), who understood media as a communication form that possesses its own logic; thus, media logic means the form in which events and ideas are interpreted and presented. In addition, Asp (1990) first associated media logic with the study of mediatization, arguing that media logic is the system of norms in the process of media production. Apparently, these grand narratives seem to describe media logic as an undifferentiated concept, into which all the studies related to media effects can be placed (Deacon and Stanyer, 2014). Thus, critiques of media logic have been common in recent discussions of mediatization theory (e.g., Couldry, 2008, 2012; Lundby, 2009). One of the concerns is to avoid the indiscriminate use of media logic when conceptualizing specific communication phenomena or invoking other theories, such as materiality, media affordances, social construction, and actor–network theory. Therefore, media logic is more akin to a rhetorical lens that invites us to scrutinize the technological features of the media as well as the contextualized social institutions and cultures. We understand the process of risk response reshaped by OCDs as follows:

> *actors (online users)—OCDs as media actors (key media logic: human–technology interaction, the social context of media exposure)—actors (online users) → the networked publics and social practice*

In this mediatization theoretical framework, we focus on three sub-processes to discuss the potential of OCDs to reshape social interactions: human–technology interaction, social context, and the networked publics and social practice.

Human–Technology Interaction

Human–technology interaction is an active multidisciplinary field, involving research in psychology, communication, sociology, and philosophy. However, as Thüring and Mahlke (2007) worried, previous research has almost exclusively concentrated on the aspects of usefulness and usability. Technological affordance is perhaps a potential explanatory framework for examining the connection between actors and the technological environments in which they are located (Gaver, 1991). Affordance theory originated in perceptual psychology, where Gibson (1979) interpreted it as the possibility of action available in the environment. It aroused researchers' interest and has since become a fundamental concept in ecopsychology (Bickhard and Richie, 1983; Stoffregen, 2000). Affordances in the literature about telecommunications are usually used to explain the characteristics, features, or hints of technology (Aakhus, 2007; Leonardi, 2011). Among the applications of media research, smartphones (Schrock, 2015; Mascheroni and Vincent, 2016; Jin and Cai, 2021) and social media platforms have been extensively discussed (Kaun and Stiernstedt, 2014; Ilten, 2015). Notably, Evans et al. (2017) proposed a set of threshold criteria to distinguish between "characteristics" and "affordances," providing a constructive starting point for researchers to make inductive and conceptual deductions about phenomena. Those studies have shown that affordance is often used to describe the connecting relationship between subject and object, and the plurality of branching concepts is derived from the complexity of the object. For this reason, technological affordance applies to our discussion of human–technology interaction, which suggests a relational approach to understanding how people interact with technology (Leonardi, 2013) and aims to reconcile the contradiction between technological determinism and social constructionism.

Moreover, as Nagy and Neff (2015) noted, when the concept of affordances migrated to the field of communication technology and media studies, researchers continued to emphasize that affordances are environmental and material while ignoring or denying what is perceptual and imaginary. This context deviated from the original theoretical intent. Since the operation and propagation of OCDs are internet mediated, we expect that the specific characteristics and capabilities of the technology platform have an impact on the interaction mechanism. Nevertheless, technology has become more than a tool in human society over the digital era; it is the material basis for triggering a series of consequences of social action or changes in institutional structures. Technological affordances "create possibilities" for "everyday life" in a social sense (Wellman et al., 2003), and they have changed communication practices or habits (Schrock, 2015). Thus, the materiality of technologies is shaped in part by their sociality, a relational entity that bears traces of human activity (Turkle, 2004), including even psychological factors such as imagination, anxiety, and anticipation. Analysis of Belli (2021) of how socio-material networks' affordances enable online collaboration supports this proposition. In a word, affordances can cause imagination, action, and other consequences, but they are not themselves the consequences. Therefore, this paper understands technological affordances as the potential actions that arise from the given technological features and forms, and poses the following research question:

RQ1: What are the technological affordances of OCDs?

Media Exposure Context

On July 20, 2021, rare heavy rains formed floods that affected some communities in Zhengzhou. At 21:00, the first version of the examined OCD was created by a college student living in Zhengzhou, in the form of a spreadsheet named "Information on persons to be rescued." After 5 min, two volunteers were added to the second version as collaborative managers to work on the information layout and checks. Within 2 h, the OCD was inundated with hundreds of user-initiated requests for help, such as, "A family of three trapped on subway line 5," and "We urgently need a lifeboat to transfer the injured." At 00:00 on the 21st, the OCD had a new sheet added, "Supportable," showing some evacuation locations such as libraries, gyms, and cafes. Apparently, the OCD was being used as a form of risk communication in a crisis. Risk communication is defined by the U.S. National Academy of Sciences as a systematic, structured, scientifically based method for communicating effectively in high-concern, high-stress environments. These environments include any situation in which individuals or groups perceive a threat to their health, safety, or environment (Covello, 1998). This research perspective is often used to analyze how social actors use technological systems such as smartphones, online wikis, and social media to organize special responses, process and deliver information, and provide social support (Shklovski et al., 2008; Starbird et al., 2010) so the social actors can motivate the public to rationally perceive the disaster risks and take appropriate response measures to reduce risk hazards and maximize the protection of their property and health (Glik, 2007).

Inadequate communication in a crisis can result in negative emotions and stressful behaviors, so effective risk communication is a fundamental measure of the health emergency response (Reynolds and Quinn, 2008). Many studies during the COVID-19 pandemic have also shown that risk communication is now a major factor in public-initiated media exposure (Melki et al., 2020; Chu et al., 2022) and a significant way of regulating mental health (Wang et al., 2021). While classic research has often viewed government agencies and journalism as the core sectors of risk communication, digital technology now presents additional opportunities. The California wildfires are a good empirical case. Local residents took photos of the fire and updated them in real time on Twitter, so firefighters learned of the fire's movements before reporters arrived on the scene (Sutton et al., 2008). Risk communication is coupled with

digital media, and crisis response activities, both onsite and online, are becoming increasingly simultaneous and intertwined (Palen et al., 2007).

In addition, several studies have shown that building trust is an important factor in the public's acceptance of information when facing threats and information overload (Kiousis, 2001). The level of media trust depends on media types, frequency of exposure, and user experiences (Tsfati and Cappella, 2003; Johnson and Kaye, 2009). Thus, from a media constructivist perspective, trust arises from the discourse and social interaction between media and users. For example, during a crisis, when people are aware of threats, they tend to seek authoritative information from mass media that emphasize expert sources (Loges, 1994; Lowrey, 2004), but they can also selectively access journalistic disaster coverage to prevent post-traumatic stress disorder (PTSD; Romer and Jamieson, 2021). Meanwhile, social media is used more often to express emotions (Denemark and Chubb, 2016). In many cases, the relationship between media use and media trust does not follow a perfectly rational model, as Tsfati and Cappella (2003) argued, in which the contents of the media messages constitute social attitudes and informs social behavior. Public opinion is seen by most risk researchers as a mass phenomenon that readily responds to information inputs and that tends to evade the psychosocial aspects of risk communication (Wilkinson, 2010). Therefore, relevant research should be conducted and not merely in the form of cross-sectional surveys but also by paying attention to more affective narratives.

The chosen risk communication strategy is closely linked to the type and progression of crisis events. In many classic cases of risk communication, persistent risk threats—such as health issues including SARS, COVID-19, HIV, and GMOs—focused more on the risk perception aspect in attempts to motivate citizens to adopt public policies and prevention recommendations and to influence their health behaviors (Slovic, 1987; Lee-Baggley et al., 2004; Brewer et al., 2007). In contrast, sudden crisis events such as the California wildfires and terrorist attacks fall under the topics of disaster response and post-disaster psychological support (Rogers et al., 2007; Sutton et al., 2008). Thus, this study avoids emphasizing the risk perception aspect. Because the citizens of Zhengzhou were facing an ongoing existential crisis at that time, the work of risk communication was to discuss relief strategies and care for mental health. During the flood, the central and Henan provincial governments continued to release weather conditions, rescue progress, and casualty figures. Journalism was also running feature stories. In addition, social media continued to contribute citizen journalism and emotional narratives. Tens of thousands of people simultaneously posted requests for help or made personal donations at the OCD. Other netizens discussed the incident intensely, and rumors were widespread. Therefore, this paper poses the following research questions:

> RQ2: (a) How did the flood-affected groups use media for the risk response? (b) What were the characteristics of the OCD-mediated risk communication compared to other forms of digital media?

Networked Publics and Social Practice

Networked publics are usually understood as a contested and messy term with multiple meanings used across different disciplines (Boyd, 2010). Similar to the concerns of mediatization studies, contributions on networked publics highlight that "publics can be reactors, (re)makers and (re)distributors, engaging in shared culture and knowledge through discourse and social exchange as well as through acts of media reception" (Ito, 2008). Thus, the mediatization of social practices should try to move toward the space where interactions occur between people, technology, and the imagined collective. These processes lead to some uncertain affective results, such as the erosion of community vitality and social cohesion that occur under same-day-delivery online shopping conditions (Xi et al., 2021). To be sure, digital media are not only containers for citizens' emotional expression but also active creators of socio-emotional space (Giaxoglou, 2015; Sumartojo et al., 2016). When some political and cultural issues become mediatized, the affective flow becomes highly relevant (Hepp, 2012; Deacon and Stanyer, 2014; Savaş, 2019). This phenomenon or trend of social publics engaging in online activities around emotional ties is conceptualized by Papacharissi (2015, p. 126) as affective publics: a networked public formation of connection—identification—disconnection that is mobilized through expressions of sentiment.

The magnitude of the impact of flood events is usually quantified in climate and economic terms. However, in the aftermath of a flood response, concern for the victims and the disaster's long-term effects urgently requires an emotional component (White et al., 2010). Emotion is likened by some researchers to Higgs Boson's particle in the social sciences. Among efforts to apply the "affective turn" of global social science research to the interpretation of media technology and user activity, Papacharissi's research makes a clear and valuable contribution. In her book *Affective publics: Sentiment, technology, and politics*, she theorized the structure of the affective public: First, the public in the internet era is primarily an affective community. They gather around media and platforms, invite affective coordination, support affective investment, and spread affective expression. Second, based on understanding of Boyd (2010) of networked publics, affective publics are considered publics transformed by networked technologies. Technological affordances are thus an important driver for the formation of affective publics, and shareability is summarized as the core affordance characteristic that either invites or discourages a particular type of social activity. Third, the sharing of sentiments on social media platforms is not limited to the intragroup but interacts with the larger social context and institutional environment. The media do not directly facilitate the negotiation of collective identities, so networked publics need specific political and cultural discourses. In psychological experiments, sentiment can be measured directly by a variety of methods, but communication studies require specific mediators. Affective publics often leave distinct digital footprints in unique ways, such as various forms of media texts (Dean, 2010; Papacharissi, 2016), so this paper poses the following research question:

RQ3: (a) What were the main affective flows active in the OCD? (b) How do users socially mobilize around affective ties?

MATERIALS AND METHODS

As an ideal example of executing in an online interactive space, this OCD preserved the memories from the media technologies, texts, and experiences generated by the public's interactions with specific digital media during the flood. The aim of this paper is to reveal the potential of OCD technology to reshape risk response through media logic. A mixed-method design involving online ethnography and focus groups was employed to discuss the mediatization of the risk response.

Participants

Inclusion criteria were living in Zhengzhou during the 2021 flood and being at least 18 years of age. A focus group containing 10 people was interviewed in a semi-structured manner during late January 2022. They all gave their consent for the interviews to be collected, preserved, and processed by the researchers. **Table 1** reports the demographic information for the focus group participants.

Research Design

Before discussing the OCD's performance in a targeted manner, it is necessary to understand the media usage of Zhengzhou citizens during the flood period. Thus, online questionnaires were placed on social networks by a research partner in Zhengzhou in January 2022. Participants were informed of the study's purpose and the privacy policy before completing the questionnaire. The researchers distributed 500 questionnaires, and after eliminating invalid data (the respondent did not live in Zhengzhou or was below 18 years old), a valid sample of 420 was collected. The measurement items covered the frequency of media usage, the motivation for the media exposure, media trust, and OCD exposure. All results of the descriptive statistics are illustrated in **Supplementary Material**.

TABLE 1 | Demographic information for focus groups.

No.	Gender	Age	Identities in OCD	Occupations
A1	Male	50	Help seeker	Farmer
A2	Male	43	Help seeker	Company Staff
A3	Female	23	Help seeker	University Student
A4	Male	37	Help seeker	Company Staff
A5	Female	35	Help seeker	Company Staff
A6	Male	19	Help seeker	University Student
B1	Male	23	Volunteered maintainer	Company Staff
B2	Female	26	Volunteered maintainer	University Student
B3	Female	29	Volunteered maintainer	Company Staff
C1	Male	51	Official government	Civil servant

Similar to most media technology-oriented affordances studies (e.g., Majchrzak et al., 2013; Kaun and Stiernstedt, 2014), we did not attempt to extensively map user behaviors and content generation but rather to discover the interface between technological potential and social actions. We first approached the technological materiality of the OCD, roaming contextually through the functional support and content creation aspects of the platform to inform the interviews on the issues related to the users' experiences on media usage and technology adaptation. In the focus group, the participants were first asked a few targeted and fixed questions that prompted them to share their media usage experiences during the flood. We also asked specific questions about the underlying goals, experiences, and practices associated with OCD with the document maintainers who had been granted higher privileges by the creators. To extract rich data, personalized secondary questions were created for further in-depth study. Beyond the construction process, each participant gradually and collectively built a shared story by sharing individual stories. **Supplementary Material** contains the main questions.

For the affective characteristics of the OCD, media texts from 10,589 posts totaling approximately 74,300 words were selected as the sample for sentiment analysis. We used the Jieba Chinese word splitter running in the Python environment to split and count the text. In addition, the LIWC-22 Chinese dictionary was used to identify and label the text with affective words, resulting in the four emotion dimensions of "positive," "sad," "angry," and "anxious." Then, we added and adjusted some custom words based on the specific text of the case study, and selected the one with the most hits among the four types as the affect category of a text; those without hits were marked as "others."

TECHNOLOGICAL AFFORDANCES

Editability

As an efficiency tool originally applied to mental work, OCDs enable the writing and storing of multimedia content such as text, images, video, and audio in online multi-person collaborations. In terms of the technological materiality, OCDs are fixed entities in itself. They are like blank sheets of paper that continually acquire new meaning through a series of users' editorial actions. The technology platform that supports OCD operations enables users to freely add, review, recall, evaluate, and modify multimedia information in a participatory manner within the scope of the permissions they are allowed. Two of the project's early managers interviewed, when asked why they chose an OCD as the primary digital media platform for information storage and communication, described it this way:

> *I had almost no hesitation in thinking it would achieve our goals. Because we use it regularly to register personal information in workgroups or to record brilliant inspiration for brainstorming. OCD seems easy, reliable,*

and efficient … The great user experience in the past does not lie. (Interviewee B3)

The moment I visited the OCD, it was as if I was thrown into a scene where I was performing emergency work. While this is true in reality, I want to emphasize that it was only after interacting with the OCD that I realized it fit perfectly. (Interviewee B2)

Obviously, the analysis of affordances relies on the media usage experience. OCD is very similar to Wikipedia in terms of shaping a participatory information environment. As technological mediators of human activities centrally organized around shared practical understandings, both platforms aim to significantly advance the wisdom of groups through the active participation of individuals. Compared to other digital technology systems, such as television or social media, OCDs appears to be better suited to support *ad hoc* organizations in documenting breaking events and can be considered a paradigm of timeliness and reliability. OCD tasks may seem highly interdependent and incur high negotiation costs between editorial groups. However, unlike many other cases of collective intelligence, the scalability of OCDs allows users to strategically adapt the technological conditions of the platform to achieve the stated goals. Scalability represents highly flexible and user-friendly technological features, such as automatic saving without manual confirmation and real-time recall. Furthermore, each OCD has history pages stored on the cloud server, where users can access all previous versions. However, the time and attention required to do so on traditional digital technology systems such as WeChat, WhatsApp, or Twitter can be fatal in an emergency.

Accessibility

Emergency disasters can damage digital infrastructures such as communication base stations and wires to a varying degree. Most digital technology systems require a constant supply of electricity and the internet, but smartphones allow people to access and post information during power outages, if battery support continues. Thus, mobile internet has now become the primary way of maintaining communication between victims, experts, volunteers, and government agencies in crisis (Bunce et al., 2012). Social media apps, as a way of accessing and sharing information, ensured their importance as a warning system and by providing relief to those affected by the floods in Zhengzhou. However, evaluating the role of social media in terms of efficiency, they continued to lag somewhat in terms of messaging. Based on the respondents' media usage experiences, we learned that if a family faced a flood threat who could not reach 110 (similar to 911 in the United States) had several ways available of seeking help through Weibo (the most popular social media platform for strangers on Mainland China):

1. Find the contact information of the relevant rescue team in the search bar and try to report your location accurately.

2. Choose the correct tag (e.g., #Mutual help in the Zhengzhou flood) and post the message. After that, wait for a reply.

Obviously, obtaining official relief in the early stages of the flood was difficult, which was exactly why Zhengzhou citizens were actively engaged in mutual aid initiatives through the OCD. As software developers claim, OCDs' multi-scene compatibility supports their core competencies. A series of streamlined features allow OCDs to run on mobile apps, web browsers, and even as a built-in component of some social media platforms. For those in desperate situations, OCDs can be used without loading images or videos; they do not require a high level of user media literacy or mobile hardware performance; and they consume very little cellular network traffic, battery power, and user attention.

Additionally, OCDs are inherently open access, they support decentralized operations, and they are richly scalable unless controls are artificially modified or access is restricted. Taking as an example Google Docs, various application programming interfaces (APIs) realize a seamless connection between users and related expansion features. Examples include automatically recognizing and filling in phone numbers from contacts or displaying your location information *via* Google Maps with one click. While Google services are restricted on Mainland China, fortunately, Tencent Docs, the case for this study, has similar scalability, can be shared unhindered, and runs smoothly on social media platforms. The Tencent Maps API was accessed for users to automatically mark and upload flooded, electrical leakage, collapse and evacuation spots in flooded areas. The home page was a navigational sheet that aggregated all of the OCD's functions, including internal hyperlinks that took the users to sub-pages about seeking support, danger area warnings, psychological counseling, public health recommendations, charitable donations, etc. Furthermore, OCDs are highly scalable on the server side. Interviewee B1 told us how the volunteer team negotiated with the service provider to accommodate more users. Overall, OCDs' accessibility means more opportunities for users' media exposure.

Activatability

Online collaborative document is not a "meta-media," which would need to operate in an existing polymedia environment. During the flood, the OCD was frequently viewed on social media such as WeChat groups and Weibo, with a significant attachability. We expect that social media can occasionally be used for public goals or to advance public interests (Baym and Boyd, 2012; Poell and Van Dijck, 2016), which helps to activate and maintain potential relationships and is essential for mobilizing online publics (Karatzogianni and Kuntsman, 2012). In addition, social networks and their technological support significantly influence the publics' emotional experience, either as an outlet for expressing sentiments or as a tool to reinforce existing ones (Choi and Toma, 2014). The OCD activated social connections through the social networks to which it was attached, including

information-sharing and emotional contagion. However, the online activity did not guarantee impact; it merely gave momentum to action and facilitated potential engagement, including psychological factors. Message texts were posted by users in the specified location in the OCD and occupied one or more cells. This editorial approach created opportunities for others to participate in conversations, and other users could show their support by commenting. In addition, the OCD allowed text messages to have rich formatting characteristics, such as customizable fonts, sizes, and background colors. Impressively, we found a message in the OCD from an out-of-town visitor describing himself besieged at a railroad station and complaining of bad luck, but cells around it were filled with others with pink background colors, heart-shaped emojis, and encouraging comments. The discursive practice of these affective expressions seems incredible. In contrast, while other social media platforms such as WeChat and Weibo also promoted spontaneous interaction and information-sharing, they were slightly more mediocre at activating creative expressions of sentiment.

Online collaborative documents support users in expanding weak social ties rather than in strengthening existing strong social ties. This activatability has led OCD to become a platform better capable of activating social mobilization. Activatability is not the same as collaboratability. Evans et al. (2017) similarly suggested that researchers should be cautious in assessing the threshold for using the "collaborative affordance" as a branching concept. Collaboration is a relational act and can be used to describe a practical consequence of actors, rather than a property of the technology itself. Only when OCDs interact with online users and activate their potential actions does collaboration become possible.

Normability

Coordination in unstable environments such as disaster responses or emergency medical care situations requires a high degree of caution and interrelated knowledge integration and information-processing actions (Brown and Eisenhardt, 1997). The press and social media were committed to contributing to the information flow during the Henan flood and influenced social actions to some extent. However, the public's interactions with journalism were limited because in times of crisis they looked forward to seeing dedicated rescue teams rather than journalists. Similarly, distress messages were hardly guaranteed to be widely read and effectively responded to in the fragmented information environment of social media, although some specific hashtags were set by Weibo users. As Poell and Van Dijck (2016) note, the public moment will certainly be temporary, as social media constantly tries to link user action trends to commercial advertising. Unlike the mass communication sector, social media, or Wikipedia, which have clear user agreements and community norms, OCDs do not prominently inform each user of the rules, etiquette, and guidelines of this digital space. Instead, the technology facilitates or restricts users' certain potential actions through its technological conditions.

> *What sticks in my mind is that in a panic I was trying to edit the text I had already posted, but accidentally selected others' one and pressed the delete button. The system informed me that the delete operation was invalid, and then I had known that each non-managers editing privileges were restricted to only being able to manipulate what they had posted. (Interviewee A1)*

> *It was reassuring that all the information within OCD seemed to be themed around the floods and able to contribute to the relief process. I did not find any commercial ads during my browsing, while it was appearing frequently on the Tik Tok app or TV channels. (Interviewee A3)*

> *The OCD creators were wise to choose spreadsheets over Word and slides. Cluttered information could be automatically categorized and shown in various cells. (Interviewee A6)*

Obviously, the information flow in the OCD was dense and pure, as it avoided the distraction of commercial advertising and entertainment content. Many people had never worked together previously on a public affair through online collaboration and may never do so again. However, they had some autonomy and imagination in shaping the digital technological infrastructure to achieve their own aims. The users also understood a range of cues about appropriate or acceptable behavior based on the interactive experiences, and then adapted more or less to the norms of the digital space. The normative affordance of the OCD supported the construction of an institutionalized group coordination mechanism, which is the main reason this empirical case took place on this media platform rather than on other available ones.

RISK COMMUNICATION

Participatory Risk Information Release

Geographic information systems (GIS) and internet technologies have increased the validity of perceived consequences regarding the population and improved the publics' ability to make decisions in risk response situations (Brown et al., 2017). Nevertheless, digital participation is often seen as an elite technology that requires a certain level of intellectual literacy and excludes some people from the information release process (White et al., 2010). In contrast to those previous studies, we found that OCDs' four dimensions of technological affordances facilitated public participation in risk communication and simplified the consultation process among stakeholders such as victims, volunteers, and government agencies. Through participatory knowledge-sharing and experience exchanges, basic precautions, known risk areas, evacuation routes, and available dietary supplies were identified. Moreover, the release process generated reliable, quantitative, and easy-to-use material that could be observed and analyzed by researchers. Participatory information release treats meaning and experience as emergent,

and as Deetz and Brown (2004) argued, meaning is initially formed in the relationship between goal-directed activity and what is yet to be decided in the world. Individuals may be the gateway to perceiving new cues and discussing collective decisions, which leads to productive participation. Because personal narratives are sometimes more relevant to the interests of the audience than are factual truth and data, and are more likely to raise concerns about risk, they can quickly gain attention. We believe that democratized, broad-based participatory action can improve decision-making; increase acceptance, ownership, and commitment to desired programs; and incorporate lessons learned into new programs and developments.

This information-sharing network had no fixed center and its structure evolved dynamically. The actors enhanced their positions in this network by absorbing more information and processing it effectively. If they performed poorly, others took over their tasks. For example, People's Daily and Xinhua News Agency also appeared on the OCD's homepage, but their position did not depend on their inherent social capital and information power. Instead, it was seen by the other actors as a trusted source contributing to the environmental perception. Therefore, the information release action was based on a practical contribution rather than cultural capital or power confrontation, which led to coordination mechanisms that emphasized participation, reciprocity, and reputation. Further, open, democratic as well as sustainable risk information release activities could even positively lead to mindfulness in the cognitive psychological sense, such as minimizing the level of distraction and leading to adjusting the metacognition of risk information (Kudesia, 2019). As a result, the participants acquired a collective subjectivity organized around the right to live in the practice of responding to a risk crisis.

Constructive Issue-Oriented Communication

Many risks are difficult to avoid or manage because of problems in predicting or quantifying them. Moreover, the process of media coverage is not merely a simple reproduction of events but a constant process of interpreting and transforming the meaning of reality and possibly constructing new risks. In the 2021 Henan flood, the emergency response of government departments in the early stages of the disaster was not timely enough, while families and communities became the main organizations that temporarily responded to the disaster challenges together. Journalists were not always interested in risk uncertainty, but they were interested in controversy. If the government makes an obvious mistake or if evidence shows that vested interests are trying to advance a position and working to eliminate opposition, the news media will flock to the story. Therefore, the topics of responsibility and criticism received much attention from the media coverage. In addition, meteorological statistics showed the precipitation still exceeded the average of previous years during the 3 days after the flood began, so the disaster's intensity was likely to keep increasing. As threats continued to grow, it became ever more important for media outlets to gather more knowledge, effectively display and communicate uncertainty, and encourage the public to make good decisions. Survey data show that the official news media gained a higher trust in informing people about changes. However, the limitation was that they only reported or criticized objective reality and did not make significant contributions to effective dialogs or social mobilization actions.

Each request for help and individual contribution was noted with the solution in the same line of the spreadsheet as if the OCD was a list of problems to be solved by getting the attention of the various actors. Even the structural framework of the OCD and institutional specifications were discussed by volunteers and online users on a specific sub-page, and anything appeared negotiable. Government officials were also involved in the communication process and used the reliable information thus made available to support decision-making, such as sending firefighters to safeguard confirmed evacuation routes and distributing food and medical supplies to shelters. One of the emergency management staff told us:

> *A portion of the trustworthy information in this OCD was used to discuss and design the measures in an attempt to resolve some of the issues once and for all. However, when talking to colleagues in the opinion monitoring department, they complained that the information on social media such as Weibo was too fragmented and that the process of verifying the timeliness and authenticity of each message hindered communication efficiency. (Interviewee C1)*

Unlike fear appeals or adversarial communications, issue-oriented communications focus on "what is to be achieved" and prioritizes the establishment of a participatory and constructive dialog platform. The OCD's online users fully exercised their right to participate in public affairs under multiple interactive public discourse channels and reasonably expressed their opinions and affective appeals, which may have generated positive evaluations of their risk communication effectiveness. Therefore, this constructive communication expected the resolution of crisis issues to have the effect of alleviating individual and group fears.

Controlled Content Credibility

Disinformation can reduce the credibility of media platforms (Bontcheva et al., 2013) and undermine the legitimacy of governments' risk management policies (Kim et al., 2019). Therefore, validating credibility is a key aspect that affects the effectiveness of risk communication. While journalistic objectivity is derived from the journalist's individual cognitive framework and the organization's gatekeeping rules, fact-checking is often carried out after publication. Social media, on the other hand, relies excessively on algorithms to filter information, which appear to be ineffective and have caused a series of ethical controversies in human–computer interaction. The OCD's credibility was controlled through two layers: affordances about normability and maintainers as gatekeepers. The validation

process was that every piece of information related to this flood was verifiable by external credible sources, which rejected the tendency for private matters or false facts to become public affairs. Inappropriate sources were hearsay, open forums, and subjectivist personal observations. Normability was analyzed in Section "Normability" as a potential interaction rule on the online space that all actors must follow. Meanwhile, the gatekeepers came from an active group of volunteers who guaranteed the OCD's stability through nonautomated operations. On the first day the floods swept through Zhengzhou City, this volunteer team grew quickly from three members to dozens and kept growing in the days that followed. This team verified each geographic location and contact information and assessed the priority of the requirements. A clear division of labor supported efficiency in emergency situations, minimized disinformation, and promoted collective intelligence. Thus, the team demonstrated methods and strategies for fact-checking media information.

SQUARE FOR THE AFFECTIVE PUBLIC

Temporary Public Sphere

Online users appeared to discuss the floods as a public affair rationally in the OCD, and some consensus was reached around controversies of public interest, such as how individual donations were used, priorities for rescuing stranded people, and rules for reviewing the credibility of information. Furthermore, technological availability supported actors to expand weak social ties and activated potential actions. Impartial, democratic, and rational consultation is associated with the quality of the decision-making process and can provide legitimacy criteria for the public to gather in digital platforms. The ideal situation about the public sphere and spiritual interactions can be discussed as depicted by Hannah Arendt and Habermas. While academics continue debating whether digital technologies offer potential benefits that influence the process of constructing the public sphere, Dahlgren (2005), for example, argued that most online interactions are apolitical or entertainment oriented, which may limit the deliberative potential of public affairs. However, in reality, the self-awareness and reflection of online user activity through the OCD tended to be rational and even provided a legitimate digital identity. Some users extend their volunteer contributions to adopt management roles, help mediate conflicts, negotiate risk communication procedures, and engage in other public online activities. This analysis suggests that we should use this concept in light of the discursive intent of the public sphere, which is to appeal to some form of rational public consensus that inspires political action and counters authoritarian forms of decision-making (Calhoun, 1992).

Habermas (1989) initially saw the combination of public and private affairs as symptomatic of the collapse of the structure of the public sphere, and he criticized the mass media as the main driving force behind this trend. During the 2021 Henan flood, the boundaries of public affairs tended to blur even more: On the one hand, individual actions and sentiments previously rejected by theoretical values became an essential part of risk communication; on the other hand, networked publics organized themselves around participatory autonomous actions that relied on reciprocal relationships with each other and that aimed to improve society. However, the uncertainty of the boundaries did not mean that the OCD was a free-flowing, open, discursive space. We, therefore, followed classic idea of Dewey and Rogers (1927) of media democracy, which prompted us to attempt to identify the public character of the media through shared problems and solutions. The publicness of the OCD was reflected in a common framework of action constituted by social experience and supported by technological affordances. It unified the concerns of local communities in a political sense and allowed access to external users, which promoted the social mobilization of citizens rather than their representation. Rather than simply expressing opinions through their digital participation, online publics with citizenship used their characteristics to mobilize and act. Regrettably, however, the concept of the public sphere is like a "superconductor" in the sense of physics, where the ideal situation can be maintained only at a specific temperature or pressure. Regarding OCD usage, work pressures force employees to communicate efficiently, and humanitarian crises force the public to organize response actions in an orderly manner. While technological affordances supported an online space and actively fostered the potential of the public sphere, the spirit of publicness was sequestered in the specific scene of risk communication during the flood; thus, it was "temporary."

Reconceptualizing the Affect

While the use of the public sphere to conceptualize the online space shaped by OCD faces many limitations, the "affective turn" offers an alternative, sustainable insight and the opportunity to challenge the distinction between private and public (Clough and Halley, 2007; Ekström et al., 2016). Therefore, before discussing RQ3, we must reconceptualize the "affect." Our interpretation follows understanding of Papacharissi (2015) that affect is a subjective experience of pre-emotive intensity that provides discourse and narrative for networked publics. Furthermore, it implies the potential and urgency for people to act based on their sentiments (Damasio, 1994). Affect supported the OCD users to reflexively reflect on and construct individual narratives based on objective reality, including expressing concerns about public affairs without having to identify to or negotiate political identities with the publics, which could be considered part of sustainable citizenship. Further, identity hierarchy and cultural capital were not the dominant logics of the OCD, but they were profoundly influential in the social media or journalistic field. For example, we found that under the topic of #2021 Henan floods, the opinion expression behavior of online publics on social media platforms was easily influenced by key opinion leaders, mainly in the form of emotional contagion and opinion convergence. Likewise, objectivity rules required journalists to reject subjective interference, but political dictates or commercial interests still controlled news coverage.

Emotions can be viewed as subjective mental activity, but affect is not entirely nonrational. As a relational discursive practice (Döveling et al., 2018), affect marks our original perception of the real world and can support our potential actions. We easily identified affective flows among the OCD users with collective, communal, and political characteristics, such as anxiety and excitement, fear and confidence, and despair and hope. After identifying and labeling the text with affective words through the LIWC-22 dictionary, we found that anxiety was the predominant emotion ($N = 56.57\%$), followed by positive ($N = 21.83\%$), sad ($N = 12.66\%$), and angry ($N = 7.35\%$). The dimensions of emotion and examples of each sentiment are reported in **Table 2**. The online users were also stimulated by the humanitarian crisis to develop deep affective tones of compassion and solidarity, which influenced the potential direction of the affective flow. To be clear, our understanding is based on a "mediated emotion" (Deacon and Stanyer, 2014) or "digital affect cultures" (Döveling et al., 2018).

Digital Affective Space

While text mining and semantic recognition helped us identify the main affective flows and initially answer RQ3a, the analysis of people's social mobilization around affective ties (RQ3b) requires focusing on the digital space's structure and tracking users' footprints. The relational dimension inherently signifies emotion as collective (Gergen, 2009), which indicates that networked publics that are transformed by technological affordances (Boyd, 2010). The OCD's technological affordances supported the creative connection of distributed individual nodes, incorporating more weak ties and even strangers. Therefore, the OCD could be seen as a surface or space for affective flows (Carroll and Landry, 2010), where information was shared and affect were unfolded. Online users expressed their sentiments through emoji, verbal text, or various colors, and may have been influenced by other comments to take possible actions. Especially with common experiences such as mourning, death, despair, and grief, the related affect could be reinforced during flowing. Those affective footprints showed the intersectionality of intimacy between different individuals as well as groups, commenting on certain shared affective experiences. In addition to risk communication, the affective footprints covered a wide range of topics, including counseling for mental health, contributions to community action, and reflections on urban life.

Moreover, a "Wailing Wall" was established by the OCD's administrators to pay tribute to the deceased and to provide encouragement to others. As an ongoing open message board, the space allowed all users to share their individual disaster experiences. The interweaving and overlapping of private memories from different perspectives, which collectively created a portrait of life in a catastrophic event, could have contributed in part to the practice of a "democratizing memory" (Walter et al., 2012). Significantly, these affective flows were histories written independently by online users, not journalists or political figures. The OCD was shaped as a distinctive space for experiencing affective flows, conveying the collective and public feelings of disaster victims, volunteers, government officials, and other netizens. Communication within the digital affective space not only revolved around sentiments and emotion but also supported social interactions. In contrast to the material reality space, the affective space could be a combined layer of the real event and permanently retained as a special form of mediated memory, especially in a context of uncertainty and threats.

TABLE 2 | The affective flows in online collaborative document.

Dimensions (*N*%)	Examples of each sentiment
Anxious (56.57)	The water and electricity were cut off. The water level was nearly 1.8 m and there was already a companion dead, the situation was urgent! My father has been missing for more than 18 h. Anyone nearby please help inquire about his whereabouts. The water level was up to the roof and the gas station was leaking oil, putting the place at risk of explosion.
Positive (21.83)	Go for it! The more I watch the news these two days, the more I want to weep! Zhengzhou will be safe and sound ah! The power of people's unity is infinite!!!
Sad (12.66)	My new laptop was damaged, so sad I was! Natural disasters are merciless, and we will mourn the victims.
Angry (7.35)	Why did the drainage system fail? Urban planning needs urgent improvement! 48 h have passed and we have not waited for the firefighters! It seems we have to survive on our own!
Others (1.59)	Thanks to firefighters, I'm safe (Happy). The rainstorm will continue and I think the situation will worsen (Negative).

Activities of the Affective Publics

Affective expression has always been a cultural practice (McCarthy, 1994). Digital platforms do not directly facilitate the negotiation of collective identities; thus, online users' affective expression requires specific political and cultural discourses. Concepts such as "public feelings" (Cvetkovich, 2007) and "intimate publics" (Berlant, 2008) imply that previously private individualized affective expressions can be cultural, collective, public and political in mediated spaces. While personal feelings arise from stimuli in the external environment, large-scale affective flows are derived from social events. Public affairs invite and sustain the aggregation and mobilization of networked publics based on affective ties, which shape an "affective public" (Papacharissi, 2015). As Hemmings (2005) argued, social mobilization from the internet is not achieved exclusively by appealing to reason or interests but also by creating "affective dissonance" or "affective solidarity" with considerable potential.

The OCDs' affective networks were not generated solely by digital collaboration and information-sharing, while we can continue to search and identify the affective publics' activities by accessing this digital space. Thus, their digital interactions made the affective network visible. Any user can easily identify the digital footprints left by affective publics, especially certain rhythmic affective flow (Papacharissi, 2015). This sense of rhythm was reflected in the symbiosis or interweaving of

positive and negative emotions, resulting in secondary or cumulative expressions of action. As Belli and Alonso (2021, p. 6) claimed, this intertwining and conflicting emotional contagion was reflected in the statement, "*People suffer physical and psychological pain, but they know that society will prevail.*" The affective public shaped by OCDs was thus a fusion of specific experiences, histories, cultures, and sensations of a certain moment, a structure that was hyper-local. The religious, regional, and identity differences between the participants were no longer emphasized by the OCDs' users, who instead focused on the experiential and affective power that connected them. The respondents' affective experience of participating in online activities on the OCDs was described as "*an atmosphere of intimacy*" (Interviewee A1), "*a game of hope and despair*" (Interviewee A5), and "*full of compassion*" (Interviewee B2). The affective publics' discourse practices constructed online activities as a humanitarian crisis situation, and temporarily neglected the critique of governments' failures. Likewise, socialites could not emphasize privileges on the OCDs, such as controlling public opinion or receiving more donations.

Based on the above understanding, then, this paper tends to describe OCDs as a square for affective publics. Compared to "space," the term "square" has more a public characteristic: It is both a digital and visible place of interactions, capable of being located by external actors, and an idealized deliberative space, allowing citizens to gather and discuss public affairs.

CONCLUSION AND DISCUSSION

As Livingstone (2009) declared, the era of "the mediation of everything" has arrived because advances in digital technology have supported media in their characterization of modernity and reshaping of social interactions (Plantin et al., 2018). Along with the rapid expansion of digital materiality systems, media have become the infrastructure of modern society. Different from how it was understood in the era of mass media, digital media is no longer simply a channel for information communication but also a platform for organizing and generating social action and supporting public interest and institutional arrangements (Plantin et al., 2018). As Debray (1996) noted, the media is no longer merely a static, material "object," but is now a dynamic adjustment process with initiative and dynamism. Our answers to the three research questions supported this claim, and the identified sub-processes formed a complex picture of mediatized research. OCDs act as the media logic that functions to establish connections, form interactions, and transform different forces, and they complete the transformation from ideas to material forces through technological and organizational practices, connecting different social groups, forming new interactive relationships, and mediating the allocation of social resources.

Theoretical Implications

Institutionalism and constructivism are the main research agendas of mediatization studies, with the former focusing on defining media logic (e.g., Shehata and Strömbäck, 2021; Blassnig and Esser, 2022), and the later tending to describe the reconfiguration of social reality in a polymedia environment (e.g., Cui, 2019). This paper first inspired an institutional lens for the mediatization study as a contextualized and integrated formula that covers the process of interconnectedness between media and social life (Ekström et al., 2016; Nowak-Teter, 2019). We discussed the possible forms of media logic and the mediatization of risk response through three empirical sub-processes at the technological and contextual dimensions. These results could be used to refine the mediatization theory model. **Figure 1** shows how OCDs reshaped the risk response. The following are the theoretical contributions of this paper in the fields of explaining media logic and describing the mediatization of social interactions.

Technological Affordances

This study showed a normative way of using affordances. We found that four dimensions of technological affordances—editability, accessibility, activability, and normability—supported the interactions between OCDs' functional features and users' action potential. Some communication studies have focused more on some media's specific functions and characteristics but have ignored longitudinal changes (Tenenboim-Weinblatt and Neiger, 2018) and perceptual factors such as emotional activities (Nagy and Neff, 2015). In the case of smartphones, for example, researchers have summarized more than 50 types of affordances (Jin and Cai, 2021). This paper, therefore, advocates a more generalized form of technological affordances and emphasizes its theoretical premise, which responds to the call from Evans et al. (2017).

Risk Communication

Media are often considered to play an important role in the social amplification of risk (Kilgo et al., 2019), and this study reveals that OCDs can be used strategically by the public to engage in risk response actions because of the technology's media logic, such as the participatory information release, constructive issue-oriented communication, and controlled information credibility. This information-sharing network was based on practical contributions rather than cultural capital or power confrontation and led to coordination mechanisms that emphasized participation, reciprocity, and reputation. Therefore, as a contextual element and discursive practice of media exposure, risk communication provided the online publics a socialization channel and framework for action. Compared to some functionalist studies of risk communication (Fang et al., 2021), this paper showed the possibility of considering risk response through a contextualized lens, which facilitates the discussion about the extensive social consequences of media exposure behavior. As Wardman (2008) declared, going beyond the normative, instrumental, and substantive imperatives typically employed in the utilization of risk communication requires the consideration of all potential interactions in modern society.

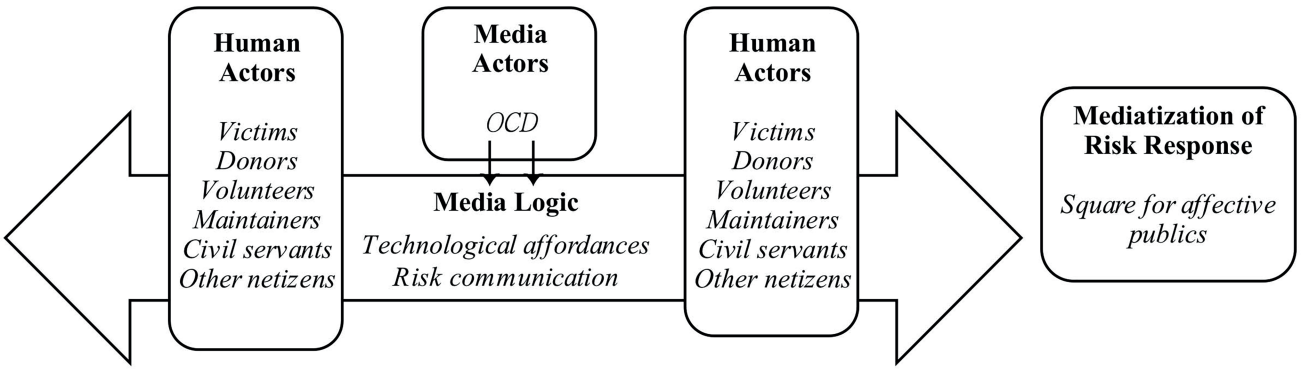

FIGURE 1 | The mediatization of risk response through online collaborative document.

Affective Publics

The form of social practice supported by OCDs appeared superficially to be a form of public deliberation, which pointed initially to a discussion of publicness. Academic debate is growing about whether digital media constitute a new public sphere (see Kaluža, 2022; Mpofu et al., 2022), and this study provides a case in a risk context. We attempted to claim that shaping the affective publics was one of the sustainability implications of OCDs. As a unique space for experiencing psychological activities, OCDs preserved the communal sentiments of the disaster victims, volunteers, government officials, and other netizens during the flood. The interweaving of affective flows such as anxiety and encouragement allowed social mobilization within OCDs to de-emphasize cultural, religious, regional, and identity differences among the participants. Dominated by the media logic, the discursive practices of the affective public constructed the online activity as a humanitarian crisis situation and temporarily neglected critical reflection on government failures. In particular, the mediatization of death, mourning, and grief can led to enhanced and diffused affective flows and give rise to possible individual narratives (Shi, 2022). Compared to disaster coverage, which is often controlled by journalism, the affective public achieved a degree of subjectivity in the form of writing media memories and leaving affective footprints, replying to studies of Burgess et al. (2018) and Lagerkvist and Andersson (2017).

Social action is becoming increasingly dependent on media logic (Nowak-Teter, 2019), especially the hybrid media systems of the digital age (Özkula, 2021). These sub-processes together provide a complex picture to capture the broad consequences of media in times of emergency. In this sense, we tend to see mediatization as an approach (Couldry and Hepp, 2013; Ekström et al., 2016). An open research agenda aims to understand how media reshape social practice; thus, it discusses broader meanings and sociocultural shifts rather than continually highlighting the media's characteristics. We thus explain the institutional significance of mediatization theory by focusing on the media logic that guides organizational activities, prescribes typical behavior, and reveals potential consequences. In addition, we attempt to affirm that in a post-pandemic era replete with risk and uncertainty, humans can still creatively adapt technological conditions to achieve their goals. The insistence on human subjectivity facilitates a profound understanding of the nature of technology and affect, and thus the values of this paper lean toward humanism. We are pursuing a hyper-local discussion, and the social context is not limited to Mainland China. OCD products from Google and Microsoft are also widely used in North America and Europe, and affective publics are equally active on Facebook or Twitter. We look forward to receiving critiques and responses from the academic community.

Practical Implications

Online collaborative documents aim to provide a response method for online social mobilization in a high-stress environment. As the 2011 Queensland floods have shown (Bunce et al., 2012), when government response is temporarily stymied, the public can perceive environmental changes and organize mutual aid actions through digital platforms. In the technological affordances section, we confirmed that OCDs perform well in a crisis compared to other digital technology systems, especially a participatory, dynamic, and constructive risk communication and information-sharing network. This research can inform government departments and organizations as they develop their digital response strategies so they can provide relevant and accessible information to the public in the event of a natural disaster. OCD technology achieves the immediacy and effectiveness of risk response. In addition, the use of an OCD in the 2021 Henan flood encouraged people who may be deeply at risk thereafter to actively participate in response actions. For example, with the Omicron virus pandemic on Mainland China in early 2022, successive community lockdowns were implemented in various cities. However, instead of being depressed, the concerned public actively used OCDs to support self-organized disaster relief. We can easily find the footprints of these risk communication

and emotional flows in social media from places such as Shanghai[1] and Jilin City.[2] This situation seems to echo the California wildfire case (Sutton et al., 2008), where, instead of waiting for official arrangements, the affected groups first took steps on their own to remain physically and mentally healthy.

Limitations and Directions for Future Research

The flood disaster had already been resolved by the time we conducted the study, and data collection relied on participant recall and self-assessment, which may have overstated or underestimated the true study sample. Furthermore, while the findings to date are far from conclusive, they do respond to many of the previous findings and suggest a range of alternative hypotheses. Future work may add more quantitative elements and insights, such as examining how maintainers' daily practices affect the rules of OCDs as digital space, because it is a challenging issue for maintainers to take the necessary actions to deal with the influx of advertisers, pranksters, and unreliable sources. In addition, the "Wailing Wall" shows that OCDs can store online users' affective expressions, so tracking respondents' psychological fluctuations during risky events will be required. We also think it is necessary to give focus on the discursive rhetoric of technology companies such as Google and Tencent, as a growing number of OCD products claim risk response as their primary goal among the pandemic.

DATA AVAILABILITY STATEMENT

The original contributions presented in the study are included in the article/**Supplementary Material**, further inquiries can be directed to the corresponding author.

[1]To view the original link, please click https://docs.qq.com/sheet/DRUdjRmttZmtrWGVq?u=71745445c17f41b9bdaa1dcaba6d5968&tab=t2pjr3&scode=&code=081Wiq000LmEMN1f4B000dgESn0Wiq0q&state=onweixinlogin&_t=1651667325209.

[2]To view the original link, please click https://docs.qq.com/sheet/DZmFnbG9ubVh0Zkpz?tab=iux1qx&u=80432a04236d4d75bff9d6fbfea6e915.

ETHICS STATEMENT

The studies involving human participants were reviewed and approved by Institute of Journalism and Communication, Sichuan Academy of Social Sciences. The patients/participants provided their written informed consent to participate in this study.

AUTHOR CONTRIBUTIONS

HJ contributed to the conceptualization, literature review, and manuscript writing. WG performed the questionnaire development and contacting participants. YZ performed the data analysis. WC conducted interviews. JP performed the supervision and financial support. All authors contributed to the article and approved the submitted version.

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SUPPLEMENTARY MATERIAL

The Supplementary Material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fpsyg.2022.892569/full#supplementary-material

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Relationship Between Hardiness and Social Anxiety in Chinese Impoverished College Students During the COVID-19 Pandemic: Moderation by Perceived Social Support and Gender

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During the COVID-19 epidemic, quarantine and financial disadvantages might exacerbate social anxiety among impoverished college students. Based on the hardiness model and the social support buffering model, the present study proposed and verified a dual moderation model to investigate the effects of hardiness on social anxiety and the moderating roles of gender and perceived social support. The hardiness scale, the perceived social support scale, and the social anxiety subscale of the self-consciousness scale were administered to 673 Chinese college students aged 18 to 23 years who were recognized as impoverished by the Chinese authorities and provided with funding. The results revealed that (1) hardiness had a significant negative effect on social anxiety, (2) perceived social support moderated the effect of hardiness on social anxiety, and (3) gender moderated the effect of hardiness on social anxiety. The dual moderated model proposed in the study provides practical implications for helping impoverished college students cope with social anxiety during the COVID-19 pandemic.

Keywords: hardiness, social anxiety, perceived social support, gender, Chinese impoverished college students

INTRODUCTION

The alleviation of poverty and its adverse effects is a concern worldwide (Rubenstein, 2013). Additionally, the mental health problems associated with poverty need to be considered (Burns, 2015). With the implication of targeted poverty alleviation in China, Chinese impoverished college students (CICSs) have received material support. The CICSs refer to students with insufficient financial capacity to meet the basic expenses of study and life in school (Ministry of Education of the PRC and Ministry of Finance of the PRC, 2007). Once universities and local authorities officially recognize these students as "impoverished or CICSs" based on government documents, they are eligible to receive funds from the Chinese government and other sources (Ministry of Education of the PRC et al., 2018). In 2020, subsidies were provided to 36,782,200 CICSs nationwide by the national and provincial governments, universities, and

foundations to help them better endure the practical difficulties of the pandemic (China National Center for Student Financial Aid, 2021). Although CICSs receive material support, they are still prone to psychological problems (Tan and Wu, 2017) and face psychological poverty (Li and Xu, 2017). Several studies have revealed that CICSs have worse mental health than the average college student (Zhang, 2000; Hu, 2010; Wang et al., 2015; Cheng et al., 2021). They tend to isolate themselves due to low self-esteem as well as high anxiety and sensitivity (Liu and Tian, 2011), avoid social activities (Luo et al., 2009), and experience social anxiety (Zeng et al., 2017). During the COVID-19 pandemic, Chinese college students experienced different degrees of anxiety (Jin et al., 2021; Pan et al., 2021), and anxiety symptoms were more pronounced in CICSs than in regular students (Liu et al., 2021).

In order to ensure the quality of learning, the Chinese education administration requires college students in low-risk regions to study on campus rather than online. Colleges and universities implement control measures such as quarantining students on campus during the academic semester to prevent the risk of infection. According to the self-presentation theory of social anxiety (Schlenker and Leary, 1982), socially anxious people exhibit certain emotions and behaviors in social encounters because of concerns about judgment from others. Under the order of quarantine on campus, CICSs are inevitably exposed to social situations in dormitories (usually 4–6 students share one room). Besides, researchers have also noted high family socioeconomic status was a mitigating factor for severe social anxiety during COVID-19 lockdowns (Itani et al., 2021). Hence, quarantine on campus and financial disadvantages might exacerbate social anxiety among CICSs under the COVID-19 epidemic background. Social anxiety adversely influences college students (Damer et al., 2010). It leads to negative externalizing behaviors, such as verbal and physical aggression, anger, hostility (Li and Ji, 2015), study difficulties and dropouts in severe cases (Davidson et al., 1993; Himle et al., 2020). It also leads to internalizing problems, including depressive symptoms or depression (Rapee et al., 2019), loneliness or social isolation (Stoeckli, 2010), and fear of positive evaluation (Weeks et al., 2008). Therefore, the social anxiety in CICSs during the pandemic is of significant concern.

Hardiness and Social Anxiety

The concept of hardiness was first used in agronomy, referring to the ability of crops to resist adverse conditions (Low, 1996). Kobasa introduced hardiness into psychology and defined it as a set of personality traits that help people manage their attitudes, beliefs, and behaviors in stressful situations (Kobasa, 1979; Maddi and Kobasa, 1984). Previous researchers regarded cognitive hardiness (Beasley et al., 2003) or personal hardiness (Maddi, 2013) as the basis of resilience. As was established by the hardiness model (Maddi, 2002; Kinder, 2005), hardiness can strengthen resilience by mitigating stress-triggered adverse health effects (Kobasa, 1979; Kobasa et al., 1981; Kobasa and Puccetti, 1983; Maddi and Kobasa, 1984; Bigbee, 1985; Wiebe, 1991; Maddi and Khoshaba, 1994; Bartone, 1999; Eschleman et al., 2010). Several studies have discussed the relationship between hardiness and anxiety. For instance, Hanton et al. (2013) discovered lower anxiety levels in the high-hardiness college athlete group. Dursun et al. (2022) reported that hardiness scores were remarkably lower in patients with generalized anxiety disorder. Kowalski and Schermer (2019) confirmed that hardiness was negatively associated with anxiety among the college student population.

As a crucial subtype of anxiety, social anxiety often manifests in social situations that even individuals in a nonclinical population can experience (Leary, 1990; Purdon et al., 2001). In the present study, social anxiety is defined as the emotional response (e.g., nervousness, fear, shyness) and behavioral response (e.g., avoidance of social encounters) that can occur when a person faces a social situation (Watson and Friend, 1969; Leitenberg, 1990). According to the self-presentation theory of social anxiety (Schlenker and Leary, 1982), socially anxious people often have a strong desire to make a favorable impression on others but are deeply concerned about the negative evaluation or criticism. Among the CICSs discussed in the present study, social anxiety is one of the most common social disorders (Zeng et al., 2017). Studies have reported that resilience can predict social anxiety (Ko and Chang, 2019; Yu et al., 2019). As the pathway to resilience (Maddi, 2013), hardiness can also predict social anxiety. For instance, Neissi et al. (2005) discovered that hardiness was negatively related to social anxiety and argued that hardiness was one of the best predictors of social anxiety by surveying 200 first-year female high-school students. Therefore, the current study explored the relationship between hardiness and social anxiety in the CICSs population. Given the above discussion, hypothesis 1 (H1) was proposed: *Hardiness significantly negatively affects social anxiety in CICSs.*

Moderating Role of Perceived Social Support

Perceived social support in the present study refers to an individual's subjective perception of social support and psychological resources such as care, attention, and respect from others (Barrera, 1986; Zimet et al., 1988; Malecki and Demary, 2002). The buffering model of social support (Cohen and Wills, 1985) reveals that perceived social support can help individuals cope with stressful situations. The buffering effect is independent of the amount of support an individual receives but dependent upon satisfaction with the support available (Sarason et al., 1983). The perception of being supported by others is often enough to help an individual cope with a problematic situation (Thoits, 1995; Taylor et al., 2004). Research has noted hardiness and social support can protect against stress (Pengilly and Dowd, 2000) and discovered a positive relationship between hardiness and social support (Maddi and Kobasa, 1984). Perceived social support consists of three sources: support from significant others, family, and friend (Zimet et al., 1988). Studies have highlighted that poor relationships with parents (Yu et al., 2019), low support from teachers (Weymouth and Buehler, 2018), and not-close peer friendships (Langston and Cantor, 1989; La Greca and Lopez, 1998) can associate with social anxiety. Although supportive relationships with

friends, mothers, and fathers each play their own role in protecting against social anxiety (Van Zalk and Van Zalk, 2015), the cumulative support of three sources is also associated with decreased social anxiety (Cavanaugh and Buehler, 2016). Therefore, perceived social support may weaken the social anxiety of CICSs (Cheng et al., 2021).

However, the relationship between social support and social anxiety is complicated. As Calsyn et al. (2005) demonstrated, the social causation hypothesis implies that social support creates social anxiety; in contrast, the social selection hypothesis postulates that social anxiety causes social support. Additionally, the reciprocal theory suggests a mutually causal relationship between social support and social anxiety (Calsyn et al., 2005). Thus, the role of social support in various relationships regarding social anxiety may be different. While the study illustrated the mediation effects of perceived care from friends on the correlation between making friends and social anxiety (Van Zalk and Van Zalk, 2015), researchers reported the moderating role of perceived social support in the association between social anxiety and mobile phone addiction (Zhou et al., 2021). Ren and Li (2020) confirmed that perceived social support moderated the relation between physical activity and social anxiety among left-behind children in rural China with similar low socioeconomic status and poverty problems as CICSs (Murphy, 2022). Therefore, we suggested that perceived social support might also moderate the association between hardiness and social anxiety in CICSs. Hypothesis 2 (H2) was proposed: *Perceived social support has a moderating effect on the relationship between hardiness and social anxiety in CICSs*.

Moderating Role of Gender

We included gender in the present study because many studies have reported gender differences in both hardiness and social anxiety. Gender is a complex social construct, and gender roles might partially explain the reported differences (Turk et al., 1998; Weinstock, 1999; Moscovitch et al., 2005). Regarding gender differences in hardiness, a study of survivors from the Sinabung eruption disaster reported that female survivors had higher hardiness levels than male survivors (Muda et al., 2016). A study investigating the relationship between gender traits and hardiness among general Chinese college students revealed that masculinity was strongly associated with hardiness (Chen, 2015). In terms of gender differences in social anxiety, studies have noted that women are more likely to suffer from social anxiety than men (Turk et al., 1998; Asher et al., 2017; Asher and Aderka, 2018). In a sociodemographic profile survey of the Canadian population, female respondents with social anxiety experienced more distress than male respondents (MacKenzie and Fowler, 2013). In an adolescent child population, gender differences were significant in the relationship between attentional bias to threat-relevant information and social anxiety (Zhao et al., 2014). Gender also moderated the relationship between peer attachment and social anxiety (Lu et al., 2015). Although rarely studies have examined gender differences in social anxiety among CICSs, Qiu et al. (2011) identified gender differences in state anxiety levels among CICSs. In light of this discussion, hypothesis 3 (H3) was proposed: *Gender plays a moderating role in the relationship between hardiness and social anxiety in CICSs*.

In summary, past studies have separately examined hardiness (e.g., Dursun et al., 2022) and social anxiety (e.g., Himle et al., 2020), and established that hardiness, along with social support, protects against stress-related illnesses (Maddi, 2002). However, to our knowledge, the literature discussing the relationship between hardiness, social support, and social anxiety is limited. Another vital gap lies in the little research focused on impoverished populations. Most literature on hardiness and resilience has focused on business executives and employees (e.g., Maddi and Kobasa, 1984; Chia and Chu, 2017), medical staff (e.g., Hurst and Koplin-Baucum, 2005), athletes (e.g., Nezhad and Besharat, 2010), military personnel (e.g., Bue et al., 2018), patients (e.g., Taheri et al., 2014), teachers (e.g., Chan, 2003), adolescents (e.g., Malkin et al., 2019), and general college students (e.g., Maddi et al., 2009). The research on social anxiety in impoverished populations is also limited (Himle et al., 2020). Therefore, the current study recruited CICSs to explore the relationship between hardiness and social anxiety based on the hardiness model (Maddi, 2002; Kinder, 2005) and the buffer models of social support (Cohen and Wills, 1985). We considered perceived social support and gender to be moderating variables. **Figure 1** illustrates the overall hypothetical model.

MATERIALS AND METHODS

Participants

Yunnan province is an impoverished region under the Chinese targeted poverty alleviation policy scheme. It is affected by COVID-19 cases imported from neighboring countries due to its location on the southwest border of China. The data were collected from September 19 to 23 in 2021, when the sampling college was under control measures of closed-off. The purposive sampling method was employed to ensure the participants were: (1) quarantined on campus and (2) officially recognized as "CICSs" before the present study. The college counselors (responsible for psychological counseling for CICSs) assisted the investigators in recruiting participants and distributing online questionnaires through the online chatting rooms of WeChat (a

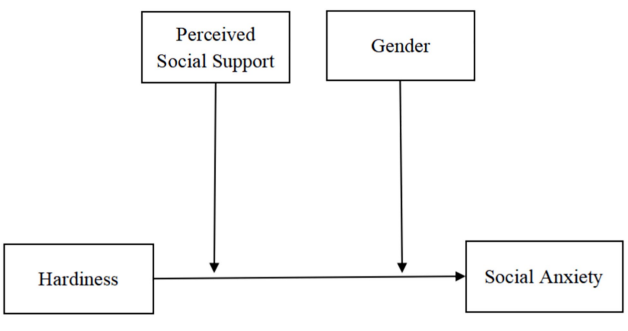

FIGURE 1 | Hypothetical model.

popular Chinese social medium). The college counselors were trained about the study purpose and procedures to control information bias.

Following the Declaration of Helsinki (Goodyear et al., 2007), the current study was conducted with voluntary cooperation considering participants' privacy and wishes. All participants gave their informed consent for inclusion before participating in the study. They were informed that (1) the study's purpose, (2) their data would remain confidential, (3) the data would be used for the quantitative statistics in the study and no risks associated, and (4) the study was not compulsive and they could quit the online questionnaire at any time. The online questionnaires were answered and submitted voluntarily and anonymously by participants. Finally, 684 questionnaires were distributed, 11 invalid questionnaires were excluded, and 673 valid questionnaires remained for a return rate of 98%. Among the participants, 135 (20.1%) were male and 538 (79.9%) were female, and the age range was 18–23 years.

Measures

The hardiness scale, the perceived social support scale, and the social anxiety subscale of the self-consciousness scale were used as measurement instruments. All scales have been validated in prior research with excellent reliability and validity in general college student samples. We performed factor analysis to ensure the fit of the instruments to the test samples due to the specificity of participants in this study.

Hardiness Scale

A hardiness scale developed by Lu and Liang (2008) for use with Chinese college students was employed in the present study. The scale comprises four dimensions: control (e.g., "when I encounter difficulties, I always try to find solutions"), challenge (e.g., "I prefer to do work that is full of challenges and often changes"), input (e.g., "I always put much passion into my work"), and resilience (e.g., "I can keep doing difficult tasks as long as it is meaningful"). The scale comprises 27 questions answered using a 5-point Likert scale ranging from 1 (totally inconsistent) to 5 (totally consistent), with higher scores indicating higher levels of hardiness. The Cronbach's α for the scale in the present study was 0.962, greater than 0.7, indicating favorable reliability (Nunnally and Bernstein, 1994). The results of confirmatory factor analysis (CFA) are presented in **Table 1**, and the standardized factor loadings (SFLs) were in the range of 0.667–0.836, greater than 0.5, indicating favorable validity (Hair et al., 1992). The composite reliability (CR) values were in the range of 0.896–0.915, greater than 0.6, and the average variance extracted (AVE) values were in the range of 0.558–0.643, greater than 0.5, indicating favorable convergent validity (Fornell and Larcker, 1981). The model fit indices were as follows: $\chi^2/df = 3.522$, root mean residual (RMR) = 0.030, root mean square error of approximation (RMSEA) = 0.061, comparative fit index (CFI) = 0.935, goodness of fit index (GFI) = 0.877, normed fit index (NFI) = 0.912, Tucker-Lewis index (TLI) = 0.929, and parsimonious normed fit index (PNFI) = 0.826, indicating favorable fit (McDonald and Ho, 2002; Hsiao et al., 2016).

Perceived Social Support Scale

The current study used the perceived social support scale developed by Zimet et al. (1988). The scale contains three dimensions: support from significant others (e.g., "There is a special person who is around when I am in need"), family support (e.g., "I get the emotional help and support I need from my family"), and friend support (e.g., "I can count on my friends when things go wrong"). It contains 12 questions that are scored using a 7-point Likert scale ranging from 1 (totally inconsistent) to 7 (totally consistent). Higher scores indicate higher levels of perceived social support. The Cronbach's α of the scale in the study was 0.943, greater than 0.7, indicating favorable reliability. **Table 2** displays the results of CFA; the SFLs were 0.822–0.884, greater than 0.5, indicating favorable validity. The CR values were 0.909–0.923, greater than 0.6. The AVE values were in the range of 0.715–0.751, greater than 0.5, indicating favorable convergent validity. The model fit indices were: $\chi^2/df = 4.771$, RMR = 0.026, RMSEA = 0.075, CFI = 0.972, GFI = 0.941, NFI = 0.964, TLI = 0.963, and PNFI = 0.745, demonstrating that the scale exhibited favorable fit.

Social Anxiety Scale

The present study used the social anxiety subscale of the self-consciousness scale developed by Fenigstein et al. (1975). The scale contains six questions (e.g., "It takes me time to overcome my shyness in new situations"), which are answered using a 5-point Likert scale ranging from 1 (totally inconsistent) to 5 (totally consistent), with higher scores indicating higher levels of social anxiety. The fourth question in the scale was reversed, and the data were analyzed using reverse scoring. The Cronbach's α of the total scale in the study was 0.933, greater than 0.7, indicating favorable reliability. The results of the CFA are presented in **Table 3**. The SFLs were in the range of 0.737–0.892, greater than 0.5, indicating that the scale had favorable validity. The CR values were 0.933, greater than 0.6. The AVE value was 0.699, greater than 0.5, indicating that the scale had favorable convergent validity. Because this scale is unidimensional, the multifactor oblique intersection model was used to test the overall measurement model fit indicators of this scale and the other two scales, as presented in **Table 4**. The three scales used in the current study have favorable fit.

Common Method Variance (CMV) Test

Harman's one-factor test was used to assess CMV. Unrotated factor analysis revealed that the Kaiser–Meyer–Olkin value was 0.960 (>0.8), and the Bartlett test of sphericity reached significance ($p < 0.001$). The analysis yielded six factors, and the explanatory power of the first factor was 38.813%, which did not exceed the critical value of 50% (Podsakoff et al., 2003), indicating that CMV was not significant in the present study.

Statistical Methods

First, descriptive statistical analysis, correlation analysis, scale reliability tests, and CMV tests were conducted using SPSS 21.0, and CFA was performed using AMOS 21.0. Second, the

TABLE 1 | CFA of the hardiness scale.

Dimension	Item	SFL	CR	AVE
Control	1. When I encounter difficulties, I always try to find solutions.	0.766	0.910	0.558
	2. When facing an unfavorable situation, I try to turn the situation around.	0.788		
	3. I can keep my spirits up even when things are not going well.	0.758		
	4. Whenever there is a problem, I try to find its root cause.	0.762		
	5. When someone is angry with me, I try to calm them down.	0.667		
	6. No matter how complicated a problem is, I can always clear my mind quickly.	0.755		
	7. I often regard the difficulties I encounter in life as a challenge rather than a threat.	0.761		
	8. I remain calm in the face of criticism from others.	0.710		
Challenge	1. The changes in my life and work often excite me.	0.732	0.903	0.573
	2. I like to try new and exciting things.	0.724		
	3. I prefer to do work that is full of challenges and often changes.	0.836		
	4. I prefer to be responsible for important work.	0.757		
	5. Breaking the rules inspires me to learn.	0.785		
	6. I am willing to give up a stable life for the chance to face big challenges.	0.721		
	7. Embracing new scenarios in my life is important to me.	0.735		
Input	1. Work and study are fun.	0.788	0.896	0.589
	2. I look forward to working or studying almost every day.	0.743		
	3. I get excited and am positive about working hard.	0.773		
	4. The busy pace of life makes me feel fulfilled.	0.735		
	5. I always put much passion into my work.	0.830		
	6. I put effort into even the simplest things.	0.730		
Resilience	1. I can always achieve my goals through my own efforts.	0.784	0.915	0.643
	2. I can keep doing difficult tasks as long as they are meaningful.	0.829		
	3. I am not afraid of facing difficulties in what I decide to do.	0.819		
	4. I do not easily give up my ideals and goals.	0.813		
	5. If I work hard, any difficulty can be overcome.	0.761		
	6. If I set a goal, I will not give up even if I encounter obstacles.	0.802		

CFA, confirmatory factor analysis; SFL, standardized factor loading; CR, composite reliability; and AVE, average variance extracted.

moderating effects of perceived social support were tested using Model 2 of PROCESS, and bootstrap confidence intervals were used to determine whether the two moderating effects in Model 2 were significant (Hayes, 2013).

RESULTS

Descriptive Statistics and Correlations for All Variables

The descriptive statistics for the variables are presented in **Table 5**. The results indicated that the CICSs in the current study had moderate levels of social anxiety and moderate-to-high levels of hardiness and perceived social support during the COVID-19 pandemic. The correlation analysis results indicated that (1) gender was not significantly correlated with any of the other three variables in the current study, indicating the requirement of controlling on gender was not necessary for the regression analysis; (2) hardiness and social anxiety were negatively correlated (correlation coefficient = −0.204; $p < 0.001$), and (3) hardiness and perceived social support were positively correlated (correlation coefficient = 0.569; $p < 0.001$), and (4) perceived social support was negatively correlated with social anxiety (correlation coefficient = −0.088; $p < 0.05$). The absolute values of the correlation coefficients among the three variables were smaller than 0.8, indicating a weak-to-moderate correlation between the variables and no collinearity problem (Cohen et al., 2009).

Differential Analysis for Gender

Since the moderating role of gender is one of the main concerns of this study, descriptive information on hardiness, social anxiety, and perceived social support among males and females are presented in **Table 6**. The *t*-test of independent samples demonstrated that gender had no significant differences in all three variables. The results confirmed again that the regression analysis in the present study did not require controlling on gender as a background variable.

Moderating Roles of Perceived Social Support and Gender

To illustrate that the current study's regressive framework and moderation tests were justified, regression analysis hypothesis testing was used to test the linearity, normality, and homogeneity of variance. First, a scatter plot for hardiness and social anxiety demonstrated a negative linear relationship between hardiness and social anxiety in the study. The results indicated that the research data satisfied linearity (Hayes, 2013). Second, the Durbin–Watson value was 2.039 (between 1.5 and 2.5), denoting no autocorrelation. The results indicated that the research data satisfied independence (Tabachnick and Fidell, 2001). Third, the skewness absolute values for the 45 items ranged between 0.025 and 1.007, and the kurtosis absolute values for the 45 items were between 0.010 and 1.928. The results satisfied the standards of the absolute value for skewness <2 and kurtosis <7 (Curran et al., 1996) and indicated that the research data satisfied normality. Finally, the regression standard residual

TABLE 2 | CFA of the perceived social support scale.

Dimension	Item	SFL	CR	AVE
Significant others	1. There is a special person who is around when I am in need.	0.826	0.909	0.715
	2. There is a special person with whom I can share my joys and sorrows.	0.834		
	3. I have a special person who is a real source of comfort to me.	0.836		
	4. There is a special person in my life who cares about my feelings.	0.884		
Family	1. My family really tries to help me.	0.863	0.914	0.726
	2. I get the emotional help and support I need from my family.	0.869		
	3. I can talk about my problems with my family.	0.822		
	4. My family is willing to help me make decisions.	0.853		
Friends	1. My friends really try to help me.	0.869	0.923	0.751
	2. I can count on my friends when things go wrong.	0.860		
	3. I have friends with whom I can share my joys and sorrows.	0.871		
	4. I can talk about my problems with my friends.	0.865		

CFA, confirmatory factor analysis; SFL, standardized factor loading; CR, composite reliability; and AVE, average variance extracted.

TABLE 3 | CFA of the social anxiety scale.

Dimension	Item	SFL	CR	AVE
Social anxiety scale	1. It takes me time to overcome my shyness in new situations.	0.737	0.933	0.699
	2. I have trouble working when someone is watching me.	0.799		
	3. I get embarrassed very easily.	0.886		
	4. I do not find it hard to talk to strangers.	0.836		
	5. I feel anxious when I speak in front of a group.	0.892		
	6. Large groups make me nervous.	0.857		

CFA, confirmatory factor analysis; SFL, standardized factor loading; CR, composite reliability; and AVE, average variance extracted.

scatter plot was used to test the problem of homogeneity. The scatter plot demonstrated that the residual means were on the same straight line; therefore, the data satisfied the homogeneity of variance assumption (Hayes, 2013).

Model 2 of PROCESS was used to incorporate both perceived social support and gender into one model to test the moderating effects of these variables. The results displayed in **Table 7** reveal that hardiness significantly negatively predicted social anxiety ($B = -0.529$; $p < 0.001$). The results were verified using the bias-corrected nonparametric percentile bootstrapping method; the 95% confidence interval (CI) was discovered not to contain 0 (lower limit of CI [LLCI] = −0.722, the upper limit of CI [ULCI] = −0.347). Therefore, H1 was supported.

The results displayed in **Table 7** revealed that the interaction between hardiness and perceived social support exhibited a significant negative predictive effect on social anxiety ($B = -0.189$; $p < 0.01$), which was verified using the bias-corrected nonparametric percentile bootstrap method. The 95% CI did not contain 0 (LLCI = −0.323, ULCI = −0.005), meaning that H2 was supported. Perceived social support moderated the effect of hardiness on social anxiety. The study conducted a simple slope analysis for the relation between hardiness and social anxiety at low and high levels of perceived social support (−1 SD, Mean, +1 SD) to illustrate the interaction effect further. **Figure 2** demonstrates that the social anxiety level reduces slightly for CICSs with low perceived social support as the hardiness level improves (simple slope = −0.280; $t = -3.274$; $p < 0.01$). In contrast, for CICSs with a high level of perceived social support, the social anxiety level reduces significantly as the hardiness level improves (simple slope = −0.589; $t = -6.102$; $p < 0.001$). The negative effect of hardiness on social anxiety was stronger for CICSs with high perceived social support than for those with low perceived social support, indicating that perceived social support enhanced the negative effect of hardiness on social anxiety in this study.

The interaction between hardiness and gender was also a significant predictor of social anxiety ($B = 0.347$; $p < 0.05$). Using the bias-corrected nonparametric percentile bootstrap method, we observed that the 95% CI did not contain 0 (LLCI = 0.004, ULCI = 0.705). The results supported H3, indicating that gender moderated the effect of hardiness on social anxiety. The simple slope analysis was conducted to further explain the moderating effect of gender and the moderating effect was plotted. **Figure 3** illustrates that in male CICSs, social anxiety reduces slightly as the hardiness improves (simple slope = −0.032; $t = -0.247$; $p > 0.05$). In contrast, in female CICSs, social anxiety reduces significantly as the hardiness level improves (simple slope = −0.468; $t = -6.241$; $p < 0.001$). The negative effect of hardiness on social anxiety was stronger for female CICSs than for their male peers.

DISCUSSION

The descriptive statistics results in the current study indicated that social anxiety in CICSs was moderate ($M = 2.898$ out of 5) during the pandemic and deserved focused attention, but little research has been conducted to explore this topic. The

TABLE 4 | Model fit indices of the measurement model.

Standard	$\chi^2/df < 5$	RMR < 0.08	RMSEA < 0.08	CFI > 0.9	GFI > 0.85	NFI > 0.9	TLI > 0.9	PNFI > 0.5	HOELTER.05 > 200
Results	2.624	0.031	0.049	0.936	0.852	0.900	0.930	0.834	277

TABLE 5 | Descriptive statistics and correlations for all variables.

Variable	*M*	*SD*	Gender	Hardiness	Social anxiety	Perceived social support
Gender	0.200	0.401	1			
Hardiness	3.851	0.607	0.072	1		
Social anxiety	2.898	1.050	0.042	−0.204***	1	
Perceived social support	3.887	0.755	−0.028	0.569***	−0.088*	1

*n = 673; Gender was treated as a dummy variable, 1 = male, 0 = female; M, mean; SD, standard deviation. *p < 0.05; ***p < 0.001.*

TABLE 6 | Differential analysis for gender in all variables.

Variable	Groups	Hardiness		Perceived social support		Social anxiety	
		M(SD)	*t*	M(SD)	*t*	M(SD)	*t*
Gender	Male	3.938 (0.674)	1.866	3.845 (0.767)	−0.718	2.985 (1.103)	1.076
	Female	3.829 (0.588)		3.897 (0.753)		2.876 (1.037)	

present study proposed and verified a dual moderation model to investigate the effect of hardiness on social anxiety in CICSs and tested the moderating roles of perceived social support and gender. The results revealed that hardiness negatively predicts social anxiety in CICSs and that perceived social support and gender moderate this correlation.

Theoretical Implications

The relationship between hardiness and social anxiety among the impoverished population has rarely been examined in past literature to the best of our knowledge. Our results reveal that hardiness directly affects social anxiety, supporting the hardiness model (Maddi, 2002; Kinder, 2005). Individuals experience social anxiety when stressed with doubts about their ability to make a socially desirable impression on others (Leary, 1995; Schlenker, 2012; Leary and Jongman-Sereno, 2014), and hardiness helps individuals sustain their mental and physical health under stress (Maddi, 2002). Supplementing previous research, which regarded hardiness as a negative predictor of anxiety (Kowalski and Schermer, 2019), our findings demonstrate that hardiness also negatively predicts social anxiety consistent with Neissi et al. (2005). CICSs have received little attention in studies on hardiness or social anxiety. The present study specifically addressed CICSs, and the results confirm that H1 hardiness significantly negatively affects social anxiety in CICSs. This indicates that although economic pressure and quarantined on campus during the COVID-19 pandemic may exacerbate social anxiety in CICSs, hardiness can be an essential protective factor.

Second, our results reveal that the higher the level of perceived social support, the stronger the effect of hardiness on social anxiety. The findings support H2 that perceived social support has a moderating effect on the relationship between hardiness and social anxiety in CICSs, consistent with the social support buffering model (Cohen and Wills, 1985). When social support was measured quantitatively, a direct effect was discovered; by contrast, when social support was constructed qualitatively as perceived social support, the interaction (moderation) effects of the buffering model were reported (Bellman et al., 2003). CICSs may avoid socializing because of the financial and psychological pressure caused by poverty (Luo et al., 2009). Even though China's poverty alleviation efforts have ensured that CICSs receive various types of material support from the government, CICSs may differ from other students in perceiving social support. The findings suggest that the level of perceived social support compared with actual support, may have cognitive effects on individuals' social anxiety, which is consistent with previous research (Sarason et al., 1983; Thoits, 1995; Taylor et al., 2004).

Third, our results reveal that the effect of hardiness on the social anxiety of women is greater than it is on men. It supports H3, which states that gender plays a moderating role in the association between hardiness and social anxiety in CICSs. The results might be better understood in the context of gender role theories (Eagly et al., 2000). Scholars have reported gender differences in hardiness personality (e.g., Muda et al., 2016) and social anxiety (e.g., Asher and Aderka, 2018). These gender differences may be related to the gender roles that individuals of both sexes construct through their specific sociocultural upbringing and learning (Carroll and Wolpe, 1996; Eagly and Wood, 1999). Traditionally, masculinity has been linked to personality characteristics such as defending

TABLE 7 | Testing the moderating roles of perceived social support and gender.

Variable	Social anxiety		
	B	*t*	95%LLCI 95%ULCI
Hardiness	–0.529	–6.101***	(–0.722 -0.347)
Perceived social support	0.049	0.768	(–0.084 0.170)
Hardiness * Perceived social support	–0.189	–3.172**	(–0.323 -0.005)
Gender	0.159	1.605	(–0.040 0.350)
Hardiness * Gender	0.347	2.278*	(0.004 0.705)
R^2	0.072		
F	10.354***		

*$p < 0.05$; **$p < 0.01$; ***$p < 0.001$.
B are unstandardized coefficients; LLCI, lower limit of confidence interval and ULCI, upper limit of confidence interval.

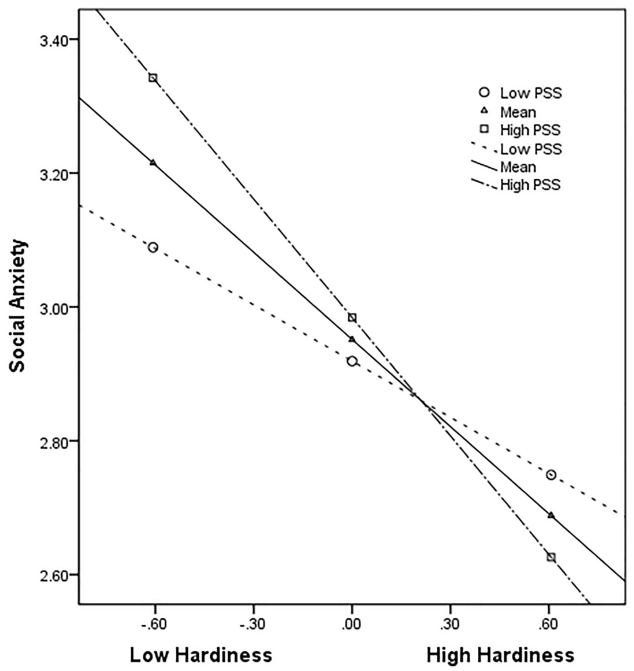

FIGURE 2 | Moderating effect of perceived social support (PSS) on the relationship between hardiness and social anxiety; the moderating effect is plotted for two levels of PSS: high PSS (1 SD above the mean) and low PSS (1 SD below the mean).

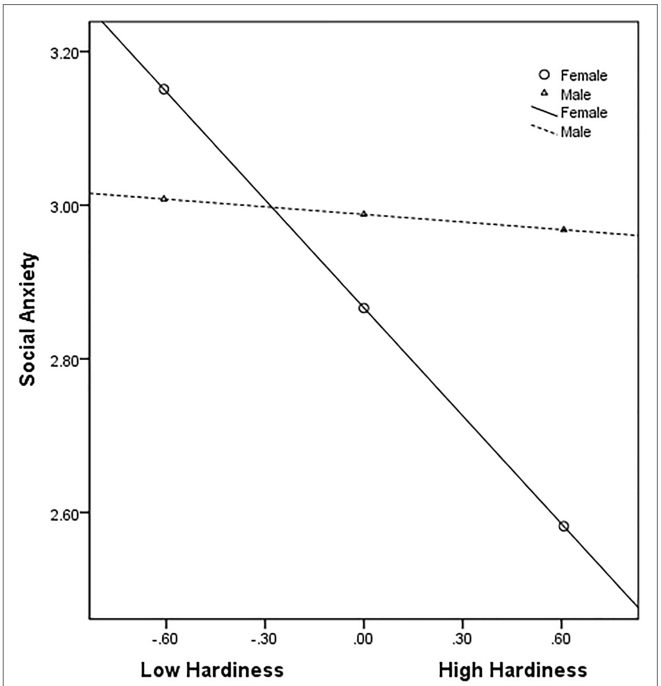

FIGURE 3 | Moderating effect of gender on the relationship between hardiness and social anxiety.

beliefs and being assertive or willing to take risks, whereas femininity has been associated with personality characteristics such as being tender, sensitive, and sympathetic (Bem, 1974). Male gender-role identification mitigates individuals' perceptions of interpersonal needs, which may lead to underestimating the feelings about social anxiety (Moscovitch et al., 2005). Hence, hardiness may have had a greater effect on the social anxiety of female CICSs. Another likely explanation is that women from Asia were more likely to endorse traditional gender-role attitudes than women in other locations (Robnett and Anderson, 2017). Female CICSs may be more sensitive to interpersonal relationships and social anxiety than male peers, consistent with previous research (Turk et al., 1998; Asher et al., 2017; Asher and Aderka, 2018).

Practical Implications

The dual moderated model proposed in this study has practical implications for helping impoverished college students cope with social anxiety during the COVID-19 pandemic.

First, hardiness negatively affects social anxiety in CICSs and serves as an essential protective factor. This result has practical implications for psychological health education in colleges and universities. Such institutions should focus on cultivating and improving the hardiness level of impoverished college students during the pandemic. Studies have proved that HardiTraining courses can lead to a tremendous increase in hardiness attitudes and feelings of social support while decreasing anxiety (Maddi et al., 2009). Therefore, colleges may arrange HardiTraining courses to help CICSs confront difficulties and challenges. For instance, the *Situational Reconstruction* activity in the HardiTraining courses can guide trainees to understand the stressful circumstance and be prepared through the imaginary rebuilding of a possible situation (Khoshaba and Maddi, 2001; Maddi et al., 2009). Hence, colleges and universities could organize seminars for CICSs to understand and be prepared for the COVID-19-related difficulties they may face through *Situational Reconstruction*. Additionally, college counselors can guide

CICSs to look at the temporary difficulties brought on by the pandemic with an optimistic attitude.

Second, perceived social support moderates the correlation between hardiness and social anxiety in CICSs. Hence, the perceived level of social support of CICSs should be simultaneously improved while providing substantial support. During the pandemic, universities and authorities should guide CICSs to actively recognize the help given by others in their life and studies. College counselors can help them correctly handle interpersonal relationships with teachers, parents, friends, and peers, and obtain emotional support from significant others. The protective effect of hardiness on social anxiety can be strengthened as perceived social support in CICSs is enhanced.

Third, we determined that gender moderates the effect of hardiness on social anxiety in CICSs. Hardiness has a more substantial impact on social anxiety in women than men. Colleges and universities should pay more attention to the gender difference regarding social anxiety issues during the pandemic. Gender-sensitive intervention models can be established to provide targeted psychological support for students of different genders.

CONCLUSION

The present study proposed and validated a dual moderation model to explore the mechanism of the effect of hardiness on social anxiety among CICSs during the COVID-19 pandemic. The results revealed that hardiness was significantly and negatively associated with social anxiety, and their relation was moderated by perceived social support and gender. Hardiness plays a protective factor for the social anxiety of a specific group of CICSs. Additionally, the effect of hardiness on social anxiety is stronger for females and individuals with high perceived social support levels. The study also provides some practical suggestions for colleges and universities.

LIMITATIONS AND FUTURE STUDIES

The present study has several limitations. First, the study was a cross-sectional quantitative survey. It reveals the predictive correlations between variables, but it cannot determine their causal relationships. Future studies could employ longitudinal or experimental designs to examine further the causal relationships among the variables. Second, the current study only recruited CICSs as participants. The dual moderation model in the present study could be verified among more diverse samples. Alternatively, a CICS group and a non-CICS group could be compared in future studies. Third, the present study was conducted on samples from Yunnan province, and the generalizability of the findings is limited. The results can be verified in other provinces and countries. Fourth, this study is also limited by its sampling conditions. The participants were from a college where the ratio of male and female students is approximately 1:3. Thus, the gender composition in the samples was unbalanced. Future studies should consider enlarging the geographical scope of sampling or validating our results in different colleges with balanced gender ratios.

DATA AVAILABILITY STATEMENT

Other data pertaining to this study are available from the corresponding author upon reasonable request.

ETHICS STATEMENT

Ethical review and approval was not mandatory for non-interventional studies (e.g., surveys, questionnaires, social media research) in accordance with the local legislation and institutional requirements. The present study was conducted following the Declaration of Helsinki. All subjects gave their informed consent for inclusion before they participated in the study.

AUTHOR CONTRIBUTIONS

XC was the primary author who proposed the research proposal and completed the article for this study. JLiu, JLi, and ZH worked as investigators and writer's assistants. JLi served as the research advisor. XC, JLiu, JLi, and ZH revised the manuscript was revised collaboratively. All authors contributed to the article and approved the submitted version.

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How do Internet moms raise children? The reshaping of Chinese urban women's parenting psychology by COVID-19 online practices

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With the acceleration of social transformation and "mediatization," urban women's parenting practices have become an important factor affecting the demographic structure and national development. The global COVID-19 pandemic has further contributed to the networking of social life and the creation of "Internet moms" who rely on the Internet for parenting interactions. Using a mixed-methods design, this paper conducted participant observation and in-depth interviews with 90 mothers from various industries born after 1980/1990 across multiple geographies in China to examine the impact of urban women's Internet practices on the psychology and practice of parenting during the COVID-19 pandemic, as well as how they were empowered by media technologies to practice motherhood and complete their role socialization through the sharing of parenting information, experiences, and actions. The purpose of this qualitative study was to investigate the changing impact of Internet-based parenting practices on Chinese urban women's daily lives during the COVID-19 pandemic. Through the analysis of these influences, it was found that the whole society, including urban parenting groups, paid attention to self-expression and self-worth and further hoped to arouse society's recognition, face up to the identity of "mother" and "female," and give more attention and support to women. The study also found that, as interpersonal communication channels were hindered during the COVID-19 pandemic, the power of the Internet, represented by social media, has created a new platform for information empowerment, action mutual, and ideation of motherhood for urban women formerly bound to family and parenting matters. From individual, family, and individual parenting experiences to group, social, and shared scenarios, urban women are engaged in emotional and memory interactions, including motherhood-related expression, experiences, and collaboration. This shift from virtual to physical has reshaped their parenting view, helping them break through the confines of family experience and traditional customs in addition

to providing psychological motivation to express their gender concepts, shape their self-image, construct gender power, and interpret intimate relationships, pushing them to become more reflective of the times, as well as more capable and authoritative.

KEYWORDS

"Internet moms'" parenting psychology, parenting practices, urban women, mediatization, parenting psychology

Introduction

Raising children has long been the focus of family activities. In general, mothers have been the main performers of this child-rearing work. There are rich social factors behind what seems to be a natural ability among ordinary women. Thousands of years of civilization in China have left behind not only a rich historical and cultural heritage but also deep and complex social customs and social experiences. In traditional agricultural societies, parenting experience tends to rely on intergenerational inheritance for various reasons, including social and family structures. These appear in child-rearing as a set of mature experience system constraints from preparation for pregnancy to child-rearing. Women tend to be the primary bearers of these constraints. With the interaction of multiple factors including technological advances, improvements in health care, and social changes, traditional parenting practices, and experiences are gradually being abandoned. Women entering urban life are reluctant to trust traditional parenting experiences because they have different parenting concepts (Baranowski et al., 2021), while lacking access to traditional parenting knowledge. These women need to create a whole new knowledge system around child-rearing, from pregnancy, birth to parenting, and education. Modern society's neglect of the topic of women's childcare has also led women to take on more and more social responsibilities with less and less social support (Van Cleaf, 2018). As a result, the transition to motherhood has led to a complex and socially unsupportive "social disconnect" (Britton et al., 2019), and urban women are often caught up in contemplating "How do I parent effectively?" (Carlson, 2017), and "how to parent scientifically."

As the new media power of multiple technologies penetrates daily life, human society has gradually moved closer toward "mediatization" (Hepp et al., 2015). The "mediatized life" has become an important part of people's social life. How mediatized societies reconfigure our social world (Mazumdar et al., 2021), how journalism and public attention are constructed (Kunelius and Reunanen, 2016), and how people are responding to these changes (Nadia et al., 2019) have become central keywords in exploring the interrelationships between people and the media, technology, and even other people, as well as between media and media. Mediatization has changed the traditional mode of information production and consumption and has extended the boundaries of content production and communication to the general public. Today's digital devices have become an important part of the human body, and the development of the Internet has made it deeply embedded in people's daily lives, making the media a true "extension of people" through the deep link between the virtual and the real. State institutions, non-governmental organizations, social groups, and individuals, all are included in the digital media environment. In this context, urban women are also using these media in new ways to access a wealth of information about parenting. In this social environment, urban women's parenting practices are naturally embedded in a mediatized society that is throwing off the shackles of family and parenting matters through the Internet and bridging the gap between traditional and scientific parenting (Zhu et al., 2019). Urban mothers are beginning to explore new virtual social interactions based on motherhood. Through virtual community interactions, urban mothers are writing and expressing themselves online as part of digital identity, shaping their self-image, constructing gender power, and interpreting intimate relationships. They are learning about scientific parenting, exchanging parenting experiences, and sharing parenting stories thus creating an "online parenting" (Florean et al., 2020) knowledge system that differs from traditional parenting concepts. As a result, their parenting psychology has also changed. The framework of mediatization provides a new theoretical perspective to interpret current cultural and social changes (Hjarvard, 2014). Considering urban women's mediatized parenting practices from this perspective is thus relevant for analyzing the mediatized survival and expression of the socially disadvantaged group of urban women raising children.

The global COVID-19 pandemic has increased the role of the Internet in daily life practices, promoting the process of mediatization across society as a whole and influencing the way people think and practice. According to the 49th Statistical Report on the Development of the Internet in China released by the China Internet Network Information Center (CNNIC) (2022), as of December 2021, China's Internet users spent 28.5 h online per capita per week, up 2.3 h from December 2020, and

the Internet has been deeply integrated into people's daily lives. Managing the parent–child and family relationships during the pandemic is not only a family issue but also a social issue. There are numerous new perspectives for analyzing family social relations during the pandemic, which have included focusing on parenting stress in young parents (Adams et al., 2021), parenting styles and parent–child relationships (Chung et al., 2020), differences in parenting attitudes (Forbes et al., 2021), parental psychological flexibility (Gould et al., 2020), and the relationship between parenting and parental burnout (Bastiaansen et al., 2021). For the underprivileged group of urban mothers (Mazumdar et al., 2021), the COVID-19 pandemic has further detached their child-rearing practices from their daily life and derailed their socialization process. The pandemic has also prompted them to write new stories in the new Internet era. According to the "China Parenting Report under COVID-19" released by China's professional parenting platform Parenting Yuer.com (Yuer, 2020), the daily activity of parenting online communities increased by 22% year-on-year during COVID-19, and the daily activity of online consultation services increased by 50.58%. Urban mothers seek and establish social relationships through social media to overcome the lack of social interaction in parenting practices during the COVID-19 pandemic via para-social interaction. Although mothers tend to be primarily responsible for parenting, the parenting practices and psychological changes in this underprivileged group during the pandemic have failed to receive widespread attention. In this context, urban women who are raising children have to cope with the impact of the "social isolation" of the COVID-19 pandemic on their parenting activities, while also trying to adapt to the interaction between media and COVID-19 pandemic in answering the question, "How should I raise my children?" With the influence of COVID-19 on everyday social life, more and more young mothers are choosing online parenting as a new way of parenting. This shift in parenting is both a change in parenting behavior and the result of mediated and social interaction. Today, mediated parenting is becoming a new and more popular form of parenting, reflecting not only the mediated nature of everyday parenting among Chinese urban parenting women but also the daily life of mediatized parenting. The impact of the COVID-19 pandemic on the health of women in urban areas is not only related to changes in parenting styles and attitudes but also has a profound impact on family structures, social structures, and the education of young people. Considering this group as the entry point for research, we can not only analyze the impact of the COVID-19 pandemic on the parenting activities of urban women in the context of the interaction between media and socialization and further provide a new perspective for exploring the impact of the COVID-19 pandemic on Chinese families and society, but also draw the attention of the whole society, including urban parenting groups, to self-expression and self-worth through the discussion of motherhood. From this perspective, the study of the impact of the COVID-19 pandemic on the parenting psychology and parenting activities of urban women with children has both practical urgency and social value. It has been argued that media becomes powerful only when it is integrated with practice, unleashing its "molding force" (Hepp, 2012). To respond to the concerns of this group, this study therefore uses the mediatized society as a theoretical framework and investigates the mediated parenting practices of Chinese urban women during the COVID-19 pandemic in depth, as well as the reshaping of their cognition and behavior by online para–social interactions.

Materials and methods

Aims

This qualitative study investigated the changing impact of Chinese urban women's use of the Internet for parenting practices on their daily lives during the COVID-19 pandemic, including changes to parenting practice, parenting psychology, and perceptions of parenting (O'Brien Caughy et al., 2001), and parent-child relationships. Of particular interest were shifts away from traditional parenting practices during the pandemic and how these changes affected participants' parenting psychology.

Participants and procedure

The study sample consisted of urban women of childbearing age (mainly mothers born after 1980/1990) from a wide range of industries in China: 47 were born after 1990, 39 after 1980, and 4 after 1970; 49 had a bachelor's degree, 30 had a postgraduate degree, and 11 had less than a bachelor's degree. Among the 90 mothers, there were three pregnant women (all of whom received good news about their babies during the study) and one who had a miscarriage in April. The mothers were responsible for 115 babies, including 89 under the age of 6. To protect the privacy of the participants, the names of the participants in the study are presented as numbers (M01–M90; see **Table 1**).

Because the researcher is part of the group of urban mothers, the initial participants were drawn from the researcher's social circle (i.e., friends and colleagues of the researcher). Based on in-depth interviews with these participants, the researcher used the snowball sampling method to obtain a sufficient number of participants to reach 90 participants. Before becoming participants, individuals were informed of the study objectives, volunteered to become study participants, and were given sufficient information to be informed before the start of the interview. After obtaining the participants' consent, data were collected via Internet phone.

TABLE 1 Participants.

No.	Age range	Education level	Age of children
M01	Post-1990	Bachelor's	1 year
M02	Post-1990	Bachelor's	6 months
M03	Post-1990	Bachelor's	3 months
M04	Post-1980	Bachelor's	3 years
M05	Post-1980	Bachelor's	7 years/3 years
M06	Post-1990	Bachelor's	5 years/2 years
M07	Post-1990	Bachelor's	5 years
M08	Post-1980	Bachelor's	7 years
M09	Post-1990	Postgraduate	1 year
M10	Post-1970	Bachelor's	7 years/6 months
M11	Post-1990	Postgraduate	1 year
M12	Post-1970	Below Undergraduate	8 years/3 years
M13	Post-1980	Bachelor's	8 years
M14	Post-1980	Postgraduate	5 years/2 years
M15	Post-1980	Below Undergraduate	7 years/1 year
M16	Post-1980	Postgraduate	8 years
M17	Post-1990	Bachelor's	1 year
M18	Post-1990	Postgraduate	2 years
M19	Post-1990	Postgraduate	4 years
M20	Post-1990	Below Undergraduate	3 years
M21	Post-1990	Bachelor's	7 months of Pregnancy
M22	Post-1990	Below Undergraduate	5 months of Pregnancy
M23	Post-1980	Bachelor's	6 years/1 year
M24	Post-1990	Bachelor's	1 year
M25	Post-1980	Bachelor's	2 years
M26	Post-1990	Below Undergraduate	3 years/6 months
M27	Post-1990	Below Undergraduate	1 year
M28	Post-1990	Below Undergraduate	Miscarriage in the 4 months of Pregnancy
M29	Post-1980	Postgraduate	5 years
M30	Post-1980	Bachelor's	6 years/2 years
M31	Post-1980	Postgraduate	7 years/1 year
M32	Post-1980	Bachelor's	1 year
M33	Post-1980	Bachelor's	3 years
M34	Post-1990	Bachelor's	2 years
M35	Post-1990	Postgraduate	3 years
M36	Post-1980	Postgraduate	10 years
M37	Post-1980	Postgraduate	7 years/3 years
M38	Post-1990	Bachelor's	3 years
M39	Post-1990	Below Undergraduate	6 months
M40	Post-1990	Bachelor's	5 years/5 years
M41	Post-1980	Bachelor's	6 years/4 years
M42	Post-1980	Postgraduate	2 years
M43	Post-1990	Bachelor's	6 years
M44	Post-1980	Bachelor's	6 years/3 years
M45	Post-1980	Postgraduate	4 years/2 months
M46	Post-1990	Bachelor's	3 years
M47	Post-1990	Postgraduate	6 months
M48	Post-1990	Postgraduate	2 years
M49	Post-1980	Bachelor's	2 years
M50	Post-1980	Postgraduate	3 years
M51	Post-1980	Bachelor's	8 years/3 years
M52	Post-1990	Bachelor's	4 months of pregnancy
M53	Post-1990	Postgraduate	3 years
M54	Post-1990	Bachelor's	6 months
M55	Post-1980	Postgraduate	8 years/4 years
M56	Post-1980	Postgraduate	1 year
M57	Post-1990	Bachelor's	4 months
M58	Post-1980	Postgraduate	6 years/6 years
M59	Post-1970	Postgraduate	2 years
M60	Post-1990	Below Undergraduate	3 years
M61	Post-1990	Postgraduate	2 years
M62	Post-1990	Postgraduate	3 years
M63	Post-1980	Below Undergraduate	7 years/7 months
M64	Post-1980	Bachelor's	7 years/4 years
M65	Post-1990	Postgraduate	5 years
M66	Post-1990	Bachelor's	3 years
M67	Post-1980	Bachelor's	7 years/1 year
M68	Post-1980	Bachelor's	7 years
M69	Post-1980	Bachelor's	8 years/3 years
M70	Post-1980	Postgraduate	8 years
M71	Post-1990	Bachelor's	7 years/2 years
M72	Post-1980	Postgraduate	7 years
M73	Post-1980	Postgraduate	6 years
M74	Post-1990	Bachelor's	5 years
M75	Post-1990	Bachelor's	2 years
M76	Post-1990	Below Undergraduate	1 month
M77	Post-1980	Bachelor's	2 years
M78	Post-1990	Bachelor's	1 year
M79	Post-1980	Postgraduate	7 years/5 years
M80	Post-1970	Bachelor's	11 years/3 years
M81	Post-1980	Bachelor's	11 years/4 years
M82	Post-1990	Bachelor's	3 years
M83	Post-1990	Bachelor's	2 years
M84	Post-1980	Postgraduate	7 years
M85	Post-1980	Bachelor's	6 years
M86	Post-1990	Bachelor's	3 years
M87	Post-1990	Postgraduate	4 years
M88	Post-1990	Bachelor's	2 years
M89	Post-1990	Bachelor's	4 years
M90	Post-1990	Bachelor's	4 years

Instruments and data analysis

This study adopted a mixed-methods design combining semi-structured, in-depth interviews involving both participation and observation. This mixed design method can more objectively obtain data on the experience of Chinese urban women's parenting practices through mediation during the COVID-19 epidemic. Additionally, the mixed design method can make up for the limitation of data collection of a single research method to a certain extent, and ensure the data collection of the research to the greatest extent can provide solid support for the research findings.

The use of participant observation had two roles in this study: first, to allow the researcher to enter the social life environment of the research subject, participate in the subject's activities, and gather information through actual personal observation. Ultimately, observation, questioning, feeling, and comprehension can be used to better understand the issues under study. Childcare scenes in daily life can be found everywhere: Communities, parks, shopping malls, playgrounds, hospitals, early childhood centers, supermarkets, and children's restaurants are public places where urban women with children often gather. These places provide a good opportunity for the researcher to conduct the participatory observation. By observing the daily lifestyles and routines of urban mothers and further participating in their daily parenting activities (holiday gatherings, rituals, and ceremonies), the researcher can maintain continuous contact with them and observe their social interactions in online communities and social media to obtain information about their perceptions and practices in the process of pregnancy, childbirth, parenting, and education. The second role was designed to complement the in-depth interviews and compensate for the shortcomings of the in-depth interviews in the process of data collection. The whole participatory observation ran from December 2019 until June 2021 (i.e., 1 year and 6 months). The observation notes were divided into three parts: handwritten log, electronic memos, and audio recordings.

The semi-structured in-depth interviews lasted approximately half an hour to 1 h, depending on the actual differences between each participant. The purpose of the interviews was to explore the personal and general experiences of urban women during their social interactions and parenting practice through the Internet, especially the changes and differences in their parenting practices and parenting philosophies during the COVID-19 pandemic. To collect more comprehensive and objective data, semi-structured in-depth interviews and participant observation were carried out in parallel, and some of the interview participants were collected during the process of participant observation. We proactively identified urban women engaged in parenting who met our research needs through participatory observation and conduct interviews after observing them for a month. In the interviews, participants shared their parenting philosophies, knowledge, experiences, and changes brought about by their use of the Internet to access parenting information during the COVID-19 pandemic. The semi-structured in-depth interview questions were divided into three categories: personal growth and parenting situation, parenting information access and learning during COVID-19, and perceptions and changes in motherhood during COVID-19 (**Table 2**).

After all interview data and participant observation notes were recorded individually, the text was initially organized and analyzed. The raw data were then analyzed sentence-by-sentence and categorized by thematic keywords using textual analysis to identify specific manifestations of urban mothers' parenting practices. Different thematic analyses (Brooks et al., 2015) were conducted to identify causal, semantic, similar, structural, and differential relationships among the texts. Due to the specificity of the textual material, some of the texts were analyzed manually and some were analyzed with the help of NVivo. The entire text analysis process took about 6 months to complete.

Results

The findings suggest that, during the COVID-19 global pandemic, Chinese urban women shifted their parenting practices to the Internet and became actively involved in the mediatized society to overcome the difficulties of parenting practices caused by the obstruction of real communication channels. While aligning their parenting practices with the mediatized society, the psychological changes in their parenting were mainly reflected in three ways: media empowerment, mutual assistance in action, and ideation of motherhood. These changes have also enabled these women to make the psychological shift from traditional experience to scientific parenting and to be more proactive in learning and sharing parenting knowledge, as well as expressing themselves through the Internet. This mediatized parenting practice during the pandemic allowed them to accept the shift in their role as "Internet moms" with a positive mindset in the process of mediatized expression and perception.

Information empowerment and scientific parenting

During the interviews, we noticed that the convenience of mediatization production (Zhen et al., 2015), information dissemination, and information sharing brought about by the Internet was fully exploited by urban women engaged in child-rearing, who rapidly applied such practices to their child-rearing. It further contributed to their psychological transformation from experienced (or traditional) to scientific

TABLE 2 Semi-structured interview question outline.

Question category	Example problem
Personal growth and parenting	Participant's profile (age, hometown, education, occupation and income status, among others)
	Participant's marriage information (marital status, basic information of partner, among others)
	Participant's mertility information (number and age of children, among others)
	Participant's parenting information (maternity, care, feeding, consumption, education, among others)
Parenting information access and knowledge learning during COVID-19	Participants' parenting knowledge gathered from families during COVID-19
	Participants' parenting knowledge gathered from the media during COVID-19
	Participants' use and concerns about online parenting during COVID-19
	Information participants acquired before and after COVID-19
Perceptions and changes in motherhood during COVID-19	Participants' perceptions of online parenting knowledge during COVID-19
	Participants' perceptions of being a mom and online parenting during COVID-19
	Participants' perceptions of self-perception, social roles, and online parenting during COVID-19
	Participants' perceptions of parenting concepts before and after COVID-19

parenting. Driven by a common social identity, seeking mutual help through media interaction has become a norm in current motherhood practice. The new generation of mothers—built based on groups for check-ins, mutual support, and experience sharing—is building relationships, sharing experiences, and growing together at the intersection of strong and weak relationships (Granovetter, 1973), releasing the tension between virtual and reality-based media empowerment.

Taking parenting WeChat groups as an example, young mothers' daily online interactions involve a wide range of information and diverse interaction methods. Topics included motherhood, intergenerational discrepancies (Helga, 2013) in parenting concepts, personal experiences, sharing of parenting knowledge, and mother and baby product recommendations, among others. They also discussed public topics and news events about young children and expressed their negative feelings about motherhood (Lehto, 2020). Information is the basic element of human society, and it forms information chains through different media (Mei et al., 2004), thus providing the underlying support for normal human production and life. When the spatial and temporal boundaries of traditional information dissemination are broken, information begins to diffuse in a non-linear way. In this diffuse flow of information, mediatization has an impact on daily life. The personal lives of urban women raising children were visually presented in this virtual community communication context (Mezgár, 2009). In the interviews, we further found that the media empowerment brought about by the Internet created changes in the psychological aspects of parenting for these women on three levels, including the sharing of goods, memories, and knowledge.

The first level is the sharing of goods. During the interview process, we met a young mother who used to be an overseas parenting product buyer, and there were more than a thousand moms with similar needs on her WeChat. She therefore created a WeChat group called "Parenting Products Unused Exchange Group" and wrote the following on the group's bulletin board: "Moms who want to sell items can mark up the price and send it to the group, so I can help you share it with other groups. Anyone who likes a certain product can also send me a message." This WeChat group was very active during the pandemic, and it shared many unused parenting products every day, allowing many young mothers to discuss and interact with each other. The items shared in the group included early learning machines, Lego toys, bubble machines, scooters, excavator toys, intelligent accompanying robots, inflatable swimming pools, children's pianos, and the like. Receiving more comprehensive parenting information and having more abundant parenting goods are the most important concerns of urban women with children. In traditional Chinese society, parenting goods are obtained through traditional acquaintance networks (Chen et al., 2013), such as family inheritance and sharing among friends. However, during the COVID-19 pandemic, this social sharing bond was cut off. As a result, young mothers tried to help themselves through the Internet. Initially, it was more of an occasional, sporadic behavior based on websites, but later, as this behavior extended to social media, unused parenting goods exchange groups—mainly on WeChat, Sina Microblog (Chinese Twitter), Red Booklet (Chinese Instagram), and Zhihu (Chinese Quora)—quickly became the main place for mothers to find parenting goods. Unlike the sharing of goods in person, the sharing of goods in virtual space proceeds more along the lines of information sharing based

on goods. From secondhand transaction in WeChat groups to social media group chats, goods passed between different individuals initially as information, completing a "journey" across time and space. The sharing of goods online is not simply the sharing of goods and information or goods and goods—that is, the sharing of these objects carries not only the physical objects themselves but also the emotional connection with urban women raising children based on the sharing of objects, combining motherhood and practice in a material way (Turner and Norwood, 2013). This media-based sharing of goods both mediatizes the parenting practices of these women and even involves the goods in this mediatization process. The concept of scientific parenting is also spread through the "physical-emotional" interaction field (Lewin and Cartwright, 1951) formed by the interaction between people and goods and between people and people, promoting deep acceptance of this concept.

The second level is the sharing of memories. During the participatory observation process, we discovered an application (app) called Qinbaobao for which young mothers form the main user group. Users can upload photos, videos, and parenting diaries, and the uploaded information is intelligently categorized according to date and content, making it easy to find. After posting a message, the user can invite her friends and family members to join her parenting group; they can browse, comment, like, and share the message after entering. Examples include "Baby's first month of life story" or "How to be a good mother while working" and other stories about the growth of young children (Johnston and Swanson, 2006). The app also has an interactive community function to meet users' needs for online communication and information sharing. As a digital form of self-representation (Blum-Ross and Livingstone, 2017), users can share snippets of their parenting lives through the app, and other users can comment on, like, and share those snippets. Some of the app community leaders have reached 100,000 followers because they often share photos and content in the community. In the traditional Chinese parenting model, photos or images of the first month after birth, birthdays, and school promotions are special, precious parenting memories. However, as mediatization continues to permeate human daily life, this traditional pattern of only special nodes being remembered is gradually breaking down. This media-driven de-nodalized mode of memory has further changed mothers' memories of parenting during the COVID-19 pandemic, as well as their attitudes toward parenting memories. During the COVID-19 pandemic, urban mothers not only recorded and shared their parenting memories, but also found new spaces for self-expression and self-fulfillment, and found psychological reliance on the group via media-based community interaction (Thorns and Eryilmaz, 2014). With the mediatized connection, these women seek emotional comfort by sharing their parenting stories, helping each other by sharing parenting information, and seeking value recognition by sharing the joint growth of parents and children. If sharing in traditional societies focused more on the entry point of the individuals who practice motherhood, the sharing of women's motherhood memories online tends to focus on the environmental and cultural conditions of motherhood performance (Enzhi, 2019). The formation of a sense of belonging and identity in the collective memory of media-based community interactions is oriented toward shaping the psychological value of parenting for mothers—more so than traditional parenting models—and can lead to a positive shift from a "child-centered" (Saldinger et al., 2004) to a "mother and child-centered" approach in the psychology of parenting for urban child-rearing women.

The third level is knowledge sharing. Through various media platforms, young mothers have more access to parenting knowledge, and in the process of communicating with others with similar parenting experiences, new parenting knowledge takes shape as they learn from and communicate with each other.

> *Constipation during the COVID-19 pandemic was a headache for mothers, and I had no experience in dealing with this problem myself, nor did I have any knowledge of parenting. Fortunately, there was a mother in my WeChat group who had the same problem with her child. She gave me a lot of advice and recommended probiotic products. I myself also learn about probiotics on mother and baby forums. . . (Excerpts from M62 interview materials)*

In various WeChat groups and parenting apps, parenting knowledge is fragmented across the network; this information is enriched, supplemented, borrowed, used, questioned, and absorbed in the exchange among mothers. Chinese society has undergone a profound transformation since the 1980s and, in the process, moved from tradition to modernization. The highly compressed modernization process has had a great impact on ideas about parenting (Meng, 2020), and much parenting knowledge has been abandoned in the wave of progress. In the interviews, we found that many young mothers born after 1980/1990 questioned traditional parenting knowledge. In the parenting knowledge system of older generations, there are no terms such as probiotics and Heimlich method. However, the new generation of mothers who have been nurtured by online parenting knowledge can respond to these professional terms proficiently. "Probiotics can promote the absorption of children's gastrointestinal function," "If the food is stuck, the Heimlich method needs to be used immediately"... They have taken the initiative to shift the channel of learning about parenting from home to society at large and from in-person interactions to the Internet, ultimately coming to use the media as their main source of parenting knowledge. This kind of learning was initially only available to some mothers. With the

outbreak of the COVID-19 pandemic, this mode of learning has rapidly become popular among urban women raising children, given the huge demand for parenting knowledge. What urban women learned about parenting through the media during the COVID-19 pandemic not only made up for their own parenting shortcomings, but also gave them solid support for their beliefs in scientific parenting, which helped them to psychologically accept, agree with, and support the concept. This psychological change through mediatized parenting practices is continuing beyond the COVID-19 pandemic and has extended from the virtual to the real. It is having a concrete impact on the real lives of urban mothers. This impact is reflected in their lifestyles, consumption patterns, and many other dimensions, and it is likely to be passed on to their children.

Mutual action and parenting community

In a mediatized society, the media exerts a constant influence on daily life as an internal driving force. Although media interactions superficially bring about changes in the perceptions and values of urban women, ultimately the psychological changes brought about by these media interactions are also applied to social practices through their parenting. In the interviews, we found that, during the COVID-19 pandemic, the online community generated effective media mobilization through a strong sense of collective emotion and solidarity, whether it was through the mutual information support of the WeChat group or the social interaction of social media. The media mobilization would also further lead urban mothers to form a collaborative, expressive, and active parenting community. The mothers support each other psychologically, help each other in action, and express their opinions, which is a positive step for urban women in defending their rights and interests and participating in social topics.

The first aspect that needs to be considered is the collaborative community. During the COVID-19 pandemic, mothers exchanged goods and shared experiences through the Internet over a long period. Mothers gradually shared similar values and views on parenting and also built a foundation of trust, which was a prerequisite for the creation of a collaborative community. In our interviews, we found that urban mothers used WeChat groups and other social media not only to share their experiences but also to watch over each other and co-parent. During the interviews, we met a mother (M15) from Beijing who was invited by her sister to join a group called "English, Chinese, and Math Parents' Group" during the pandemic, with 87 mothers in total. Her sister told her that she should follow everyone in the group to learn about parenting, to see what children are learning now, what is being talked about in the field of early education, and to learn more about schooling, which would be useful in a couple of years.

> *After being invited into the group I found that there was a lot to learn. The group is set tasks every day, and the mothers monitor each other. Everyone is willing to participate. I found that it made quite a difference to both my children and me… When mothers in the group share their children's growth process or achievements, I will always unconsciously compare them with my own children, or use them as a reference. This strengthened my confidence in sticking to interactive learning with other mothers in the group...*
> *(Excerpts from M15 interview materials)*

Through the WeChat group, mothers could share photos or videos of their children's learning in the group every day, which triggered other members to imitate them and create a scene of common learning and sharing in the group. Although the sharing of lessons learned is an important element, this practice is also a cyber-ritual for mothers to collaborate (Jacobs, 2007). On the one hand, it is a self-presentation from multiple narrative subjects, and on the other hand, it co-constructs a mediatized parenting discourse, providing concrete and intuitive reference perspectives for other mothers. There are also WeChat groups for pregnant women, which have been set up to provide help to urban mothers during the pandemic. One such group has no less than 500 chat messages per day, covering topics such as fetal movement communication, maternity confusion, pregnancy anxiety, vaccination exemption (Tangherlini et al., 2016), and the spread of the COVID-19 pandemic. These messages are updated quickly and frequently interact. People also share experiences and resources in the group to provide practical offline assistance: "My baby was born at 7 pounds, and it was still a normal birth, it was so painful to give birth," "I had a cesarean 2 days ago, and my wound is still painful," and "Don't be afraid, we are with you." Through sharing their experiences in preparing for pregnancy and daily life, they encouraged each other, supported each other, built confidence, relieved anxiety, brought each other great psychological support and assistance with practical information, and tided over the difficulties together. Some of the WeChat groups also have volunteers who make manuals for pregnant women to protect themselves from the pandemic and await their delivery with peace of mind or provide attentive company to lonely and helpless pregnant mothers, answering their questions at any time and relieving tension and anxiety. Through this mutual support, the volunteers communicate with pregnant mothers promptly and help them with maternity checkups, hospital appointments, contacting family members, purchasing daily necessities, and other matters. Although this collaborative action is transmitted in the form of media, it is real for both the individuals who transmit the information and for those individuals who act on it. Thus, the media-based collaborative

community not only influences the parenting practices of urban women but also contributes to their psychological formation of an individualized collectiveness (Soon and Kluver, 2014).

The second aspect is the expressive community. During the participant observation, we found that WeChat groups were most likely to generate retweets from mothers on topics such as food safety and defective toys. The voices of a single individual are not enough to attract widespread attention, so in this case, seeking collective voices online is a relatively convenient and feasible path. Mothers gather together through online communities, driven by the same or similar social identities and social experiences, to transform individual expression into collective expression, thus enhancing the right to speak out and express themselves at events, and achieving social resistance and balance.

Pregnant mothers in Wuhan became a special group during the COVID-19 pandemic. At the beginning of the pandemic, major hospitals focused attention on treating COVID-19 patients, and even specialized maternity and children's hospitals were included in the pandemic treatment system. It became difficult for pregnant women in Wuhan to find either standard maternity appointments or hospitalization for delivery. In the absence of help from society at large, pregnant mothers began to express their voices online and on social media, hoping to spark societal attention. The dense network of information garnered the interest of web celebrities and news media, and this "neglected group" quickly gained attention through their intervention. On January 26, 2020, the "Wuhan Pregnant Women WeChat Group" was established to help pregnant mothers in Wuhan during the COVID-19 pandemic; the following message was posted on the WeChat group's web bulletin board: "We provide medical information, vehicle information and psychological counseling." At the same time, there was also the "Hubei Maternity Free Consultation Group" organized by local doctors in Wuhan, with more than a dozen professional doctors from all over the country promptly replying to consultations and requests for help from group members. Urban women raising children through the media quickly gathered many voices, to express their needs, not only to convey their voices to the community, and receive the support of society. The key factor that enables the formation of media communities is that they transcend existing social relationships and give them new life by bringing people with diverse life backgrounds and social experiences together. This further promotes the psychological homogenization of cognitive and behavioral patterns in the process of interaction and communication. Urban parenting women make the most of social interactions at the mediated level, trying to break out of the constraints imposed on them by family life at the spatial and temporal level. Through more frequent and closer contact with others and society, whether close by or distant, they can improve their relationships and lifestyles, thus embracing a wider range of living spaces. The community of expression formed by urban child-rearing women during the COVID-19 pandemic, although superficially for self-help, behind the scenes shows a profound awareness of mediatized expression and a more psychological concern for the self on the part of these women. They are trying to make their voices heard, and these voices are not only making society more aware of them as a group; but in doing so, the group itself becomes more psychologically aware of its own power and the power of mediatized society in their daily lives. The psychological shift in parenting topics from private to public triggered by media expression during the COVID-19 pandemic is likely to affect more and more urban mothers, who could continue to actively express their voices through the Internet media to defend their rights and interests and to participate in social and public issues.

The third aspect is the active community. During the interviews, we met a mother from Hangzhou (M73) who shared a process that appeared during the COVID-19 pandemic in which mothers communicated with the kindergarten through media interactions; this mother showed us the chat logs in the WeChat group. Her daughter attended a small, private kindergarten with a high fee, and the school infrastructure was satisfactory. The school advertises a Canadian education system and faculty, with daily classes with foreign teachers. Parents have a classroom WeChat group for communication and a "Baby's Home" group created by a dozen mothers. One month before the summer holiday, the class visual education teacher was reassigned because the school was opening a new campus, and the parents of the students were not informed. The moms started discussing this issue with each other in the "Baby's Home" WeChat group.

> *Parent A: "Hello everyone, I heard that Shiny, the school's visual arts teacher, was reassigned and the school did not inform parents in advance. It seems that Annie, the dance teacher, has also resigned. These two teachers are very popular with the children, so let's talk about it and see if we can talk to the school."*
> *Parent B: "My son said he hadn't been to visual arts class for many days, and he was crying in the morning."*
> *Parent C: "It's not good for children to change teachers so often."*
> *Parent D: "Well, I think we have to unite to get the school's attention."*
> *Parent A: "Let's go together tomorrow and ask for a tuition refund. It's too disrespectful to children and parents."*
> *Parent C: "The key is that the tuition is still so high and the teachers are still unstable. If the school cannot deliver on*

> *the promises made prior to enrollment, we should be given a refund."*
> *Parent B: "Many of the classes have not lived up to the previous promise. The very beginning promised to have drama class, and I haven't seen it. The school promises to give students daily English communication before enrollment, and I feel that there are very few opportunities for this on a regular class. . ."*
> *(Excerpt from M73's WeChat group chat log)*

The WeChat group went from initiating messages to exchanging messages, negotiating ideas, initiating actions, and ultimately organizing actions in just half an hour. The discussion among the mothers gradually spread from the initial teacher reassignment to recent teaching content, the flashy curriculum, excessive tuition, food safety, undersized playgrounds, substandard educational commitments, and a host of other issues, which mothers normally tended to ignore or felt the school would not pay attention to were listed in this chance in-depth discussion. The mothers started soliciting issues and agreed on a specific time to go face to face with the school representatives. According to a follow-up from the mother (M73) on how things were going, the mothers discussed and decided that four parents would go as representatives to communicate with the school, and some of these issues were later resolved. For women, integrating into a larger group through media communities and forming a "community" through daily communication and interaction can not only reduce the individual's ability to overcome risks in the face of uncertainties but can also create a link between discourse and action, from offline to online, driven by similar life experiences, giving rise to virtual and real action practice (Miller and Madianou, 2012). This WeChat group was not only a kind of mutual help in action but also a kind of psychological mutual help, which made a positive contribution to further strengthen the identity of the child-rearing community.

During the COVID-19 pandemic, urban women's media action not only reduced their stress and anxiety in the face of external events but also increased their confidence in speech and action through collective action. This media action support allowed urban mothers to come out from the limits of individual experience and feel psychologically that they are not just independent individuals, but that they have something to rely on, they have support, which enhanced their sense of well-being (McDaniel et al., 2012). The COVID-19 pandemic may eventually end, but the impact of the parenting community formed by online mutual support on the psychology of urban mothers may not. In the future, the online and offline parenting model could play an increasingly important role in the parenting practices of urban women, further stimulating a sense of autonomy in action and encouraging more group members to team up for active sharing and voluntary support.

Motherhood imagination and media shaping

During the COVID-19 pandemic, a wide variety of news and information on "how to be a good mother" was published, and the images of "super mothers" and "perfect mothers" in dramas and variety shows were completely different from traditional mothers. The new view of parenting shaped by the media has influenced urban women's psychology and practice of parenting.

For urban mothers, digital technology and social media are gradually shifting forward in time to the moment when they feel they "become mothers" and use their power to construct the image of motherhood imagination among mothers. In the interviews, we often asked, "When did you feel that you had become a mother?" The responses we heard at the beginning of the COVID-19 pandemic tended to be: *"When the baby cried loudly" (M04)* or *"When the baby in my womb kicked me during a pregnancy test" (M42).* This question may have a new answer given the media interactions of urban mothers during the COVID-19 pandemic, as many women are already learning online about parenting while pregnant. Mediatized parenting is gradually becoming a new option for more and more urban women to interact with their children during the pandemic. During the participatory observation, we found an app called Babytree, which is divided into four sections: parenting, social interaction, shopping, and pregnancy services. The app provides pregnant women with information about recipes, fetal education, maternity check-up, and fetal movement in different stages of pregnancy, and can also answer questions from pregnant women.

> *"When I was first pregnant, I used to browse Babytree, which was so informative that I didn't have to buy any parenting books." (Excerpts from M19 interview)*
> *"Every time I go for a maternity check-up, I can't say a few words to the doctor, and I can't read the lab reports I get back. So, the information about exactly is the condition of one's body, other than the bulging tummy visible to the naked eye, is almost unavailable. But through the media, it is possible to see the basic condition of the child at each stage of pregnancy." (Excerpts from M90 interview materials)*

The app also offers pregnant women and new mothers a variety of social networking options to share news of their pregnancy with other pregnant women. This is

unimaginable in traditional Chinese societal norms for pregnancy and parenting practices. According to traditional Chinese customs, pregnant women are not allowed to share the news of their pregnancy with others during the first 3 months of pregnancy. Now, however, pregnant women can connect and share their experiences with other mothers in pregnancy preparation or preparing to become mothers on the Internet. It has been both a joy to share and an enriching experience for my own pregnancy preparation.

We also found that, during the COVID-19 pandemic, many mothers chose to announce their motherhood by displaying ultrasound images of their fetuses on social media. The media not only creates a physical attachment between mother and baby but also builds on it again to create a closer parent–child interaction. The different apps cover almost all maternity and parenting content for women before, during, and after they become mothers. The figures, 3D animations, and anthropomorphic words used in the app to present the indicators of the child's growth and development are all attempts to create a warm parent-child bond, to help mothers construct a concrete image of the baby inside the womb and increase intimacy. At the same time, the data records of the pregnant women in the app, the maternity reports, and the nutritional advice sent to pregnant women are constantly reinforcing the role of pregnant women as mothers and the motherly responsibilities they should take up for the health of their fetus. Media thus shapes responsibility and achieves the construction of intimacy. From pregnancy to a fetus, from unfamiliarity to familiarity, and from maternity checkups to nutrition, urban women gradually start their role initiation as mothers while using the media.

During the participatory observation, we found that the presentation of parenting in the media was not only a presentation and discussion of the current reality of parenting in China but also a reconstruction of this central topic in life through narrative. Through this format, the online media attempts to reproduce the contradictions and conflicts that arise in the process of parenting, so that mothers can empathize and be inspired, as well as seek to guide value choices and parenting concepts that are in line with social development. In the concept of traditional Chinese society, a mother must completely give up her ideals, goals, and even her own life to provide her children unreserved love and unconditional care, and to meet the society's image of "superhuman" and "perfect" mothers and the expectation of "anything can be done." However, as the American poet Adrian Rich said, "If the role of women is compressed to almost the same time as the role of mother, the value of the female individual is eliminated." In the past 2 years, with the media's extensive discussion of parenting topics, more and more urban women of childbearing age have begun to rethink about their own life situations and reflect on their roles. Some women also took to social media with the slogan "I'm mom, I'm myself."

> *"Don't just praise the greatness of mothers, every mother is a living person, affirm the value of mothers, see the dedication of mothers, whether she is a housewife or a professional woman, whether she is beautiful or aging. It is not natural for mothers to give to their children, we need to understand the selfishness of mothers and be less demanding of them." (From the social media account of the network name "Mengmeng," the excerpts have obtained her consent).*

The media's central reflection of social values and consciousness has also become an important force in the formation and development of new social concepts. During the COVID-19 pandemic, diverse media formats—whether it was news and information that communicated scientific parenting concepts, or films and television productions that portrayed diverse images of mothers—have been providing a media mirror of current Chinese parenting issues. These imaginings of reality, in turn, continued to influence urban mothers' ideas about and practices of motherhood.

In China, dramas are characterized by high social acceptance and strong penetration. During the COVID-19 pandemic, mothers were not able to participate in normal social interactions, so the purpose of watching films and dramas for leisure and entertainment via online media platforms became one of their main ways to relax. Influenced by social identity and life experience, movie and TV dramas with child-rearing themes are most popular among urban women with children. The study found that during the pandemic, the image of mothers in parenting dramas was no longer the traditional one-size-fits-all, but included various types of maternal roles, including working mothers, single mothers, and mothers of second children. These rich maternal roles are deeply rooted in the hearts of people through the popularity of dramas, and many women, while watching the dramas, also empathize with the power of the characters in similar life situations and see their reflections in the characters. In the participant observation, we found that the very contrasting maternal roles that appeared in the film and TV series *A Love for Dilemma*, which aired in 2021, were welcomed by the mothers. The two mothers, one who lets her children develop on their own and the other who cares for them in every way, map out their different parenting philosophies in the real world. These contrasting models of motherhood truly restored the diversity of mothers in real life, presenting the different parent–child relationships and ways of getting along in different families in daily life. In *A Love for Dilemma*, a mother who had previously left her child to develop on her own is confronted with tremendous parenting anxiety, resulting in a psychological change leading to the question, *"Am I a bad mother? [. . .] I*

should have started paying attention to her learning long ago!" Self-doubt and self-denial sent her into deep anxiety about her parenting style.

Some movies and dramas feature a range of motherhood models, from the stay-at-home-mom who is weak and subservient to her husband to the working mom who is brave enough to leave her family and start a successful business. This transformation of maternity presented through the media is extremely touching for urban women in similar life situations who are raising children. During the COVID-19 pandemic, urban mothers have also actively compared the images of mothers presented in the media with themselves, and have tried to change their parenting psychology and deepen their role identity. Through social media and WeChat groups, urban women express their views and perceptions of the images of mothers portrayed in dramas in comparison to their own lives. Through constant interaction with the media, these mothers are more likely to gain group recognition, thus contributing to the awakening of urban women's self-awareness. This change is not only helping urban women overcome the misconceptions of traditional parenting and form a scientific parenting mentality but also subconsciously encouraging women to break through themselves, strengthen their perception of self-presence (Daniel and Mirca, 2012), get out of the family, and realize their own value in life.

Parenting shows are also a medium of expression that has received attention from urban women raising children. Unlike the idealized mothers in traditional media, these shows present the experience of motherhood and parenting through mundane, everyday details (Lopez, 2009). During the pandemic, parenting shows simulated the lives of different families, showing the conflicts and contradictions that may arise during the parenting process, as well as the diverse parenting approaches in different families. In the participant observation, we found that, at the beginning of the COVID-19 pandemic in 2020, more than ten parenting shows were launched in China. Some of these shows were child development-centered, while others were focused on mother-parenting, education sharing, or the family relationship. Each type of show delivers different parenting psychologies and practices to mothers. In the participant observation, we found a show called *Mom Is Superman,* which enhances the emotional development between parents and children through parent-child interaction in which the mother and child participate in activities together. This promotes the growth of both mother and child. Parenting shows are a reflection of parenting anxiety and women's demand for autonomy in the context of the COVID-19 pandemic, as well as the social construction of the connotations of motherhood. Through documentary-style observation, variety shows have set up perfect mother role models, and these have influenced the identity of urban women raising children. It is worth noting that during the pandemic, watching parenting variety shows has prompted mothers to think about the psychology of parenting, their role in their children's education and upbringing, and the reality that fathers are not particularly involved in the parenting process in many families in China today. These reflections were accompanied by online media interactions that quickly gained the participation and discussion of other mothers with a broad social consensus on parenting. At the same time, these reflections may lead to a change in the concept of childcare for urban women, and hopefully, raise the awareness of "motherhood" and "womanhood" in society, ultimately leading to more attention and support for women.

Conclusion

This study sought to identify issues connected to the relationship between online behaviors and the psychology and practice of parenting among urban mothers in China during the COVID-19 pandemic. We found that COVID-19 undeniably caused many inconveniences for urban women with children; however, these women were also found to be actively using the Internet to gain knowledge and help each other. The active integration with the mediatized society created new opportunities for this group. Through the analysis of empirical data obtained from in-depth interviews and participant observation, we found that the psychological changes triggered by Chinese urban women's mediatized parenting practices during the COVID-19 pandemic primarily appeared in three aspects: changes in the concept of scientific parenting due to information empowerment, identification of a parenting community due to mutual assistance in action, and motherhood imaginaries shaped by the media. From experienced parenting to scientific parenting, from family to society, urban mothers were observed to be interacting with each other on the Internet about parenting knowledge, parenting psychology, and social relationships. These changing influences complemented and reinforced each other and together influenced urban women's psychology of child-rearing and awakened their concern for their social rights and participation in social public issues in a mediatized society.

Discussion

This study examined the parenting practices in which urban Chinese women with children engaged online during the COVID-19 pandemic, as well as the changes in the psychology of parenting that resulted from these practices. In an evolving mediated society, the use of the Internet for social interaction is a part of normal social activities. However, before the outbreak of the pandemic, urban women engaged in online parenting practices that were fragmented and isolated, complementing real-world social parenting practices. At the beginning of the pandemic, many mothers also tried to reconstruct the structured

life they had before (Kusin and Choo, 2021). However, as health prevention policies became more restrictive, urban mothers began to try to move away from traditional social patriarchal institutionalization and experiment with purposeful maternal childcare practices via the Internet (Green and Joy, 2015). As more and more mothers joined, the Internet gradually became the main way for urban women to acquire parenting knowledge, share parenting experiences, and engage in social interactions during the pandemic. This virtual practice also influenced, to a certain extent, urban women's psychology of parenting, and these psychological changes appeared in their online participation, transition in parenting identity (Richter et al., 2021), identification with the parenting community, and imaginaries of motherhood.

Importantly, these women have become psychologically free from the shackles of traditional Chinese social parenting customs and concepts, and have formed an ideal discourse community of scientific parenting supported by the interactive online parenting community (Mannay et al., 2018). Due to shifts in traditional interpersonal communication boundaries through online sharing (Davide and Laura, 2021), urban women with children can break through the acquaintance circle and go beyond the family circle to find groups with similar life experiences online. These women face similar problems, have similar experiences, and are more likely to receive psychological support; they have similar social backgrounds, have similar knowledge and education, believe in science, and are more likely to accept the concept of scientific parenting. During the interviews, we found that these mothers generally felt that the COVID-19 pandemic period was a new window for them to get to know themselves and gain knowledge about parenting. They saw the outside world through the Internet, made new friends, and noticed problems in their daily parenting process. This has created a positive meaning for them and allowed them to accept the concept of scientific parenting more actively and change from family to scientific parenting. Some mothers believe that the traditional view of childcare formed over China's long historical development is still deeply rooted and that many customs and experiences create physical and psychological restraints on women who are raising children. Although there is a growing awareness that parenting has a different meaning for women (Bermúdez et al., 2014), there still has not been much attention paid to this group of women and childcare. During the pandemic, urban women's online parenting practices helped them to break free from the traditional customs of Chinese society and form a space for sound scientific parenting. At the same time, the parenting community formed by online practices has enabled urban women to engage in the process of meaning-making for parenting practices (Siu-ming et al., 2021), helping them to relieve mental stress, seek psychological comfort, and obtain a safe harbor of group support, which is conducive to the group's ability to unite and express their voices.

Our study also noted that, during the pandemic, urban mothers improved their ability to deal with childcare issues through online practices and gained a dawning of female autonomy (Fierloos et al., 2022). Even so, we need to acknowledge the limited existence of parenting topics as social mirrors on the Internet. Fertility issues present a large number of diverse types depending on individuals, families, regional cultures, ethnic religions, and many other factors. Online parenting practices during the pandemic also created realities that cannot be ignored: the risk of child abuse due to online stress (Chung et al., 2020; Yamaoka et al., 2021), parenting mental health (Kurata et al., 2021; Marzilli et al., 2021), and the stress of parenting due to the epidemic should all be given attention (Ben-Ari et al., 2021; McRae et al., 2021). Although these problems are particularly prominent due to the parenting practices of urban women raising children during the COVID-19 period, they have also profoundly affected urban women's understanding of parenting topics. However, for Chinese society, there are deep-seated social factors in these impacts. Continued sluggish fertility rates, rapidly aging populations, high childcare costs inhibiting the willingness to bear children, and the widening gap in parenting awareness all affect urban women's views on parenting to a certain extent. It is difficult to link media production, circulation, and reception to such a wide range of intersecting social and cultural arenas based on simple network participation. It is even more difficult to fully understand the social impact and cultural significance of the network in the daily lives of our research subjects. The government, media, and social organizations should therefore pay more attention to the group of urban women raising children, focus on protecting women's rights and interests, solve the problems they encounter, and make them feel secure in their role in society. At the same time, these mothers should be guided to actively participate in offline social interaction activities through parenting seminars and psychological counseling.

Currently, many countries around the world are still coping with the COVID-19 pandemic, and women in these countries are experiencing similar problems to those in China. We were limited in our ability to obtain information on women's experiences with online parenting practices during the COVID-19 pandemic in other countries, which is a limitation of this study. Future studies could be expanded to more countries, involving more participants, and obtaining richer empirical information. This research also only focused on the influence of online communities on urban mothers' psychology of parenting and did not consider factors such as fathers, children, and family type. Parenting is an all-encompassing social issue. Future research should pay attention to collecting empirical data from the perspective of other members of the family, as well as comparing urban mothers with other family members. This could help to further identify the psychological and operational changes in parenting brought about by online parenting practices; moreover, positive implications could also be achieved for the promotion of scientific parenting concepts.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Ethics statement

Ethical review and approval was not required for the study on human participants in accordance with the local legislation and institutional requirements. Written informed consent from the patients/participants or patients/participants legal guardian/next of kin was not required to participate in this study in accordance with the national legislation and the institutional requirements.

Author contributions

RZ: investigation, formal analysis, and writing – original draft. GJ: conceptualization, investigation, and writing – review and editing. Both authors contributed to the article and approved the submitted version.

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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Influence of personality traits on online self-disclosure: Considering perceived value and degree of authenticity separately as mediator and moderator

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The Chinese have been spending significantly more time on the Internet during post-pandemic time. When people are confined indoors, there is a greater need to construct an identity and socialize online. Personality traits and perceived value of the media are important factors that affect users' online self-disclosure. This study involved the construction of a mediation model and a moderator model to evaluate the influence of personality traits on self-disclosure on social media. Perceived value was regarded as the mediator while the degree of authenticity was regarded as the moderator. Using a quota sampling method, 1,075 Chinese netizens were surveyed in July and August 2021. The results showed that: (1) The depth of self-disclosure of subjects with extroverted personality was significantly higher than that of those with introverted personality, that is, personality traits affect the depth of self-disclosure; (2) perceived value plays a mediating role in online self-disclosure; (3) The degree of authenticity is a significant moderator in the relationship between personality and self-disclosure. In all, the results from this study contribute to our understanding of how personality traits affect perceived value of media and self-disclosure. This study tested the credibility and validity of the proposed model in the context of the recent COVID-19 pandemic lockdown in China, and the study is a novel approach in that area of research.

KEYWORDS

personality traits, perceived value, self-disclosure, social media, self-discrepancy theory

Introduction

The COVID-19 pandemic has profoundly changed people's lives and work. When people's offline movements are restricted, the experience of receiving and sharing information online has a greater impact on their psychological wellbeing. The pandemic has changed the way people interact socially. In this study, particular attention is paid to how trust is created and negotiated in online interactions. In a post-pandemic world

where multiple risks coexist, trust promotes social interaction and shared vision as well as online self-disclosure (Niu and Meng, 2019; Li et al., 2022). While working from home, many people maintain interpersonal relationships both at work and within the family by self-disclosure online. In other words, they actively display and share information with others *via* social media platforms. The information could be text, image, audio, video, or geographic location. Some studies have demonstrated that social media are indeed effective and efficient in promoting the quality of friendship by assisting students to build on existing relationships and make new friends during crisis periods, such as during the COVID-19 pandemic lockdown (Chen, 2015; Wen et al., 2016; Amosun et al., 2021). Therefore, digital interactions supported by trust in the context of globalized risk should be one of the focuses of research in computer-mediated communication.

Self-disclosure refers to the voluntary and active self-information-sharing behavior of an individual (Wheeless and Grotz, 1976). It is a decision made by someone after comprehensively weighing potential benefits and risks, and it is influenced by several factors including social environment, psychological attachment, and personality traits (Binder et al., 2009). Self-disclosure is an important step for social media users in constructing their online identity and developing interpersonal relationships. However, the nature of the Internet makes the information disclosed by users to be shared with the world in real time (Lenhart and Madden, 2007), which leads to the risk of personal information misappropriation and abuse. Many researchers have explored the factors that affect the self-disclosure of social media users. Generally speaking, such factors can be categorized into five kinds: (i) Cost, that is, the perceived risk of self-disclosure, privacy value, etc. (Xu et al., 2013); (ii) Benefit: satisfying the motivation for entertainment, getting pleasure, etc. (Culnan, 2001); (iii) Personality: personality traits, etc. (Huang, 2016); (iv) Platform: function, incentive mechanism, etc. (Van Gool et al., 2015); and (v). Environment: cultural atmosphere, etc. (Posey et al., 2010). However, the research results in this field are relatively sparse.

Significant research attention has been paid to the impact of perceived risk of privacy and risk-benefit perception on self-disclosure on the Internet (Krasnova et al., 2010; Lu, 2019; Niu and Meng, 2019; Zhang and Li, 2019). In this study, close attention is paid to the influence of personality traits (introverted and extroverted personality) on self-disclosure behavior. The complexity of self-disclosure requires mixed research methods, but few empirical conclusions can be referred to. Most research have taken interpersonal trust on social network and perceived risk as mediators for model construction (Niu and Meng, 2019; Zhang and Li, 2019), whereas a few studies have considered the impact of users' self-disclosure on online identity construction and interpersonal relationship.

To sum up, this study explored the influence of personality traits on self-disclosure and focused on the relationship between the degree of authenticity in self-disclosure and the impact of personality traits on the depth of self-disclosure. The relationship between multiple variables was analyzed through mixed research methods. According to interpersonal relationship on social media and online identity construction, the study further explored the relationship among self-presentation, self-disclosure, perceived risk of privacy, and perceived value.

Literature review

Personality traits and the depth of self-disclosure

Individual behavior is influenced by personality traits. Early research on personality traits focused on vocabulary (Fiske, 1949; Norman, 1963; Tupes and Christal, 1992), which classified personality types through semantic interpretation and analysis. To measure personality traits of different individuals in a more convenient way, Zuckerman et al. (1993) designed the *Zuckerman's Personality Questionnaire* in 1994, which measured individuals' personality traits according to five factors. McCrae and Costa (1997) summarized five traits of individuals, namely, neuroticism, extraversion, openness, agreeableness, and conscientiousness. These five traits constituted the five-factor model of personality. Neuroticism is mainly manifested in the privacy anxiety of social media users during self-disclosure. Extraversion is related to social media users' social skills, self-confidence, and positive emotions. Agreeableness is related to social media users' trust and altruism during self-disclosure. Openness refers to the complexity and depth of the spiritual and experiential life of social media users. Conscientiousness is related to information control and the reliability of social media service providers (Wang et al., 2012).

Self-disclosure of social media users is affected mainly by extroversion and openness (Aharony, 2013). Rosengren (1974) argues that individual differences such as age, gender, and personality could affect people's use of mass media. Correa et al. (2010) examined the relationship between social media use and users' personality and found that people who were outgoing, emotionally stable, and open-minded tended to use the social media more frequently. In a study on the relationship between Facebook use and personality traits, Ross et al. (2009) found personality traits to be linked to several functions and motivations and extroverted people to be more likely to join Facebook groups. According to path analysis, Hollenbaugh and Ferris (2014) and Chen et al. (2016) found that extroverted people disclosed more accurate personal information. In an Australian study, Ryan and Xenos (2011) found that Facebook users were more likely to have extroverted and narcissistic personalities. Personality traits theory is widely adopted in behavioral and social sciences research. For example,

investigating the influence of personality traits of employees could be helpful in allocating suitable jobs, reducing unsafe and insecure behaviors, improving personnel arrangements for important positions and positions prone to safety accidents, and complementing work performance management strategies (Amabile, 1983; George and Zhou, 2001).

This study aims to demonstrate that posting certain content on social media is self-disclosure behavior driven by personal will, and that different personality traits will affect the self-disclosure behavior of online social media users. Therefore, Hypothesis 1 is stated as follows:

H1-1: The depth of self-disclosure of online users with extroverted personality is significantly higher than that of users with introverted personality.

Mediating effects of perceived usefulness, perceived hedonism, and perceived value

The concept of perceived value was initially applied in the fields of management and marketing. The function and utility experienced by customers in the process of consumption were termed as customer perceived value. Scholars have developed a scale of perceived value to study customer purchasing behavior and customer purchasing evaluation, reflecting the relationship between customers and merchandise (Zeithaml, 1988; Oliver and Swan, 1989; Sheth et al., 1991; Kantamneni and Coulson, 1996; Sweeney and Soutar, 2001). With the continuous development and maturity of social media, the functions of social media, such as posting comments and sending bullet screen comments, have changed the relationship between audiences and media from that of unidirectional communication to bidirectional interaction. The role of users has also changed from being passive audiences to being active participants. As can be seen, the relationship between the audience and social media has a common point with the relationship between customers and merchandise, since both audience and customers can actively choose suitable products, leading to interpreting perceived value of media from the perspective of communication (Zhang et al., 2021). The Measuring Perceived Value Scale (MPV Scale) was developed according to the perceived value of media, dividing perceived value into five factors: emotion and social status value (EMO), entertainment value (ENT), social networking value (INT), organizational communication value (ORG), and information value (INS).

Overall, research on the perceived value of media has two strands. The first involves taking the perceived value of media as an independent variable to explore its impact on factors such as media use, satisfaction, and privacy disclosure. Perceived usefulness was found to positively affect the willingness to disclose personal information (Hunt et al., 2012; Nie and Luo, 2013). Valkenburg and Peter (2007) found that 32% of the socially anxious adolescents in their study perceived online communication as more valuable for intimately self-disclosing about a wide variety of topics than doing so offline. Krasnova et al. (2010) pointed out that the main motivation for users to disclose personal information was to maintain and develop interpersonal relationships and be entertained. Users who attempted to develop and expand interpersonal relationships were more likely to post sensitive personal information on social media (Nosko et al., 2010). Oliver (2014) regards perceived hedonism as an additional psychological need of users. The hedonic value experienced by users is positively associated with users' satisfaction with social media applications. Applications based on image processing provide millions of special effects, filters, and stickers to enhance the beautification of images. Such functions not only satisfied users' perceived hedonism but also improved their satisfaction with the applications and services.

The second research strand involves exploring the composition of the perceived value of media. Scholars have developed different scales (based on extensive research) related to the perceived value of media, which have been widely used in communication and sociology research. Hirschman and Holbrook (1982) propose that perceived value not only includes utilitarian value (the balance between perceived gains and losses) but also includes symbolic, hedonic, and esthetic values. Holbrook (1999) further classifies perceived value into interaction, experience, and preference values according to three distinct dimensions, namely, the essence, orientation, and motivation of value. Li (2017) studied the customer behavior of e-book purchasers through four factors: emotional value, social value, price value, and quality value. Zhu et al. (2019) explain why audiences were addicted to short videos using four factors: social value, content value, interactive value, and entertainment values. Currently, the most widely adopted perceived value scale is composed of five factors: perceived usefulness, perceived hedonism, perceived ease of use, privacy risk, and perceived value.

In this study, it is proposed that using social media satisfies the requirements of users in the different dimensions, which affects the perceived value of social media. Therefore, with reference to the uses and gratifications theory, as well as the influence of perceived usefulness, perceived hedonism, and perceived value on self-disclosure, the following hypotheses are proposed:

H2-1: Extroverted personality affects perceived usefulness, which in turn affects the depth of self-disclosure.
H2-2: Extroverted personality affects perceived hedonism, which in turn affects the depth of self-disclosure.
H2-3: Extroverted personality affects perceived value, which in turn affects the depth of self-disclosure.

Moderating effect of the degree of authenticity in self-presentation

The theory of self-presentation was first proposed by sociologist Goffman (1959) according to symbolic interactionism. Goffman (1959) suggested that life was like a stage, and that self-presentation was a performance on that stage. Self-presentation is defined as the goal-directed activity of controlling information to influence the impressions formed by an audience about the self (Schlenker and Wowra, 2003). When social media users edit personal data on social media platforms to construct virtual identities for online dialogue, personal data become a key tool for users to present themselves (Joinson, 2008). In cyberspace, the virtual and anonymous nature of identity offers users a certain space and freedom to edit their personal data. Users could do "selective exposure" by editing personal data, publishing media content, and conducting online conversations to improve their identity construction. Goffman (1956) conceptualize identity as an ongoing self-disclosure, arguing that the construction of identity was a process of "impression management" in which people habitually monitored audience feedback.

Hogan (2010) extended Goffman's dramaturgy theory, showing that the presentation of self in the age of social media was a continuous process, accompanied by the display of various exhibits (such as photos and short videos in WeChat Moments). Consequently, the construction of a user's identity has evolved from real-time improvisational performances to permanent online exhibitions, with social media accounts serving as exhibition halls for image-making practices of smartphone users (Carah, 2014). The content is preserved for longer periods and has greater impact on the user's personal image. Therefore, users tend to present improved images of themselves online. Some research works (Papacharissi, 2010; Guo and Yang, 2020) have demonstrated that "photoshopped" pictures used on social media conformed to the traditional concept of impression management.

In general, self-disclosure on social media is decorative. Users can create various "personalities" according to different requirements and can thus build several "virtual selves." From this, we propose the core difference between self-presentation and self-disclosure thus: self-presentation can be decorative, whereas self-disclosure is based on truth, and self-disclosed information is more in line with people's real-life situations. However, self-disclosure and self-presentation are not mutually exclusive (Schlosser, 2020); both contribute to identity construction on social media platforms. This paper therefore adapts the construction of the Self-Disclosure Scale to accommodate the current situation of multimedia technology use and the prevalence of cosmetically modified and technically enhanced social performances.

In self-discrepancy theory, it is held that it is difficult for users to fully realize or express the ideal self, ought self, and actual self in the real world (Higgins, 1987). To meet various needs (such as hobby discovery, work requirements, and social networking), users' self-disclosure on social media is often accompanied by personality expression and identity construction at different levels (Seidman, 2014). Owing to the existence of such self-discrepancy, people are more willing to present or express the ideal self and ought self on social media. Such self-disclosure not only improves the efficiency of personal image management of users but also accelerates the self-beautification tendency of self-disclosure on social media. In a study of the relationship between self-disclosure strategies on the social media platforms of police officers and the satisfaction of the public, Wang et al. (2020) found a significant positive correlation between police officers' positive self-disclosure and positive emotions expressed by their clients on social media. Previous research has shown that moderate-extroverted users are more willing to present themselves than over-extroverted users (Bao, 2013). Nonetheless, extroverted users are more willing to post carefully beautified photos with unique styles (Krämer and Winter, 2008). Thus, although social media provides new channels and ways for users to present themselves, users' self-disclosure is not 100% free from constraints.

Self-disclosure acts are often subject to assessments of authenticity (Schlenker, 1975; Buss and Briggs, 1984; Tesser and Moore, 1986; Leary, 1993); if we reveal only our desirable qualities, we are showing only a very narrow "sample" of our true selves (Jiang et al., 2020). Such selective disclosure will affect the audience's trust in the content disclosed by users. Especially in the context of global risks, where most of people's production and life behaviors are exhibited online, online trust is particularly significant. The degree of authenticity in self-disclosure has an impact on the self-disclosure of social media users, and the exact degree is determined by numerous factors, such as users' real identity, vocation, and personality traits. Nevertheless, in the virtual world constructed on social media, external constraints are reduced. Users are able to publish social media content based purely on their own preferences, emotions, and value judgments, which creates a large gap between identity construction in the real world and that in the virtual world. Studies have shown that in a quasi-social interaction environment, intimate self-disclosure behavior can more realistically reflect users' daily lives; thus, a high degree of authenticity of a user's self-disclosure helps the audience to accept the information disclosed by the user (Nah, 2022).

While most scholars have focused on exploring the different factors that affect self-disclosure, little attention has been paid to the fact that the degree of authenticity in self-disclosure may interact with, or otherwise moderate, empirical research results. The effect of the truthful presence on self-disclosure has not received significant research attention. Accordingly, this study aims to show that in the context of post-pandemic global risks, the variable of authenticity cannot be ignored because online trust is an important factor in promoting the

return of benign communication between social individuals and groups. Therefore, the degree of authenticity in self-disclosure has been introduced into this study as a moderator variable, and Hypothesis H3-1 is proposed as follows:

> **H3-1**: Personality traits have an impact on the depth of self-disclosure, but this effect is positive when the degree of authenticity in self-disclosure is stronger, and vice versa.

Perceived risk is an important factor affecting users' self-disclosure on social media. It refers to people's perception of potential losses they might encounter when chasing ideal results (Featherman and Pavlou, 2003). Derlega and Chaikin (1977) re-conceptualized self-disclosure as a form of boundary adjustment in the maintenance of privacy. Privacy breaches have also been cited as one of the reasons for the reduced willingness to self-disclose (Xu et al., 2013; Green et al., 2016). The traditional sense of Internet privacy perception refers to users' perceptions of the possibility that Internet service providers would protect their personal confidential information from improper use or disclosure (Kim et al., 2008). Many quantitative studies have shown that there is no significant correlation between perceived online privacy risk and self-disclosure (Taddei and Contena, 2013; Niu and Meng, 2019).

"Privacy paradox," as proposed by Barnes (2006) in 2006, holds that people do not realize the public nature of the Internet. On the one hand, they worry about the invasion of privacy. On the other hand, they disclose personal information actively. Bazarova (2012) proposed another explanation: even if people knew that self-disclosure had privacy risks, they would still share selective personal information in order to establish and maintain an intimate relationship on the Internet. The privacy paradox, that is, the dichotomy between how a person intends to protect their online privacy vs. how they actually behave online (and how they do not protect their information online), has necessitated scholars to explore the factors that affect the personal expression and self-disclosure of social media users. The research results illustrate two influences: positive promotion and negative inhibition. Some studies have demonstrated that trust can promote users' self-disclosure. Users would be more willing to disclose personal information if they had a higher degree of trust in social media (Chen, 2010; Colomo et al., 2010; Lo and Riemenschneider, 2010; Salleh et al., 2011). Accordingly, a higher degree of trust in social media would contribute to in-depth self-disclosure by users (Niu and Meng, 2019). In contrast, in a study on personal privacy and security of college students' use of social media, Zhang and Li (2019) found that college students' perceived risk of social media (such as the belief that publishing information on social networking sites is unsafe, and that the published information may lead to the threat of privacy leakage) would inhibit the degree of self-disclosure on social media.

The Chinese consider interpersonal relationships to be very important (Chan, 2006; Buckley et al., 2010). Therefore, the contradictions of the privacy paradox are even more significant. The Chinese are concerned about the risks associated with sharing information on social media. Yet, social media have become instrumental to their personal and professional wellbeing (Huang and Miao, 2020). This study aims to show that there are many privacy factors that affect people's self-disclosure behavior, including the balance between risk and return, personality, psychological state, and position. However, the nature of the correlation remains unclear, given the possible mediating effects of different factors. Considering this, this study raises the following hypotheses:

> **H4-1**: There are different factors that motivate users' expressions and sharing on Weibo.
> **H4-2**: There are different factors that inhibit users' expressions and sharing on Weibo.

Previous studies have found that a number of factors influence users' willingness to self-disclose on social networking sites, ranging from personality traits and interpersonal trust, to perceived social benefits and privacy risks (Abramova et al., 2017). These antecedents provide evidence for the complex nature of self-disclosure and the need for further research in this field.

According to the above discussion, Figure 1 illustrates the research model of the study.

Methodology

Respondents and sampling methods

Quantitative research methods were chosen according to the systematic and comparative analysis of the literature about the reciprocal relations among personality, perceived value, and self-disclosure. The quota for sampling was designed according to the 48th Statistical Reports on Internet Development in China released by China Internet Network Information Center, as well as the demographic statistics of China released by the National Bureau of Statistics at the end of 2020. The dimensions of quota sampling used were gender, age, region, educational level, monthly income, and place of residence. For gender, the male-to-female ratio was 5.5:4.5. For age, the bands were 19 years old and below, 20–29 years old, 30–39 years old, and 40 years old and above; the ratios of these four age groups were 1.8:2.7:2.5:3. Four regions were identified: east, central, west, and northeast; the ratios of these four regions were 3.8:2.7:2.7:0.8. Three educational levels were identified: high school and below, junior college, and undergraduate and above, with the ratios being 8:1.1:0.9. Four monthly income segments were identified as follows: below 3,000 yuan, 3,001–5,000 yuan, 5,001–8,000 yuan, and above 8,001 yuan; the ratios of these four income groups were 5.1:2:1.4:1.5. Four kinds of place of residence were identified: prefecture-level city, county-level city, township, and

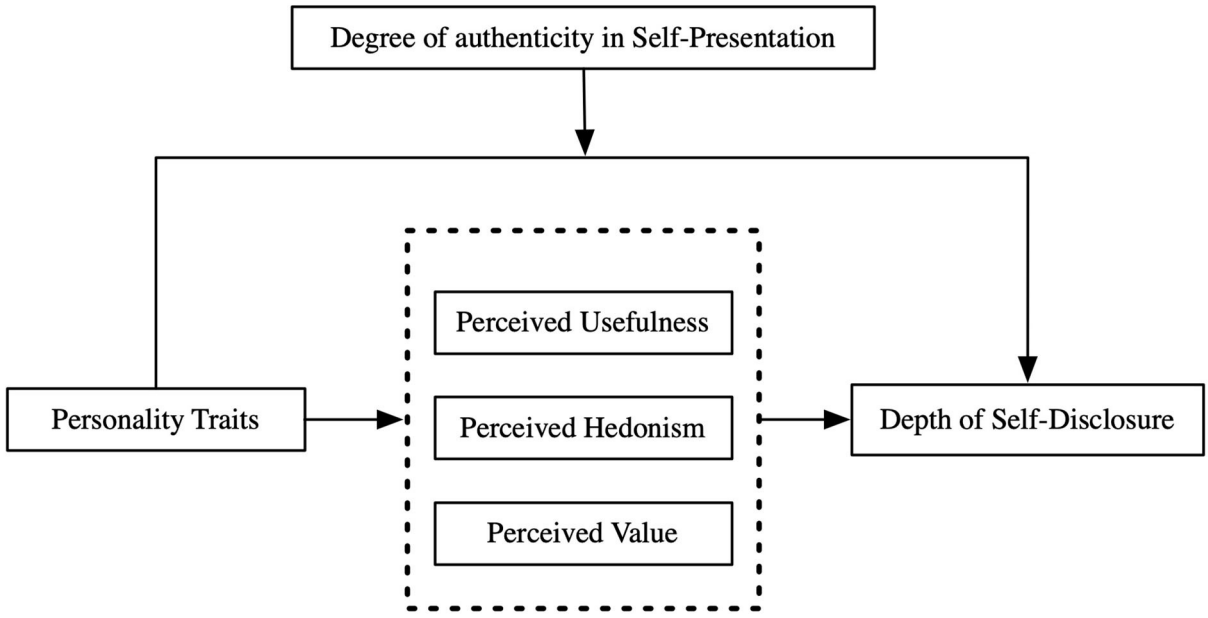

FIGURE 1
The research model.

countryside, with the ratios of these four places of residence being 4.9:4.1:0.5:0.5.

Questionnaire design

The questionnaire contained three scales that are widely regarded as mature scale by most researchers, namely, Personality Traits, Perceived Value of Media, and Depth of Self-Disclosure. Question design for the independent variable: personality traits relied mainly on the *Eysenck Personality Questionnaire-Revised, Short-Scale for Chinese* (EPQ-RSC), which was revised by Qian et al. (2000) in 2000. It has been verified to be reliable and valid; it also meets the requirements of psychometrics and is suitable for Chinese respondents. The overall scale is divided into four subscales, among which is the Extroversion Scale (E), which is used to distinguish between extroverted and introverted personalities. Thus, the variable "personality traits" is binary. According to the scoring of the questions, respondents who score 8 points or more are assigned to the extroverted personality category, while those who score $<$ 8 are assigned to the introverted personality category.

The Scale of Perceived Value of Media was adapted from the Perceived Value Scale (Voss et al., 2003; Kim et al., 2007; Deng et al., 2021), which lists three factors: perceived usefulness, perceived hedonism, and perceived value. Perceived usefulness was measured by asking the degree of agreement with statements like "Posting original posts on Weibo is valuable to me," "Posting original posts on Weibo helps me solve health problems," and "Posting original posts on Weibo helps me accumulate social connections" (adapted from Deng et al., 2021). Perceived hedonism was measured by asking the degree of agreement with statements like "I enjoy the process of posting original posts on Weibo," "Posting original posts on Weibo makes me happy," and "Posting original posts on Weibo is very interesting" (adapted from Voss et al., 2003). Perceived value was measured by asking the degree of agreement with statements like "Posting updates on Weibo is beneficial to me compared with the required effort," "Posting updates on Weibo is worthwhile compared with the required time and effort," and "Sharing my life on Weibo is meaningful for me despite privacy risk" (adapted from Kim et al., 2007). As WeChat has more than 1.2 billion monthly active users in China, it is recognized as an infrastructure-based platform with a low threshold for usage skills. Therefore, we eliminated the "perceived ease of use" from the original scale, since Weibo is intended to be an easy-to-use platform designed for the popularization of new technologies and design. Subsequent sections were designed to separately measure how the three sub-dimensions played mediating roles in the relationship between personality traits and the depth of self-disclosure. The final section of the questionnaire was designed to measure the degree of authenticity in self-disclosure. With self-assessment questions, this final part focused on the gap between the online persona and the real person of the respondents.

Finally, we paid close attention to optimizing the scale of self-disclosure. Currently, the measurement of self-disclosure in

TABLE 1 Descriptive statistical analysis of sample structure ($N = 1,075$).

		Frequency	Percentage	Cumulative percentage
Gender	Male	662	61.58	61.58
	Female	413	38.42	100.00
Age	24 years old and below	390	36.28	36.28
	25–34 years old	553	51.44	87.72
	35–44 years old	96	8.93	96.65
	45 years old and above	36	3.35	100.0
Education	Primary school and below	17	1.58	1.58
	Junior high school	67	6.23	7.81
	Senior high school; technical secondary school; vocational/occupational training school	235	21.86	29.67
	Junior college	273	25.40	55.07
	Undergraduate	436	40.56	95.63
	Master and above	47	4.37	100.0
Place of residence	Prefecture-level city	532	49.49	49.49
	County-level city	439	40.84	90.33
	Township	69	6.42	96.75
	Countryside	35	3.26	100.0
Total		1,075	100.0%	100.0%

the research mainly focuses on three aspects: depth, breadth, and quantity (Posey et al., 2010; Huang, 2016). Considering the access to multimedia technologies on social media, this study included options on forms of sharing to measure the depth of self-disclosure (video > image > text).

The full version of the questionnaire is available online at https://www.frontiersin.org/articles/10.3389/fpsyg.2022.958991/full#supplementary-material.

To ensure the reliability of the revised scale, a pilot test was conducted with 26 users. The statistical results of the pilot showed that the revised scale was reliable and valid, and thus could be used for the research.

Data collection

The questionnaire was made available online between July 30 and August 15, 2021. A total of 1,196 responses were collected. The average time to fill in the questionnaire was about 3 min. Three types of invalid responses were excluded: if the questionnaire was completed in <60 s (1 min), if the questionnaire was completed in more than 1,000 s (16.67 min), and where there were inconsistent responses. After exclusion, the number of valid questionnaires was 1,075 (refer Table 1).

The effective recovery rate was 89%, and the effective sample details in the dataset can be accessed *via* URL https://www.frontiersin.org/articles/10.3389/fpsyg.2022.958991/full#supplementary-material.

The majority of the respondents were male (61.58%) (female: 38.42%); ages below 34 accounted for 87.72% of all respondents. Undergraduates accounted for 40.56% of the total sample size. In terms of place of residence, most respondents came from prefecture-level (49.49%) and county-level (40.84%) cities. The difference between the final sample and the sampling target (actual target) was between plus or minus 0.1–7%. Therefore, the final sample was representative and could reflect the overall situation and trend of the Chinese population of Internet users.

Data analysis

SPSS 26.0 was used for the statistical analysis. More precisely, the data were analyzed using descriptive statistical means; normality tests of the collected data were carried out, and the reliability and validity of the scales were tested. Considering multiple responses, significant differences were detected between factors that motivate users to express and share their lives on Weibo and those that inhibit them from doing so. Spearman's rank correlation analysis was used to calculate the relationship between the different variables. Moderating effect analysis was conducted to measure the moderating effect of the variable, the degree of authenticity in presentation, on both personality traits and the depth of self-disclosure. The plug-in function of SPSS 26.0, Process, was used to test the mediating effects of the mediating variables, namely, perceived usefulness, perceived hedonism, and perceived value. The test level was $\alpha = 0.05$, and $p < 0.05$ was considered statistically significant.

Research results

Descriptive statistical analysis

Among the many methods of self-presentation on the Internet, sharing hobbies, book lists and movie reviews, and professional and industrial knowledge were the commonest, with 446 (15.1%), 443 (15.0%), and 413 (14.0%) users, respectively. In comparison, only 50 users (1.7%) shared their emotions and insights. The differences in self-presentation online were statistically significant ($\chi^2 = 624.68$, df = 9, $p < 0.001$).

"To manage one's social relations (500 respondents, 46.5%)" and "to facilitate one's work (500 respondents, 46.5%)" were the two main factors that motivated online sharing behavior. In contrast, only 50 persons (1.7%) shared their emotions and insights, making it a relatively insignificant factor. The motivation of the self-disclosure behavior of respondents was statistically significant ($\chi^2 = 451.86$, df = 7, $p < 0.001$), which establishes Hypothesis H4-1.

Among the factors that inhibit sharing (refer Table 2), "worry about the pressure from public opinion (482 respondents)," "worry about the pressure from social relations (460 respondents)," and "worry about privacy leak (460 respondents)" were the three most important. In contrast, only 76 respondents (2.8%) believed that sharing frequently online was naive. Factors that inhibit sharing were statistically significant ($\chi^2 = 483.95$, df = 7, $p < 0.001$), which establishes Hypothesis H4-2.

TABLE 2 Factors that inhibit sharing ($N = 1,075$).

Factors that inhibit sharing	Responses		Percentage of individual cases
	N	Percentage	
Worry about privacy leak	460	16.8%	42.8%
Less feedback from friends	418	15.3%	38.9%
Worry about the pressure from public opinions	482	17.6%	44.8%
Worry about the pressure from social relations	460	16.8%	42.8%
Lack of interesting topic	384	14.1%	35.7%
Lack the desire to share	304	11.1%	28.3%
The frequency of using social media is low	147	5.4%	13.7%
Sharing too frequently online is naive	76	2.8%	7.1%
Total	2,731	100.0%	254.0%

Tests of normality, reliability, and validity

Test of normality

The result of the normality test is presented in Table 3. According to West et al. (1995) and Kim (2013), when the absolute value of skewness was <2 and the absolute value of kurtosis (−3) was <7, the data could be considered approximately normally distributed. All the above variables conformed to a normal distribution.

Test of reliability and validity

Reliability is tested by comparing the results produced when repeatedly measuring the same object with the same methods. The reliability coefficient was positively correlated with the consistency of the results, and thus established the validity and stability. Additionally, this study tested the scales in the questionnaire through construct validity. Maximum rotation of variance was adopted to test the collected data.

Table 4 shows that the result of Cronbach's Alpha test was 0.967 (>0.8), reflecting that the results of this study are reliable. The results of Cronbach's Alpha test of perceived usefulness, perceived hedonism, perceived value, the degree of authenticity in self-presentation, and the depth of self-disclosure were above 0.8, indicating a high degree of reliability. In other words, all the variables in the questionnaire passed the reliability test. (The personality trait was a binary variable for which no test was needed.) Table 5

TABLE 3 A description of the normality of statistics ($N = 1,075$).

	Mean	Standard deviation	Skewness		Kurtosis	
			Statistic	Standard error	Statistic	Standard error
Perceived usefulness	4.0258	0.80297	−0.832	0.075	0.835	0.149
Perceived hedonism	4.0016	0.83559	−0.908	0.075	1.073	0.149
Perceived value	3.9953	0.84347	−0.997	0.075	1.298	0.149
The depth of self-exposure	3.9326	0.78426	−0.650	0.075	0.524	0.149
The degree of authenticity in self-presentation	4.0685	0.80293	−0.818	0.075	0.591	0.149

shows the KMO value was 0.981 (>0.8) and presents the results of the Bartlett test of sphericity ($p = 0.000 < 0.05$). In other words, the validity of the research data was also established.

Correlation analysis

When dealing with quantitative data, correlation analysis is a widely accepted statistical method for studying the relationships among variables. It is useful in determining whether a relationship exists among variables, and if so, to what degree. This study adopted the Spearman rank correlation analysis (refer Table 6 for details).

TABLE 4 Result of Cronbach's alpha test.

Variable	Cronbach's alpha	Number of items
Perceived usefulness	0.875	4
Perceived hedonism	0.845	3
Perceived value	0.849	3
The degree of authenticity in self-presentation	0.861	3
The depth of self-disclosure	0.917	8
Total	0.967	21

TABLE 5 KMO and Bartlett test.

Kaiser-Meyer-Olkin measure of sampling adequacy		0.981
Bartlett test of sphericity	Approximate Chi-Square	17,466.476
	Approximate Chi-Square	210
	df	
	Sig.	0.000

Table 6 shows that perceived usefulness, perceived hedonism, perceived value, the degree of authenticity in self-presentation, and the depth of self-disclosure are all significant factors in online self-disclosure, with the correlation coefficient values being 0.824, 0.809, 0.817, and 0.827, respectively, and the correlation coefficient values being >0. This indicates that the depth of self-disclosure and perceived usefulness ($r = 0.824$, $p < 0.01$), perceived hedonism ($r = 0.809$, $p < 0.01$), perceived value ($r = 0.817$, $p < 0.01$), and the degree of authenticity in self-presentation ($r = 0.827$, $p < 0.01$) are all positively correlated. The significance was at a confidence level of 0.01.

T-test of independent and dependent variables

To conduct the *t*-test, this study conceptualized the independent variable personality trait as a binary variable (extroverted and introverted personalities), and the dependent variable depth of self-disclosure as a continuous variable. The test results are presented in Table 7.

Shapiro–Wilk Normality Test was used to test the normality of the depth of self-disclosure (grouped by extroverted and introverted personalities). The results showed that the depth of self-disclosure was normally distributed in both groups, which was consistent with the *t*-test requirements. The homogeneity of variance test showed that the variances of the two groups of data were equal ($F = 0.316, p = 0.574 > 0.05$), and the *t*-test result was $t_{(df)} = 9.93$ (1,073), $p = 0.000 < 0.05$ (refer Table 8). Therefore, the depth of self-disclosure for both the extroverted personality (4.06 ± 0.74) and the introverted personality (3.53 ± 0.79) was statistically significant. However, the depth of self-disclosure of extroverted personality was significantly higher than that of introverted personality, establishing Hypothesis H1-1.

Test of moderating effect

The test of moderating effect was performed to determine whether the degree of authenticity in self-presentation, as the

TABLE 6 Spearman rank correlation analysis on the variables.

Correlation analysis	Perceived usefulness	Perceived hedonism	Perceived value	The degree of authenticity in self-presentation	The depth of self-disclosure
Perceived usefulness	1				
Perceived hedonism	0.869**	1			
Perceived value	0.829**	0.848**	1		
The degree of authenticity in self-presentation	0.798**	0.769**	0.777**	1	
The depth of self-disclosure	0.824**	0.809**	0.817**	0.827**	1

The correlation was significant at a confidence level of 0.01 (two-tailed test). **$p < 0.01$.

TABLE 7 Group statistics of different personality traits.

	Personality traits	N	Mean	Standard deviation	Standard error of mean
The depth of self-disclosure	Extroverted personality (scored 8 or higher)	813	4.0617	0.7376	0.0259
	Introverted personality (scored lower than 8)	262	3.5320	0.7909	0.0489

TABLE 8 *T*-test of independent samples.

		Levene test of the variance equation		*T*-test of the mean equation				
		F	Sig.	t	df	Sig.	The mean difference	Standard error difference
The depth of self-disclosure	Assuming that variations are equal	0.316	0.574	9.93	1,073	0.000***	0.5297	0.0533
	Assuming that variations are not equal			9.58	417.238	0.000***	0.5297	0.05530

Two-tailed test, *** <0.001.

moderating variable, affected the relationship between the independent variable (personality traits) and the dependent variable (the depth of self-disclosure) under different circumstances. Pre-processing of data is required before undertaking a moderating effect analysis. This study adopted the centralized processing method. The mean values of the variables of each group were first calculated. Then, the values of the variables of each group were deducted from the mean value of the group to get the desired values. Finally, the desired values were multiplied to sort out the interaction terms of each variable to observe the changes in the *P*-value and the R-squared.

Table 9 presents the moderating effect of using two models. Model 1 included the independent variable (personality trait) and the moderating variable (the degree of authenticity in self-presentation). In Model 2, the interaction terms were inserted between the independent variable and moderator variable according to Model 1. The purpose of Model 1 was to study the influence of the independent variable (personality traits) on the dependent variable (the depth of self-disclosure) without considering the interference of the moderating variable (the degree of authenticity in self-presentation). The results from Model 2 showed that the interaction between personality traits and the depth of self-disclosure was significant ($t = 3.352$, $p = 0.001 < 0.05$). The results demonstrate that the influence of personality traits on the depth of self-disclosure was significantly moderated by the moderating variable, the degree of authenticity in self-presentation.

Taking personality traits as independent variables, the depth of self-disclosure as a dependent variable, and the degree of authenticity in self-presentation as the moderator variable, the moderating effect analysis showed that the degree of authenticity in self-presentation had a positive moderating effect on personality traits ($b = 0.126$, $p < 0.01$, $\Delta R2 = 0.003$). When the degree of authenticity in self-presentation was high, personality traits had a strong positive impact on the depth of self-disclosure; when the degree of authenticity in self-presentation was low, personality traits still had a strong positive effect on the depth of self-disclosure, though the effect was smaller. These results confirmed Hypothesis H3-1.

Test of mediating effect

Drawing on the test of mediating effect proposed by Preacher and Hayes (2008), the plug-in function of SPSS 26.0, Model 5, was used, where personality traits were taken as independent variables (introverted personality was used as the control group for reference), the depth of self-disclosure was taken as the dependent variable, and perceived usefulness, perceived hedonism, and perceived value were taken as mediating variables. The results in Table 11 were obtained *via* 5,000 samplings (at a 95% confidence interval).

As Table 10 shows, extroverted personality (SE = 0.0284, at 95% confidence interval: [0.0309, 0.1417]) had a significant indirect effect on the depth of self-disclosure through perceived usefulness. Extroverted personality (SE = 0.0335, 95% confidence interval: [0.0414, 0.1718]) had a significant indirect effect on the depth of self-disclosure through perceived

TABLE 9 Moderating effect of the degree of authenticity in self-presentation ($N = 1,075$).

	Model 1				Model 2			
	B	Se	*t*	*p*	B	Se	*t*	*p*
Constant	3.933	0.013	295.747	0.000**	3.921	0.014	286.394	0.000**
Personality trait	0.129	0.032	4.024	0.000**	0.159	0.033	4.785	0.000**
The degree of authenticity in self-presentation	0.791	0.017	45.945	0.000**	0.797	0.017	46.250	0.000**
Personality trait × the degree of authenticity in self-presentation					0.126	0.038	3.352	0.001**
R^2	0.691				0.694			

Dependent variable: the depth of self-disclosure, se: standard error, $^{**}p < 0.01$.

TABLE 10 Test of mediating effect (taking introverted personality as the control group for reference).

Mediating path	Boot SE	Effect	95% BootLLCI-BootULCI	Conclusion
Extroverted personality – perceived usefulness – the depth of self-disclosure	0.0284	0.0820	[0.0309, 0.1417]	Significant
Extroverted personality – perceived hedonism – the depth of self-disclosure	0.0335	0.1040	[0.0414, 0.1718]	Significant
Extroverted personality – perceived value – the depth of self-disclosure	0.0274	0.1067	[0.0569, 0.1644]	Significant

BootLLCI refers to the lower limit of the 95% interval of the Bootstrap sampling, and BootULCI refers to the upper limit of the 95% interval of the Bootstrap sampling. The 95% confidence interval of the mediation effect (ind_eff) was obtained *via* the bootstrap method. The statistical results are insignificant if the confidence interval contains 0 (the upper and lower limits of the interval have contrary signs). Otherwise, statistical results are significant.

hedonism. Extroverted personality (SE = 0.0274, 95% confidence interval: [0.0569, 0.1644]) had a significant indirect effect on the depth of self-disclosure through perceived value. In other words, perceived usefulness, perceived hedonism, and perceived value have mediating effects between personality traits and the depth of self-disclosure. Therefore, Hypotheses H2-1, H2-2, and H2-3 are established.

Conclusions and discussions

The COVID-19 pandemic has had an impact on people of all ages and "is giving us all a generational experience, debunking the fragility of our stable existence" (Fiedler, 2020). People with different personalities faced more complex and frequent online communication. By combining the influences of personality, perceived value, and authentic degree, this study provides an integrative framework for understanding the mechanisms behind self-disclosure behavior, providing reference for online management of companies and personal online presence. The results of the tests of hypotheses are presented in Table 11.

First, this study confirms a positive correlation between extroverted personality and perceived value of media, as well as a positive correlation between extroverted personality and social media self-disclosure. It further establishes the moderating effect of the degree of authenticity in self-presentation on the relationship between personality traits and self-disclosure. In general, extroverted users are more likely to recognize the usefulness, hedonism, and the accumulated value of social capital while using social media. Consequently, these users tend to display deeper, wider, and more frequent self-disclosure behavior to communicate on social media.

Second, the degree of authenticity in self-presentation, which exhibits users' subjective cognition, exerts an influence on the correlation between personality traits and self-disclosure. When the degree of authenticity in self-presentation is high, the correlation will be positive, whereas when the degree of authenticity in self-presentation is low, the correlation will be negative. In contemporary society, self-beautification for self-disclosure on social media has been confirmed by numerous studies (Boyle and Johnson, 2010; Papacharissi, 2010; Qiu, 2021). Briefly, such behavior has penetrated daily contexts. Users will edit and beautify their posts on social media to different degrees (Papacharissi, 2010). They consciously and selectively display good moral qualities, insightful attitudes, and good-looking bodies when posting short videos (Qiu, 2021).

Users who are eager to communicate and want to establish serious relationships tend to show their most perfect selves on social media (Boyle and Johnson, 2010). Therefore, extroverted users equate authentic self-presentation with deep disclosure. They not only pursue deeper and wider self-disclosure, but also exhibit more authentic self-disclosure practices. In other words, they desire that the online image they project will become (closer to) their reality. Authenticity becomes the valuable foundation of all privacy sharing. A low degree of authenticity in self-presentation leaves little room for the growth of self-disclosure.

TABLE 11 Test results of hypotheses.

Research hypothesis	Results
H1-1: The depth of self-disclosure of extroverted personality is significantly higher than that of introverted personality.	Supported
H2-1: Extroverted personality affects perceived usefulness, which in turn affects the depth of self-disclosure.	Supported
H2-2: Extroverted personality affects perceived hedonism, which in turn affects the depth of self-disclosure.	Supported
H2-3: Extroverted personality affects perceived value, which in turn affects the depth of self-disclosure.	Supported
H3-1: Personality traits have an impact on the depth of self-disclosure, but this effect is positive when the degree of authenticity in self-presentation is stronger, and vice versa.	Supported
H4-1: There are differences among the factors that motivate users' expressions and sharing on Weibo.	Supported
H4-2: There are differences among the factors that inhibit users' expressions and sharing on Weibo.	Supported

Studies have shown that the anonymization of the web has created room for identity reinvention; yet, there is no data to show that identity fraud is more prevalent online. On the contrary, some studies have suggested that the anonymity and reduction of associated social risks may make people more honest in online self-disclosure than offline (McKenna, 2000).

The reduction of cues in computer-mediated communication does not take people further away from their real identities, but it sometimes allows them to express themselves more authentically. Because digital platforms have the potential to reshape the ecology of online communication and the new order of information dissemination, one of the improvements should be rethinking the value of authenticity in the online world. One way to improve the quality of people's online communication could be to improve the authenticity of online information, thereby increasing users' trust and perception of social media value. China has now implemented the mandatory display of IP addresses to provide Internet users with more reliable means of identifying creators and sharers of online content. Authentic self-disclosure can enhance the virtual social capital of netizens, promote information exchange and opportunity sharing, and help rebuild the shared vision of society in the post-pandemic world, while trust is an effective factor that improves the willingness of network members to share. As a result, enhancing trust could be considered as the core of any strategy to motivate knowledge sharing on social media.

Third, this study reveals the new trends created by the application of multimedia technology on social media. Audio and video communication forms, such as vlogs, live pictures, and live broadcasts, allow users to share their private life more realistically. As a way of attracting Internet traffic, multimedia content is widely used to shape the personal brands of Internet celebrities and marketing activities of e-commerce companies. As the findings above show, perception value plays a mediating role on the willingness of people to engage in self-disclosure online. Now, with the assistance of complex and rich technical affordances, users are provided with more choices and considerations for online self-disclosure. As there is room for growth in the perceived value enhancement, the online self-disclosure of future users may be more deeply connected to real life.

Furthermore, self-disclosure is closely related to self-presentation, image showcasing, and identity construction. Therefore, one of the innovations of this study is the incorporation of the dimension of identity construction into the self-disclosure scale. In addition to highlighting self-disclosure as a way of gaining support, this study also showed that self-disclosure is an important strategy for managing personal image. Furthermore, this study found that extroverted users were more active in the management and maintenance of personal image on social media, which, accordingly, brought more social capital and greater perceived value of media to these users.

Finally, this study established that the factors that motivate or inhibit users' self-disclosure on Weibo are diverse. Occupation, age, gender, profession, etc. may affect users' judgments and choices. More work is still required in the areas of social media self-disclosure and image management. One limitation of the study is that it did not focus on the proportion and causality of the influencing factors. As the connections between virtual space and real society are becoming increasingly close, future research is required to investigate the influence of other factors, such as socializing, occupational needs, and privacy protection on the degree of self-disclosure of Internet users.

Data availability statement

The datasets presented in this study can be found in online repositories. The names of the repository/repositories and accession number(s) can be found in the article/Supplementary material.

Ethics statement

Ethical review and approval was not required for the study on human participants in accordance with the local

legislation and institutional requirements. Written informed consent from the patients/ participants or patients/participants legal guardian/next of kin was not required to participate in this study in accordance with the national legislation and the institutional requirements.

Author contributions

YL, GF, and XZ contributed to conception and design of the study. GF and YiW collected the questionnaire data and organized the database. XZ and YaW performed the statistical analysis. YL and GF wrote the first draft of the manuscript. XZ, YaW, and YiW wrote the sections of the manuscript. All authors contributed to manuscript revision, read, and approved the submitted version.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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Supplementary material

The Supplementary Material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fpsyg.2022.958991/full#supplementary-material

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Personal network protects, social media harms: Evidence from two surveys during the COVID-19 pandemic

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Background: The classic debate regarding the complex relationships between personal network, social media use, and mental well-being requires renewed examination in the novel context of pandemic-related social isolation.

Data and method: We present two surveys conducted at (i) the earlier months of the pandemic and (ii) the end of large scale social-lockdown measures in the U.S. to explore the social and behavioral antecedents of mental health states relating to social media use. Study 1 tracked the longitudinal changes of personal network, social media use, and anxiety level of a group of individuals (N=147) over a three-month period during the pandemic. Study 2 replicated and extended the theoretical model to a race-representative U.S. adult sample (N=258).

Results: Both studies consistently show that (1) more time on social media worsens anxiety. It also mediates the relationship between personal network size and anxiety. That is, a small personal network predicts more social media use, which is in turn related to increased anxiety. (2) Moreover, the effect of social media use on anxiety is mainly explained by news consumption on social media, rather than non-news related usage. (3) This link's strength is moderated by one's perception of COVID-19 impact, such that news consumption on social media increases anxiety more when the perceived impact is higher.

Conclusion: These results demonstrate communication technologies' increasingly critical and multifaceted role in affecting mental health conditions.

KEYWORDS

anxiety, social networks, social media use, news exposure, COVID-19

Introduction

Associated with the rapid spread of the COVID-19 pandemic is the escalated mental health concerns for the public (Pfefferbaum and North, 2020). We are not yet clear about the acute or long-term consequences of the COVID-19 lockdown measures on vulnerable groups (Cauberghe et al., 2021). This study explores the mental health implications of social

isolation and examines whether social media is helpful or detrimental to people secluded during the pandemic.

The relationships between social media, sociality, and mental well-being have been a topic of debate for decades, but the existing findings are mixed (Twenge et al., 2020). The "digital media harm" view argued that social media use is associated with worse mental health conditions (Orben and Przybylski, 2019). The more optimistic view suggested that social media connects us by providing an accessible or enhanced channel to find new contacts, maintain existing relationships and join online communities; thus, it could be beneficial for mental health (Bessière et al., 2008).

COVID-19 further complicated the already complex link between personal network, social media, and well-being. We are thus motivated by these new characteristics that may challenge the generalizability of existing findings. First, as social distancing limited much face-to-face communication and gatherings, social media has become a critical way to satisfy social interaction needs. When used properly, social media may serve as a constructive coping strategy that can reduce anxious feelings during the COVID-19 quarantine (Cauberghe et al., 2021). Second, increased social media use has been associated with several negative mental outcomes (Orben and Przybylski, 2019). The COVID-induced reliance on social media (Valdez et al., 2020) may exacerbate these negative effects and result in an intensified feeling of loneliness, fear, and anxiety. Third, a sense of isolation and loneliness may be more widely shared in a time of pandemic and social distancing. This changing nature of "isolation" will inevitably change patterns of social media use. It is thus both theoretically important and practically relevant to continue the investigation about the impact of social media use on mental health in this context.

Joining a stream of research that has extensively documented the relationships between social media use and mental well-being, we extend prior research in three aspects. First, we conducted two studies using samples of distinct demographic characteristics. Study 1 is a longitudinal survey that tracks social media usage and anxiety levels of a group of individuals over three months in the earlier stage of the pandemic. Study 2 was conducted at the end of May 2021, when the U.S. gradually resumes normal life. It contains a race-representative sample of U.S. adults to generalize and extend the findings obtained in Study 1. Second, it introduces one's personal network as an important social antecedent of social media usage. Third, the present study distinguishes between social media use for different purposes and proposes a conditional effect (moderated mediation) of one's perception of COVID-19 impact. This will help better determine "why" and "for whom" social media use matters.

Personal network and mental health

A large body of social and epidemiologic research has established social support as a critical predictor of improved physical and psychiatric conditions (Child and Lawton, 2020). One aspect of social support that is often the focus of social network research is the size of one's personal network (Marin and Hampton, 2007). This type of network is made up of a focal person's nominated social contacts in a name generator question (Child and Lawton, 2020). Having a large personal network indicates a high level of perceived social support.

Being embedded in strong social networks can improve mental health by activating several social-psychological mechanisms. The social influence mechanism encourages individuals to conform to the normative behaviors popular in one's social circle. A survey during COVID-19 showed that people adhered to social distancing measures most when they thought their close social circle did (Tunçgenç et al., 2021). The social resource mechanism explains how one gains emotional, instrumental, informational and appraisal support from their social contacts (Kanekar and Sharma, 2020; Yamamoto et al., 2020). In addition, the *stress-buffering* model works by modulating responses to negative life events that may cause mental illness. A longitudinal study of Swiss elders confirmed that self-reported satisfaction with communication during the COVID-19 was associated with less decline in positive affect and less increase in loneliness (Macdonald and Hülür, 2021). Thus, we re-test this protective effect of personal network:

RQ1: Does personal network size decrease anxiety level?

Personal network and social media

Literature about the link between one's social network and social media use can be broadly split into two camps. A first camp assumes that maintaining social relationships and social media usage are somewhat at odds, and thus argues that there may be a *trade-off* effect between size of personal network and social media use (Bessière et al., 2008). Two theoretical reasons can explain why more social connections predict less time spent on social media.

First, the *time constraint* mechanism argues that maintaining social relations requires time and energy (Dunbar, 2016), so having more offline social connections will reduce time spent on social media. An assumption of their argument is that social media is not useful for maintaining strong ties and people spend most of their social media time on asocial activities. Also, online networks may not be as useful in providing social support compared to offline networks (Mazzoni et al., 2016). A critique of these assumptions is that social media today serves a wide range of purposes, which earlier studies did not assess. In a pandemic, it is difficult to determine if social media use is a "solitary" activity or "social" activity. Second, personal predisposing characteristics precede social media use – that is, isolated or lonely feelings predict more addictive internet use (Brand et al., 2019). Individuals who are not well connected socially may need to satisfy the unmet social needs, find entertainment, or escape daily life *via* social media. Empirical findings confirmed that people use social media more when they have small social networks (Hill and Zheng, 2018; Boursier et al., 2020) or feel lonely (Cauberghe et al.,

2021). In the pandemic, this motivation may be particularly strong because the average anxiety and depression level increased for most people (Taylor et al., 2020). Both mechanisms would thus predict that small personal networks increase social media use (the *trade-off* effect).

Nonetheless, another camp predicts an opposite and positive relationship between personal network and social media use (the *social augmentation* effect). Social media is considered as an extension of one's sociality. People who excel at offline social interactions were found to be also good at developing online relationships (Vergeer and Pelzer, 2009; Rosenfeld and Thomas, 2012). Social media also lend themselves well to socializing with new people with diverse backgrounds and revitalizing old connections (Dunbar, 2016). Thus, having a large network may be positively related to spending more time on social media.

Due to the theoretical inconsistency between the *trade-off* and the *social augmentation* effect, we ask:

RQ2: What is the relationship between personal network and time spent on social media use?

Social media use and anxiety

The paradoxical relationship between social media use and mental health has been a topic of extensive debate since the 1990s. Two contradictory predictions have been discussed. The negative perspective states that frequent use of the Internet harms mental health outcomes (Orben and Przybylski, 2019). Possible theoretical explanations suggested so far include (1) the limited capacity theory: maintaining online social networks erodes time and cognitive energy that could have been spent with offline and truly meaningful connection (Dunbar, 2016); (2) the friendship paradox and the happiness paradox: in a friendship network, it can be mathematically proven that my friends are more popular and happier than me on average (Bollen et al., 2017); (3) the contagious emotion theory: during times of crisis, the contagious and negative sentiments will quickly saturate online communities with the help of social media which further leads to collective mental challenges (Iglesias-Sánchez et al., 2020; Valdez et al., 2020). The positive perspective, however, argues that mental well-being improves by receiving social support, regardless of the communication channel used. Increased social media use thus substitutes for what can be established in offline interactions and provides even more accessible ways of communication (Bessière et al., 2008).

In the context of COVID-related quarantine, both perspectives have received some empirical support. On the negative side, cross-sectional survey studies of Chinese adults show that a higher amount of social media exposure was positively associated with higher odds of anxiety (Gao et al., 2020) and more negative affect and secondary traumatic stress (Zhao and Zhou, 2020). Similarly, a cross-sectional survey with participants from four countries (Geirdal et al., 2021) and an Italy-based cross-sectional study during the lockdown (Boursier et al., 2020) reported that longer social media use was associated with significantly poorer mental health conditions.

Meanwhile, some other scholars noted the positive side of social media as a coping mechanism to reduce information uncertainty and anxiety. A cross-sectional survey among Belgian adolescents revealed that actively monitoring the COVID-19 situation and trying to learn more about preventive measures *via* social media is useful for boosting feelings of happiness (Cauberghe et al., 2021). A social media content analysis using a Spanish corpus explored the contagious emotions present on social media and discussed how this might be an opportunity to use it as a "collective therapy" to allow for positive affect to spread (Iglesias-Sánchez et al., 2020). Social media also provided a critical channel for users to proactively seek health information, such as knowledge about vaccines and preventive measures, which may be helpful in reducing the perceived risks associated with the disease (Li and Zheng, 2022; Zheng et al., 2022). These studies, however, were unable to ascertain the causal direction between social media use and mental conditions. Arguably, social media could be a compensatory tool to satisfy unmet social or informational needs (Mazzoni et al., 2016; Brand et al., 2019).

Considering the mixed findings so far, we ask the following research question:

RQ3: What is the relationship between time spent on social media use and anxiety?

Differentiating social media use for news and non-news purposes

Many media psychology studies conducted before the pandemic have found that different types of social media use have differential effects on mental health outcomes (Kingsbury et al., 2021). Most of these studies have not yet produced consistent findings. For example, Frison and Eggermont (2016) distinguished between three types of Facebook use (active public, active private, and passive) to examine their differential associations with depression among a sample of Belgium adolescents. Passive and active public use was found to predict depressed mood, but active private use was not. A cross-sectional study among Norwegian university students assessed five social media use types (passive social, passive non-social, active non-social, active social public, and active social private use) and their nuanced associations with suicide intentions (Kingsbury et al., 2021). Non-social use of social media was associated with decreased suicide intentions. Whereas the empirical findings remain mixed, one message is consistent: differential social media use types lead to differential mental effects and the mechanisms are highly complicated (Sharma et al., 2020).

Our research focuses on two types of common social media use: news-related versus non-news-related. Whereas social media is commonly used for non-news purposes such as sharing one's

life and socializing with one's personal network (Bessière et al., 2010), recent studies on COVID-19 particularly emphasized the "information seeking" affordance of the technology. Using social media to access news has long been established as a key social media usage type (Glynn et al., 2012). In a highly risky and uncertain situation like COVID-19, obtaining news online becomes necessary for many. Digital trace data revealed that both the overall social media usage (Valdez et al., 2020) and Google search queries (Bento et al., 2020; Galido et al., 2021) soared during the early months of the pandemic. Some researchers even argued that users are not as keen with the "social" features of social media, and information retrieval becomes the primary purpose (Kaya, 2020).

News-related social media use has been found to be particularly relevant to mental health during the pandemic. While the increased reliance on social media for news may be used to combat feelings of uncertainty, it may actually result in worsened mental health outcomes (Aalbers et al., 2019). A pre-COVID study found that lower satisfaction with one's life was significantly associated with increased Facebook news usage (Glynn et al., 2012). During the pandemic, an Iran-based cross-sectional survey found that people who followed more COVID-related news tend to experience higher anxiety (Moghanibashi-Mansourieh, 2020). A Chinese online survey showed that spending ≥2 h daily on COVID-19 news *via* social media were associated with probable anxiety and probable depression in adults (Ni et al., 2020). Contrary to these studies reporting the negative impact of news use, an online survey conducted in Cyprus during the lockdown revealed that users' social media news use during COVID-19 did not create panic and did not affect the well-being of users (Kaya, 2020).

However, the above studies were conducted during earlier months of the pandemic, and the heightened interests in accessing COVID-related information appeared to be quite short-lived—people's search interests triggered by local COVID cases did not last for longer than 2 weeks (Bento et al., 2020). The studies were mostly cross-sectional and produced mixed findings regarding the link between news consumption on social media and mental health. We thus follow these studies in distinguishing between social media use for news versus non-news purposes and explore these effects with a longitudinal research design. This distinction will help shed light on *why* social media benefits (or harms) and clarify the boundary conditions of this impact. This leads to a research question:

RQ4: Do social media use for news-related vs. non-news purposes have differential effects on anxiety?

The role of perceived COVID-19 impact

The perceived impact of COVID-19 is an important variable significantly associated with a battery of important social and health outcomes, including health anxiety, financial worry, loneliness, perceived social support (Tull et al., 2020), and psychological distress (H. Wang et al., 2020). Of particular interest to our study, perceived severity of COVID-19 matters for one's health information behavior. A U.S.-based online survey found that perceived COVID-19 severity and perceived susceptibility to infection are predictors of one's information seeking behaviors (Qu et al., 2021). When the perceived severity is high, people probably become more sensitive to the uncomfortable feeling associated with news consumption. Information avoidance becomes a strategy to cope with the stress and frustration brought by news.

However, no study yet has addressed if one's subjective perception of COVID-19 conditions the strength of the link between social media news use and anxiety. It is possible to speculate that those who do not perceive the situation to be severe would not be as influenced psychologically when they were exposed to COVID-related news on social media. They might just consider the news to be irrelevant. However, when people who felt negatively impacted consume lots of news on social media, it may further exacerbate the negative effect of social media news on anxiety (Boursier et al., 2020; Stainback et al., 2020). We thus are also interested in understanding the moderating effect of perceived COVID-19 impact, or whether those who perceive more impact of COVID-19 will be hurt more by the negative impact of social media news use.

RQ5: Does perceived COVID-19 impact moderate the relationship between social media news use and anxiety? If yes, how?

Summary of research objectives

Taken together, the goal of the current research is to explicate the relationship between personal network, social media use and mental health during COVID-19. We report two studies to answer our proposed research questions. The first study aims to examine the effect of social media use on anxiety. It also probes an antecedent of social media use—personal network size. Moreover, Study 1 tests whether the impact of social media differs by its usage type. The objective of the second study is two-fold: 1) to replicate Study 1 using data from a different subpopulation; and 2) to examine the effect of a moderator—perceived COVID-19 impact—on the effect of social media use on mental health.

Materials and methods

We test the proposed models with two surveys that examine (i) a subpopulation suffering from COVID-related discrimination, and (ii) a cross-sectional, race-representative U.S. sample.

Study 1: Data collection

This study recruited a sample of East Asian international students pursuing a degree in the U.S. higher education system. East Asian students are noteworthy for this study, especially at the earlier months of the pandemic. The group simultaneously suffer from at least four layers of stressors: (a) The fear of virus infection and the pandemic-related social isolation experienced by the general public; (b) The stressful and difficult adaptation experiences (Jang, 2016); (c) Anti-Asian discourse or even behaviors due to the controversy about the East Asian origin of the coronavirus (Gover et al., 2020; Litam, 2020); (d) Adaptation challenges unique to the East Asian culture (Liu, 2009). We are interested in exploring whether digital communication tools can help alleviate the negative affect experienced by the group.

We conducted a two-wave survey spanning 3 months. From May 10 to May 15, 2020, we sent out the first wave of the web-based survey to a nationwide sample of East Asian international students. The sample is drawn from a wide variety of sources, including online forums of international students, online forums for East Asian immigrants in general (with a special focus on Chinese, Korean and Japanese immigrants), campus-specific Facebook groups of international student associations across the U.S., and instant messenger groups created by international students. After removing one participant that completed the questionnaire under a minimum necessary time of 2 min (this threshold is set as the minimum time needed to read through and process all the questions based on our pilot tests), the first wave received 251 completed responses. From August 15 to August 20, 2020, 3 months after the initial survey, we followed up with the second wave. This wave returned 149 complete responses (59.6% follow up rate). We then excluded (1) one person who reported having used social media for an unrealistic amount of time—over 20 h a day in Wave 1, and (2) one person who self-reported to be 17-year-old, although all respondents confirmed themselves to be above 18 in the consent form before starting the survey. The following analyses were from this final set of 147 individuals. There were no missing response items because the survey system required all answers to be complete. The questionnaire was approved by the Institutional Review Board (IRB).

Study 2: Data collection

We collected data from May 31 to June 2, 2021 *via* the Qualtrics online panel service, which employed a quota sampling procedure to match the target race distribution of the U.S. national demographics.[1] We used two methods to screen out low-quality responses: (1) the system does not record responses finished in less than half of the median time estimated from a preliminary test. The vendor thus provided us 272 completed submissions that fulfill the minimum time requirement. (2) Consistent with Study 1, we also excluded 14 participants reporting that they used social media more than 20 h a day. The quality check retained 258 valid responses. Since we set the survey system to require all answers to be complete, there were no missing values. The questionnaire design was approved by the Institutional Review Board (IRB).

Study 2: A race-representative U.S. sample

The racial distribution of survey respondents in Study 2 was generally consistent with the racial distribution in the U.S. population (U.S. Census Bureau, 2021): White 72%, Black or African American 13%, Asian 5%, two or more races and other 10.00%. Our respondents were similar to the general adult population in terms of age (mean = 45.8 vs. 47 according to the U.S. Census Bureau estimate for the population over 18). Our sample contained more women (66%) than the total population (50.8%). They reported a median of 4 h of daily social media time (mean = 5.85, SD = 5.35), and 19 people (7.3%) reported zero hours of daily social media time. Only integer numbers are allowed for estimating social media use, so those who felt they did not use social media up to 1 h may choose to report 0.

Measures

Anxiety

The dependent variable (of both studies) anxiety was measured by the Generalized Anxiety Disorder scale (Spitzer et al., 2006). This scale includes seven items asking about different anxiety symptoms in the past 2 weeks, and the respondent self-report the frequency of symptom occurrence, ranging from 0 (no occurrence in the past 2 weeks) to 3 (happening daily in the past 2 weeks). The measure is a validated metric in a variety of populations and is commonly used in research (Williams, 2014; Paez et al., 2020). In Study 1, both waves of the anxiety scale had high reliability (Cronbach's alpha score of 0.90 at wave one and 0.90 at wave two). In Study 2, this scale also had high reliability (Cronbach's alpha of 0.94).

Personal network size

A personal network is a social network from the perspective of the center person (Marin and Hampton, 2007). The size of one's personal network thus often refers to the number of most close social contacts reported by the respondent (though other interpretations of the network are possible, such as a network made up of coworkers/classmates).

The survey instrument was adapted from extensive prior literature that has used personal network size as a proxy for

1 For more information about Qualtrics' s quota sampling procedure, visit: https://www.qualtrics.com/support/survey-platform/survey-module/survey-tools/quotas/

perceived social support and demonstrated the reliability of the measure (Marin and Hampton, 2007). In public health research, this construct was shown to play a role in predicting a wide variety of health outcomes (Gardy et al., 2011; Preller et al., 2014; Marroquín et al., 2020; Tunçgenç et al., 2021). Supplementary Table S3 in Supplementary Material provides a summary of select prior applications. Personal network size was obtained by asking the respondent to identify a list of contacts that fit certain intimacy criteria as specified in the question. Following prior literature (see a list of prior applications in Supplementary Table S3), we asked, "think of the people you usually interact with within a typical month, by both online and offline communication methods. They could be family, friends and acquaintances or persons you feel close to."

This question allowed the respondent to write down up to six social contacts' names. Setting six as the upper limit followed many prior studies that measured the most intimate personal network size (see an expanded list of prior applications in Supplementary Table S3). This corresponds with the hierarchical social relations theory (Pollet et al., 2011), which suggests that the core layer of humans' social network is typically no larger than five or six. Empirically, self-reported networks have been found to be similar in size with the naturally observed ego-networks on social media platforms (Haythornthwaite, 2000; Kim et al., 2007). Even though social networks are multidimensional, and it is hard to capture one's full network with only one question, Marin and Hampton (2007) has empirically shown that an effective single-item question could reliably reflect the size of one's network as obtained from a multiple-item questionnaire ($r = 0.6$ to 0.7).

In Study 1, 57.04% of the participants reported six contacts – the maximum number allowed, and 61.24% of the participants in Study 2 reported six contacts. This means most of the variance observed in this measure stems from the fact that nearly half of the participants nominated less than six names. The detailed distribution of this variable is shown in Supplementary Table S1 (Study 1) and Supplementary Table S2 (Study 2).

Social media use

We assessed time spent on social media in total and on news-related activities. Social media, in this study, is defined as web-based services that allow individuals to construct a public or semi-public user profile, connect with a list of users, and exchange information with others within the system (Boyd and Ellison, 2007). To help narrow down the concept of "social media," participants were instructed to think of their behaviors on a list of mainstream social media platforms. The list is based on a 2019 Pew social media use report (Pew Research Center, 2019) and our interviews with Chinese, Japanese, and South Korean first-generation immigrants about the popular digital platforms in these countries. The final list includes YouTube, Facebook, Instagram, Pinterest, Snapchat, Twitter, WhatsApp, Reddit, WeChat, Kakao Friends, and Line. Note that social media is a subset of digital communication platforms, and we did not cover emails, live streaming platforms, Facetime, or Zoom – which are critical tools in our digital life but were not considered as typical social media.

First, we asked participants to estimate the total time per day spent on social media, which instrument has been widely used (Shensa et al., 2017; Paez et al., 2020). The question asked, "on a typical day, about how many hours do you spend using social media?" Participants were provided with open-ended boxes to write down a number to indicate daily hours. The distribution of this variable can be found in Supplementary Figure S1 (both studies).

Also, we differentiated news use from general use, because news use may be particularly problematic in the context of COVID-19 isolation (Aslam et al., 2020). The question was adapted from Bessière et al. (2008), which identified news consumption as an important purpose of social media use. We asked, "on a typical day, about how many hours do you spend browsing news feed on social media?" Participants were similarly asked to write down a number to indicate hours spent. News here is defined as published materials reported in media outlets on recent topics (Lazer et al., 2018), and we make no assumption about the content of the news being correct or incorrect.

Perceived impact of COVID-19

This variable was added and tested as a moderator of social media's impact on anxiety in Study 2. The variable was measured by the question "To what extent has the situation associated with COVID-19 affected the way you live your life?" on a 5-point scale (1 = "no impact at all" to 5 = "impacted my life a great deal"), following Tull et al. (2020) and Qu et al. (2021).

Control variables

In Study 1, three demographic variables were collected at the first-wave survey, including respondents' *age*, *years stayed in the U.S.* and *English proficiency*. Additionally, *anxiety* level at the first-wave survey was entered into the analysis. In Study 2, the control variables included respondents' *age* and *sex*.

Study one results

Main effects

The age the respondents ranged between 18 to 40 ($M = 25.45$, *Mode* = 23, SD = 3.99). Typically, they have stayed in the U.S. for around 3 years ($M = 2.85$, *Median* = 3, SD = 1.63). Self-identified men make up 47.29% of the responses and 52.70% are women. Table 1 provides descriptive statistics and correlations of key variables.

Path analysis with bootstrapped estimation of standard errors was conducted. To accurately capture the temporal changes in participants' mental conditions, we also included the lagged dependent variable, as recommended in Bessière et al. (2010). Figure 1 shows the results of the mediation models.

TABLE 1 Study 1 descriptives and correlation (N=147).

Variable	Mean	SD	1	2	3	4	5	6	7	8
1. Anxiety (t2)	5.91	4.25								
2. Anxiety (t1)	6.23	4.60	0.47***							
3. Ego-network size	4.55	2.06	−0.13	−0.17*						
4. Social media use (t2)	5.14	3.35	0.24***	0.10	−0.13					
5. Social media use non-news (t2)	1.84	2.52	0.13	0.06	0.04	0.60***				
6. Social media use news-related (t2)	3.30	2.74	0.18*	0.07	−0.20*	0.67***	−0.19*			
7. Age (t1)	25.45	3.99	0.16	−0.05	−0.12	−0.07	−0.19*	0.08		
8. Years in U.S.(t1)	2.85	1.63	0.16	0.02	−0.03	−0.16	−0.16	0.00	0.34***	
9. English proficiency (t1)	3.46	0.96	0.04	0.09	0.04	−0.23**	−0.21**	−0.08	0.23**	0.50***

*p < 0.05; **p < 0.01; and ***p < 0.00.

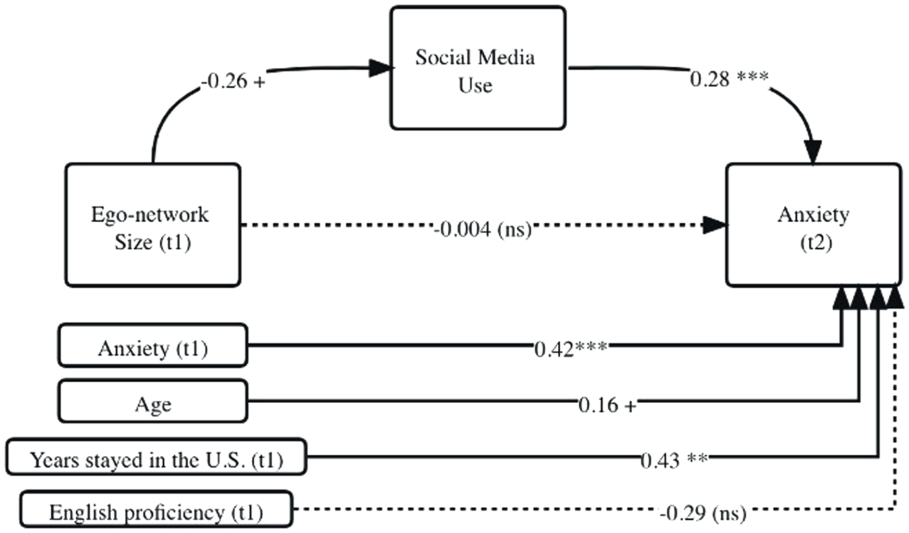

FIGURE 1
Model test results: personal network size, social media use and anxiety (Study 1). +p<.0.10, **p<0.05, ***p<0.01. Coefficients are unstandardized.

To answer RQ1, we found that the size of one's support network has no direct relationship with anxiety. After taking into account the mediation effect of social media, a larger support network size at a prior time did not predict anxiety in the future (b = −0.004, ns).

Regarding RQ2, the results showed that personal network size decreased the amount of time spent on social media in the next time period at a marginally significant level (b = −0.26, p < 0.1). That is, people who had a larger network at a prior time used social media less often in the future.

Analysis for RQ3 showed that increased social media use could lead to increased anxiety (b = 0.28, p < 0.01). Additionally, we tested for the indirect path effect (the impact of personal network size on anxiety through social media use) using the bootstrapped estimate approach as suggested in Hayes (2009). The indirect path coefficient estimate was −0.07 (unstandardized, 95% CI = −0.20 to −0.05), showing a significant mediation effect. These results demonstrated that social media use fully mediated the effect of personal network size on anxiety. The overall model for anxiety (t2) had an R^2 value of 33.5%. The baseline linear model predicting anxiety with network size and control variables had an R^2 value of 27.39%. The addition of social media use as a mediator in the model resulted in a ΔR^2 = 6.11%.

Differential effects of social media use types

The mean social media usage time was 5.14 h daily (SD = 3.35). The survey included an item asking respondents about their time spent on news consumption on social media. The current sample self-reported to spend an average of 3.3 h a day on news consumption (SD = 2.74). Social media use for non-news purpose was then calculated as the total hours of social media use minus the hours spent on news consumption (M = 1.84, SD = 2.52). A note of caution for interpreting these numbers is that the measure of non-news related social media use may be a conservative one. It is possible that people read their friends' posts when they consume news on social media given the nature of the technology,

and this mixed social media use is not covered by our measures. However, this should not hurt our results regarding the main effect of news-related social media use since our measure directly gauged the hours people spent on reading news on these platforms.

To address RQ4, both news and non-news social media use were entered as mediators and the proposed model was re-tested. Figure 2 illustrates the model test results. The path analysis revealed that only social media use for news consumption remained a significant mediator between personal network size and anxiety. As shown in Figure 2, the path from personal network size to news-related social media use was negative and significant ($b = -0.27$, $p < 0.05$). The path from news-related social media use to anxiety ($b = 0.26$, $p < 0.05$) remained positive and significant. Bootstrapped estimate of the indirect effect *via* news-related social media use (unstandardized estimate = −0.07, 95% CI = −0.22 to −0.014) confirmed this indirect effect. Hence, news-related social media use (but not non-news related social media use) mediated the relationship between personal network size and anxiety.

Together, the analysis further confirmed that time spent on news-related social media is the key variable that explains the relationship between social network size and anxiety. This observation did not apply to social media use for non-news purposes. The overall model for anxiety (t2) had an R^2 value of 31.7%. Compared to the baseline linear model with network size as the predictor and the control variables, differentiating the two types of social media use in the mediation model led to a ΔR^2 of 4.31%.

Robustness check

Cross-lagged panel model

Since we employed social media use at Time 2 to predict anxiety level at the same time, one may question whether the relationship between the two variables was correlational. As a robustness check, we conducted a cross-lagged panel model to validate this relationship (Figure 3). In the hypothesized model, all variables at Time 2 were predicted by their initial value at Time 1 and by the value of the respective independent variable at Time 1. Additionally, the covariance between social media use for news and non-news purposes were allowed at the same time period.

The cross-lagged model confirmed the main model because the path from the initial anxiety level at Time 1 did not significantly predict social media use at Time 2 (neither news-related nor non-news related), but news-related social media use at Time 1 positively predicted anxiety at time 2 ($b = 0.29$, $p < 0.01$). The model fitted the data well, with $\chi 2/df = 1.90$, $p > 0.1$, CFI = 0.98, GFI = 0.98, RMSEA = 0.07, SRMR = 0.05, NFI = 0.97. This model confirmed the directional relationship from social media use to anxiety, rather than the other way around.

Step Heckman model for selection bias

Another potential concern of our analysis is the unit nonresponse error, as we employed a longitudinal design where respondents can voluntarily follow through or drop out from the second-wave survey. If the respondents self-selected themselves into

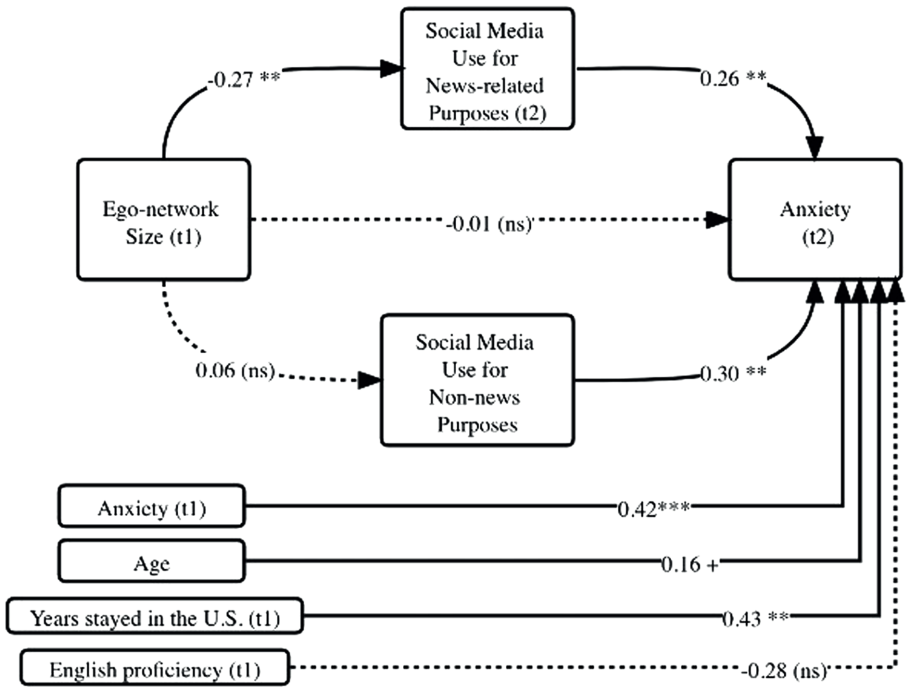

FIGURE 2
Path analysis results with two mediators: social media use for news-related and non-news purposes (Study 1). Dotted lines represent non-significant paths. $^{+}p<0.10$, $^{**}p<0.05$, $^{***}p<0.01$. Coefficients are unstandardized.

the second wave on the basis of some endogenous attributes and such variables were correlated with anxiety or social media use, our estimates would suffer from selection bias. We tested for this selection bias using a 2-step Heckman selection model. This model tested for the assumption that the error of the selection function (first step model) and the error of the outcome function (second step model) are correlated. A significant test statistic would suggest the presence of selection bias. The analysis reported an inverse Mill's ratio of-10.28 ($t = 0.33$, $p = 0.71$). The non-significant inverse Mill's ratio indicates that no selection bias was detected by this test.

Study two results

The descriptive statistics and correlations are presented in Table 2.

A moderated mediation model was analyzed to replicate the findings of Study 1 and to also test for the newly added moderator of perceived COVID-19 impact. Mediators and the moderator were mean-centered before entering into the model as suggested for moderation analysis (Dalal and Zickar, 2012). Figure 4 presents the results.

Consistent with Study 1, personal network size decreased the amount of time spent on news-related social media use ($b = -0.09$ $p < 0.05$). That is, people who had a smaller network tend to use social media more often for news-related purposes. Increased social media use for news could lead to increased anxiety ($b = 0.67$, $p < 0.1$).

Regarding the newly added moderator, perceived COVID-19 impact positively interacted with news-related social media use ($b = 1.01$, $p < 0.01$), which demonstrated that news-related social media use may be particularly harmful to those who feel they are impacted by COVID-19. To test for the index of mediated moderation for this path (from network size to news-related social media use to anxiety, and moderated by perceived COVID-impact), we calculated the product of the following paths' coefficients: Coefficient from network size to news-related social media use * Coefficient of the interaction term (of news-related social media use and perceived COVID-impact). The bootstrapped confidence interval of this index did not include zero ($b = -0.10$, 95% CI = −0.25 to −0.02) which confirmed the moderated mediation effect. The moderated mediation relationship did not apply to social media use for non-news purposes (95% CI contains zero). The overall model for anxiety had an R^2 value of 30.7%. Compared to the baseline linear model predicting anxiety with network size and control variables, this moderated mediation model increased the overall explanatory power ($\Delta R^2 = 1.3\%$). These results corroborated findings in Study 1.

Summary of results

Table 3 summarizes the key findings, addressing each research question.

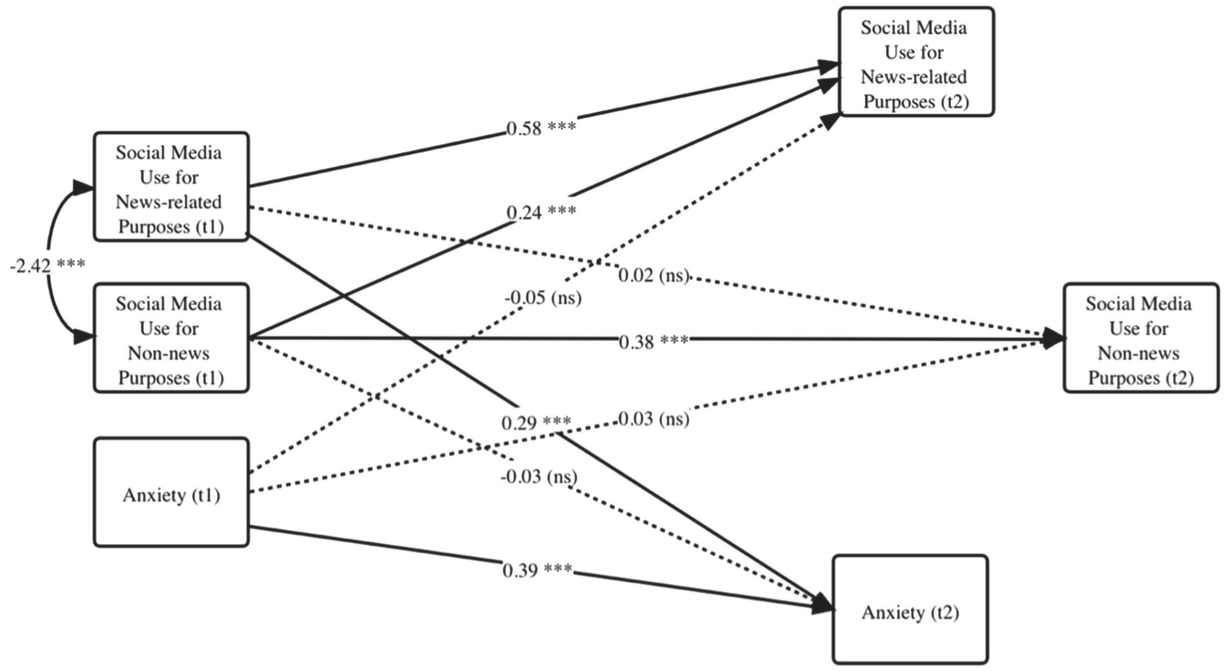

FIGURE 3
Cross-lagged panel model between social media use and anxiety at two time points (Study 1). Dotted lines represent non-significant paths. $^{+}p<0.10$, $^{**}p<0.05$, $^{***}p<0.01$. Coefficients are unstandardized.

TABLE 2 Study 2 descriptives and correlation (N=258).

Variable	Mean	SD	1	2	3	4	5
1. Anxiety	7.92	6.26					
2. Ego-network size	4.81	1.74	−0.07				
3. Social media use news-related	4.66	5.05	0.30***	−0.17**			
4. Social media use non-news	1.19	3.19	0.07	0.12*	−0.22***		
5. Perceived COVID-19 impact	3.78	1.04	0.01	0.13*	−0.09	0.08	
6. Age	45.82	17.20	−0.53***	0.07	−0.44***	−0.13*	0.14*

*p<0.05; **p<0.01; and ***p<0.001.

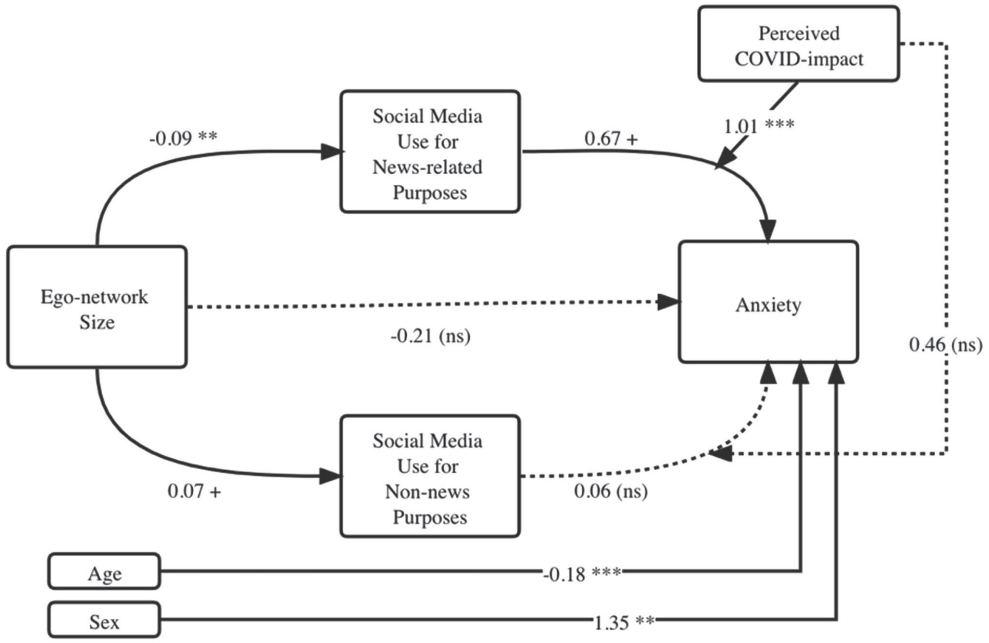

FIGURE 4
Moderated mediation analysis results (Study 2). Dotted lines represent non-significant paths. ^{+}p<0.10, **p<0.05, ***p<0.01. Coefficients are unstandardized.

TABLE 3 Summary of key findings.

	• Study 1 finding	• Study 2 finding
• RQ1 (personal network and anxiety)	• No direct effect	• No direct effect
• RQ2 (personal network and social media use)	• Larger personal network size →less social media use	• Larger personal network size →less social media use
• RQ3 (social media use and anxiety)	• Social media use → higher levels of anxiety	• Social media use →higher levels of anxiety
• RQ4 (differential effects of news vs. non-news social media)	• Social media for news →higher levels of anxiety; • Social media for non-news →higher levels of anxiety	• Social media for news →higher levels of anxiety
• Additional moderator of perceived COVID-19 impact	• NA	• Perceived COVID-19 impact positively moderates the link between social media for news and anxiety

Discussion

Principal findings

Adopting the social network perspective, we conducted two surveys to investigate how personal network and social media use are related to anxiety during a public health crisis. Overall, more social media use time predicted higher levels of anxiety. Second, a large network decreased time spent on using social media (especially using social media for news), which then reduced anxiety (see Figures 2, 3). In this sense, a strong social support network provides mental "protection" by distracting us away from

potentially disturbing news on social media. Amid large-scale social lockdown, this finding reminds us of the critical supporting role that our closest social circle plays. Third, consuming news on social media resulted in increased anxiety, which was amplified for individuals already feeling the impact of COVID-19 (see Figure 4). Social media today has become a primary source for information consumption (Geirdal et al., 2021). These findings warn us of a situation where those who already feel impacted by the pandemic may experience more anxiety when they consume news on social media. It confirmed prior findings that researchers should be cautious of *how much* people consume news amid a global pandemic (Aslam et al., 2020).

Social media's negative impact on mental health

The findings of the two studies were consistent in that social media use was associated with heightened anxiety. This conclusion was consistent with recent correlational studies (Boursier et al., 2020; Cauberghe et al., 2021; Geirdal et al., 2021), but our study provided more robust evidence because of the unique research design. Most studies examining social media and mental illness during the pandemic adopted a cross-sectional design, and understandably so – scholars needed to first have a quick assessment of the prevalence of mental conditions during the pandemic across a variety of populations and establish a correlational relationship. This article extended prior studies by adding a longitudinal design, and a comparative replication study. Total social media use predicted higher anxiety levels in the longitudinal survey of East Asian international students studying in the U.S. (Study 1) and a cross-sectional, race-representative sample of U.S. adults (Study 2). The two samples and data collection periods were highly distinct, so the consistent findings were quite robust. Study 1 focuses on a subpopulation that may be suffering from a series of social and political stressors during the earlier months of the outbreak, while Study 2 replicated and extended Study 1 with a more representative sample after the pandemic had developed for nearly a year and when half of the U.S. population has been vaccinated.

It also tested the possibility of the bidirectional causal relationship between social media use and anxiety. The robustness check using a cross-lagged effect model helped us rule out an alternative explanation—it may be anxiety (a personal predisposing factor) leading to more social media use. With the two-wave data, we found that it was social media use predicting higher anxiety, but not the other way around. However, it is possible that the two variables reinforce one another if observed in the long term. A limitation of the two-wave survey design is that we were unable to fully explicate causal relationships beyond a single time interval. A three-wave panel study before the pandemic (Tandoc and Goh, 2021) found that Facebook use at time 1 predicted increased depression level at time 2, and depression level at time 2 intensified Facebook use at time 3. Our finding was consistent with their reported first path (time 1 to time 2), but we did not have data to further untangle the intricate dynamics between social media and mental health over longer time spans.

Debate about personal network and social media use

Addressing the debate about the relationship between personal network and social media use, we found support for the trade-off effect (larger social network leading to less social media use) instead of the augmentation effect. In fact, the "trade-off" effect observed here does not mean that family-and-friends time competes with new-friends time. Two different samples both revealed that the time and energy spent on maintaining close relationships only reduced the amount of time on consuming social media news, and not for other purposes.

Thus, this article points to a new interpretation of the "trade-off effect" between personal network and the necessity of information-seeking on social media. An individual with stronger and more fulfilling relationships may feel less anxious to access news on social media, which is the primary purpose of social media use reported by our respondents. The theory of incidental news exposure (Lee and Kim, 2017) offers a possible explanation, positing that social networks can serve as a source of incidental information, thus reducing the necessity of checking the news online. In addition, the conditional effect of perceived COVID-19 impact supports the idea of COVID Stress Syndrome (Taylor et al., 2020), which argued that news-checking and reassurance-seeking behavior is a strategy to cope with COVID stress. When people obtained enough social support to ease COVID stress, the need for news-checking may decrease.

Types of social media use and differential effects on mental health

Moreover, the present study addressed the call for more careful considerations about the types of technology use and their differential consequences (Kingsbury et al., 2021). It also helped explain the mixed findings regarding the effects of social media use on mental well-being. Our analysis showed that social media use for news, compared to non-news use, consistently predicted higher levels of anxiety in both studies. The results hold after considering the possible bidirectional relationships using a cross-lagged effect model.

While prior literature conducted in the pre-pandemic situation mostly focused on differentiating between passive and active social media use (Wang et al., 2018; Yuen et al., 2019; Kingsbury et al., 2021), not enough attention has been paid to social media use specifically for news purposes and its mental health impact. In the context of COVID-19, the "information-seeking" affordance of social media becomes a crucial aspect highlighted in many empirical observations (Bento et al., 2020; Stainback et al., 2020; Galido et al., 2021). Literature provided at least two theoretical explanations regarding this negative link

–– due to the context of a crisis, or due to the proliferation of misinformation that overwhelmed viewers.

On the one hand, it is reasonable that news-related activities during crises, in general, predict negative mental outcomes. This conclusion has been validated multiple times in contexts of major disasters such as exposure to the 9/11 attack and the Iraq War (Silver et al., 2013), 2013 Boston Marathon bombings (Holman et al., 2014) and the 2016 Orlando Pulse nightclub massacre (Thompson et al., 2019). This article provided another test of the negative impact of news exposure during times of crises, and more importantly, it focused on social media-based news use, instead of a combined news exposure (that is not channel-specific) like the above-mentioned studies.

On the other hand, we speculate that the proliferation of misinformation during the pandemic, which some even named as an "infodemic" beyond the disease pandemic, also leads to undesirable consequences. Studies on COVID-19 have shown that misinformation was more frequently tweeted than science-based evidence or legit public health recommendations (Pulido et al., 2020), and it could demotivate information seeking and thoughtful processing of COVID-19 information (Kim et al., 2020). However, our data do not contain information regarding misinformation consumption *via* social media, which is a critical direction for future research.

Admittedly, this finding should be interpreted with caution because social media is a multitude of activities involving complicated psychological processes (Hyun and Kim, 2015). A simple binary distinction between news and non-news uses is not exhaustive. Literature has suggested several variables related to social media news use that is worthy of future investigations: the content of news (i.e., whether it is a description of the crisis or not), the different modes of news consumption behaviors (i.e., such as news reception, news following, and news dissemination), the motivation of news consumption (i.e., whether it is driven by fear or driven by a need for knowledge), the legitimacy of the information (i.e., true content versus misinformation/disinformation), and the audience's processing strategy of negative news (i.e., whether one denies or accepts the information). We also acknowledge that the current study did not cover online activities on channels that are not defined as social media (such as Zoom, Facetime, live streaming sites, or even emails), despite their importance during the pandemic. Studying some or all of the activities on the digital technology applications discussed above will lead to fruitful results in the future. The current project joins many other such efforts to understand this highly complex process. We believe it provides some initial evidence that social media should be considered as a primary source of information consumption.

Limitations and future directions

This study has several limitations. First, even though our measure of network size was shown to be reliable (Marin and Hampton, 2007), self-reported social network size was a proxy of "perceived" social support instead of "received" social support. Perceived and received social support have been conceptualized as different variables. We chose a measure of perceived social support because perceived social support, rather than the received one, was found to be the primary factor that influences health outcomes (Haber et al., 2007). Nevertheless, network size only emphasized one quantitative aspect of one's social network and may not fully represent one's ability to accrue social support or the quality of the support one received. We also did not have information about the structure of one's personal network, such as density, centrality, tie strength, or subgroups, which could provide valuable insights into one's interpersonal environment. Future work can examine these network variables and ask for more contextual information such as the perceived quality and amount of support received.

Likewise, we relied on self-reported measures of social media usage. Whereas we adopted this measure from prior studies examining social media use (Hill and Zheng, 2018; Paez et al., 2020), we acknowledge that it is subject to personal perceptions, recall error, and may be primed by one's more recent social media usage. Future studies can combine behavioral trace data that objectively record online social interactions with self-reported data to explicate these relationships further.

Third, the unique research context – a major public health crisis – limited the findings' generalizability. It could be that the effect is moderated by the occurrence of public crises such as natural disasters or political upheavals, during which social media is likely to facilitate the spread of negative sentiments (Aslam et al., 2020).

Fourth, the positive interaction effect between news-related social media use and the perceived impact of COVID-19 was merely a correlational connection, instead of a causal one. We cannot determine if it is COVID-19 stress caused more news consumption and reassurance-seeking or the other way around. This issue could be best resolved by collecting three or more waves of longitudinal data, or even conducting randomized control trials.

Fifth, the sample sizes were relatively small, compared to representative national surveys. This could limit the generalizability of the current findings.

Lastly, we collected online panel data obtained from Qualtrics and used pre-determined quotas to match U.S. population race distribution. This decision serves the purpose of this article well, because we were primarily interested in people who had social media access (Walter et al., 2016). However, we acknowledge that there are documented limitations of such panels, such as respondents' pre-existing Internet access and that participants' willingness to opt-in paid research panels, which may bias the results.

Conclusion

Two studies across different subpopulations consistently found that more social media use was associated with

increased anxiety. Personal network is a critical social antecedent of social media use. Maintaining a strong social support circle will protect us by lowering the time spent on social media and thus lowering anxiety. Additionally, social media's negative role is mainly explained by news-related activities on social media, and the strength of this relationship is conditioned by one's perception of COVID-19 impact. Together, these results demonstrate the increasingly critical and multifaceted role of communication technologies in affecting mental health conditions.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Ethics statement

The studies involving human participants were reviewed and approved by University of Southern California Institutional Review Board. The patients/participants provided their written informed consent to participate in this study.

Author contributions

RR contributed to conceptualization, methodology, data investigation, writing of the manuscript, visualization, and funding acquisition. BY contributed to conceptualization, data investigation, and writing of the manuscript. All authors contributed to the article and approved the submitted version.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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Supplementary material

The Supplementary material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fpsyg.2022.964994/full#supplementary-material

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Unpacking the effects of personality traits on algorithmic awareness: The mediating role of previous knowledge and moderating role of internet use

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The COVID-19 pandemic has accelerated the integration of algorithms in online platforms to facilitate people's work and life. Algorithms are increasingly being utilized to tailor the selection and presentation of online content. Users' awareness of algorithmic curation influences their ability to properly calibrate their reception of online content and interact with it accordingly. However, there has been a lack of research exploring the factors that contribute to users' algorithmic awareness, especially in the roles of personality traits. In this study, we explore the influence of Big Five personality traits on internet users' algorithmic awareness of online content and examine the mediating effect of previous knowledge and moderating effect of breadth of internet use in in China during the pandemic era. We adapted the 13-item Algorithmic Media Content Awareness Scale (AMCA-scale) to survey users' algorithmic awareness of online content in four dimensions. Our data were collected using a survey of a random sample of internet users in China (n = 885). The results of this study supported the moderated mediation model of open-mindedness, previous knowledge, breadth of internet use, and algorithmic awareness. The breadth of internet use was found to be a negative moderator between previous knowledge and algorithmic awareness.

KEYWORDS

big five, personality traits, algorithm, awareness, previous knowledge, mediating role, moderating role, internet use

Introduction

Recently, the Coronavirus disease (COVID-19) pandemic has deepened our dependency on the internet and accelerated the integration of algorithms in our daily lives. The number of internet users has increased greatly during the pandemic. According to the International Telecommunication Union (ITU), the number of internet users grew from 4.1 billion in 2019 to 4.9 billion (or 54% of the world's

population) in 2021 (ITU, 2021). Furthermore, internet users in China are spending more time online for news consumption, information acquisition, social interaction, entertainment, etc. (CNNIC, 2020). Meantime, we are increasingly living in a society that is governed and structured by algorithms, which are broadly defined as encoded procedures driven by specified calculations, which transform input data into a desired output (Gillespie, 2014). In the algorithm-driven online environment, social media and other types of platforms decide what flow of content we see, determine what ads we would like, make content recommendations that cater to our needs, and moderate content by detecting and removing content that is deemed inappropriate (Rainie et al., 2022).

The increasing integration of algorithms among online platforms have stimulated studies examining issues surrounding users' algorithmic awareness. Algorithmic awareness mainly refers to whether individuals are aware of the operations and impact of algorithms in their everyday life. The existing studies relating to algorithmic awareness have centered on two different perspectives, namely, the specific and general perspectives. Researchers holding the specific perspective tend to define and measure algorithmic awareness based on whether users have awareness of the roles that algorithms play in particular platforms, e.g., Facebook and Google (Rader, 2014; Eslami et al., 2015; Rader and Gray, 2015). On the other hand, scholars also argue that in a society with an increasing utilization of algorithms in almost every aspect of individuals' lives, being aware of specific algorithms used by particular platforms demonstrates more than enough awareness (Eslami et al., 2015). Hence algorithmic awareness is defined within a broader level and is often interwoven with discussions on experiences, privacy concerns, normative values, and literacy surrounding algorithms. Cotter and Reisdorf (2020) focus on search engines and define algorithmic awareness as the extent to which internet users are aware of why and how algorithms are used to prioritized certain information in their online search results and the potential impact of algorithms on them and certain social groups. In addition to special type of platforms, studies have also been conducted to examine whether users are aware of algorithms in different domains of their daily life. In a qualitative interview study conducted among 30 German internet users, the authors examined users' awareness of algorithmic operations in eight domains of internet use, and found that the participants were well aware of algorithm use in areas of advertising, online shopping, and streaming media use, whereas they had little awareness of algorithm use in the domains of news selection, navigation systems, jobs and dating services (Dogruel et al., 2020).

Furthermore, results of several empirical studies have shown a relatively low level of awareness of algorithms among users, despite the increasing usage of algorithms. From a more general perspective, the results of population surveys among internet users demonstrate that users' awareness of the dynamics of algorithm usage is limited (Grzymek and Puntschuh, 2019; Gran et al., 2021). Most European internet users do not know what an algorithm is, even though they are widely used in many everyday online applications. In Norway, which is a country with nearly universal internet adoption, approximately 60% of users reported having low or no awareness of algorithms (Gran et al., 2021). From a more specific perspective, research focused on particular types of algorithms on specific online platforms has provided additional insights into users' awareness of the algorithms they encounter. For widely adopted social media such as Facebook, most respondents (60%) are not aware of Facebook's use of algorithms to filter their news feed (Eslami et al., 2015). In other words, they believe that they can see all the posts that their friends create on Facebook. Although participants from another study displayed a higher level of awareness (73%) of Facebook's algorithm use, this was more likely representative of the increased level of awareness among more skilled internet users, as this study was conducted among Amazon's Mechanical Turk users (Rader and Gray, 2015).

Considering the impact of algorithm-driven platforms on shaping user' online environment and their low level of algorithmic awareness, it is crucial to investigate factors that can predict users' awareness of algorithms. At the individual level, being aware of the operations and impact of algorithms is essential for users to protect their privacy (Rader, 2014), increase their level of autonomy online (Dogruel et al., 2020), diversify the sources of their information and increase their income, which are dependent on acquiring online attention (Klawitter and Hargittai, 2018; Bishop, 2019). Furthermore, on the societal level, users' increasing level of awareness could also contribute to a more fair and transparent design of algorithms (Shin et al., 2022a), and thereby offer potentials to ensure algorithms as a tool for social justice. Thereby, this study aims to examine the factors that influence users' algorithmic awareness in China during the pandemic era. More specifically, the purpose of this study is to examine the relationships between the Big Five personality factors, algorithmic awareness, previous knowledge, and breadth of internet use.

Literature review

Personality traits and algorithmic awareness

Personality traits are generally defined as relatively stable patterns of feelings, thoughts, and behaviors reflected by individuals' tendencies to react under certain circumstances (McElroy et al., 2007; Roberts, 2009). The Big Five framework consists of five subscales of personality traits, namely, agreeableness, extraversion, conscientiousness, neuroticism, and openness to experience. Each dimension of the Big Five personality framework represents a domain of unique

personality traits. Individuals with a high level of openness tend to be more curious and seek new experiences; more conscientious individuals are more likely to be well organized, responsible, and reliable; more extraverted individuals tend to be more energetic, assertive, and excitement seeking; more agreeable individuals are more likely to be friendly, warm, and helpful; and those with a high level of neuroticism tend to be more anxious and moodier (Sharan and Romano, 2020). The Big Five personality traits have been widely used for describing personal characteristics in the last three decades (Zhang et al., 2021) and have been shown useful in explaining individual differences in social attitudes and behaviors (McCrae, 2000).

The increasing integration of artificial intelligence (AI) in many domains of society has also stimulated studies to examine the relationships between personality traits and AI. Personality traits have been shown to play a moderating role in the acceptance of medical AI, with openness and conscientiousness strengthening the relations between human-computer trust and acceptance of AI for independent diagnosis and treatment and conscientiousness and agreeableness lessening the association between human-computer trust and acceptance of AI for assistive diagnosis and treatment (Huo et al., 2022). Furthermore, the Big Five personality traits have also been demonstrated to have an impact on human-AI trust (Sharan and Romano, 2020). More agreeable and conscientious people are more likely to have a higher level of trust in automation, according to a study conducted among participants from America, Taiwan, and Turkey (Chien et al., 2016). In addition to trust in automation, people's trust in virtual reality (VR) teams has been found to relate to the Big Five personality traits, with agreeableness and extraversion negatively predicting trusting behavior and openness negatively relating to technology anxiety (Jacques et al., 2009). In addition to acceptance and trust in AI, personality traits have also been demonstrated to be associated with attitudes toward autonomous vehicles (AVs); more conscientious individuals tend to have greater concern with AVs, those with a high level of emotional stability and openness seem to be more eager to adopt AVs, more conscientious individuals are less likely to adopt AVs, more open individuals tend to be more willing to relinquish driving control, and more extroverted individuals are less likely to relinquish such control (Charness et al., 2018).

Recently, in addition to the above areas mentioned, algorithm technologies have been increasingly integrated into many of the popular internet platforms. This new type of technology has played a crucial role in automatically determining what content users encounter in the online environment. However, there has been a lack of research examining the roles of personality traits in the usage of algorithm technology in online platforms. Although some scholars have proposed integrating personality traits into an educational recommender system, drawing on the correlation between personality traits and academic performance demonstrated by previous studies (Gianotti et al., 2019), there is still a lack of empirical study examining the relationship between personality traits and algorithmic awareness and other related issues. However, the above-mentioned development in research on AI and personality traits and the recent theoretical development on the awareness of algorithms seem to provide new opportunities to integrate these two lines of research. In the area of algorithmic awareness, building on previous conceptualization of algorithms as experience technologies (DeVito et al., 2018; Cotter and Reisdorf, 2020), Swart (2021) defines algorithmic awareness as users' understanding of the presence and operations of algorithms in the context of news selection on social media. Building on previous discussions on fairness, accountability, and transparency of algorithmic awareness, Shin (2021a) constructs awareness with four subscales: fairness, accountability, transparency, and explainability (FATE) Shin and Park (2019), Shin (2021b), Shin et al. (2022a) and proposes that FATE can be extended as a basis of algorithmic literacy (Shin et al., 2021c; Shin, 2022b). Specifically, in the area of algorithmic content recommendations, Zarouali et al. (2021) constructs the framework of algorithmic media content awareness (AMCA) in four dimensions, including users' awareness of content filtering, automated decision-making, human-algorithm interplay, and ethical considerations. Furthermore, the ACMA framework, as proposed by the authors, can be seen as a theoretical concept used for examining how variables (e.g., media use. tech savviness, etc.) predict variations in awareness.

Drawing on the studies presented above surrounding the relationship between personality traits and AI, as well the development of theoretical framework in algorithmic awareness, we employ AMCA to measure users' awareness of how algorithm operations as well as theoretical framework to explore predicting factors of algorithmic awareness in this study. We propose our first research question as follows:

> RQ1: Are there correlations between certain dimensions of the Big Five personality traits and algorithmic awareness?

Besides, previous studies have demonstrated that demographic factors are predictors of users' awareness of the use of algorithms in online applications. A recent national survey in Norway has shown strong associations between age, gender, education, geographic location and awareness of algorithms (Gran et al., 2021). More specifically, those who are older, less educated, female, and living outside the most populated urban areas seem to have a lower level of algorithmic awareness compared to those who are younger, well educated, male, and live within urban areas. Moreover, those whose occupations require higher level of engagement with several specific algorithm-driven platforms tend to have higher level of awareness (Klawitter and Hargittai, 2018). Thus, drawing on results of these studies, we include variables of age, gender, and education as control variables of this study.

Mediating role of previous knowledge in algorithmic awareness

Internet users' previous knowledge about algorithms contains all they have heard of or learned regarding algorithm technologies. This knowledge can be either general, for instance, knowing that there is a new technology called an algorithm that has been increasingly influencing the information we encounter in our daily lives (Hargittai et al., 2020), or very specific, for instance, knowing that social media platforms such as Facebook use algorithms to filter users' news feed based on their online behaviors (Rader, 2014; Rader and Gray, 2015).

On the one hand, the acquisition of users' previous knowledge of algorithms is associated with several factors. First, demographic factors have been demonstrated to contribute to users' acquisition of algorithm-related knowledge. Similar to previous knowledge gap studies, males, young individuals, and well-educated individuals are more likely to have a higher level of knowledge regarding algorithms (Grzymek and Puntschuh, 2019; Cotter and Reisdorf, 2020). Second, algorithmic knowledge can also be obtained from other sources. Users can learn about algorithms through reading media reports on the related topics, gaining information through interpersonal networks, or professional training courses for those graduating or working in related areas (DeVito et al., 2018; Bishop, 2019; Cotter, 2019). Moreover, personality traits may also be able to facilitate users' practices of accumulating knowledge of algorithms, through increasing their level of technology acceptance and usage (Devaraj et al., 2008), increasing their time spent online (Swickert et al., 2002; Landers and Lounsbury, 2006), though sometimes this could lead to certain problematic use (Kayiş et al., 2016; Zhou et al., 2018).

On the other hand, previous knowledge can contribute to one's awareness of algorithms. Users' knowledge of algorithms reminds them that a new technology called an algorithm has been widely used in online platforms, although many do not know whether their frequently used applications have used this technology or how exactly the technology operates. Previous studies on users' awareness of algorithms, although they do not aim to examine the mediating role of previous knowledge between personality characteristics and algorithmic awareness, have provided evidence on the predictors of gaining algorithm knowledge and the impact of previous knowledge on increasing awareness (Grzymek and Puntschuh, 2019). In particular, those whose income is highly dependent on increasing the online visibility of their content, which is manipulated by algorithms, are more motivated to integrate their previous knowledge while on specific platforms and to exert more effort toward increasing their awareness of algorithms in arranging online content (Klawitter and Hargittai, 2018).

Therefore, it is reasonable to speculate that users' previous knowledge about algorithms lays the foundation for their awareness of how algorithms operate either on specific platforms or in certain domains of internet use. Although there has been a lack of research examining the relationship between users' previous knowledge and algorithmic awareness, implications from several studies seem to provide insights into this issue. Thus, drawing on the above discussions, we propose our second research question as follows:

> RQ2: Is there a mediation effect of previous knowledge between certain dimensions of the Big Five personality traits and algorithmic awareness?

Moderating role of internet use in previous knowledge and algorithmic awareness

It is worth noting that passive exposure to the algorithms alone does not guarantee users' awareness of the algorithms' use. Algorithms are experience technologies that cannot be easily understood without firsthand usage (Blank and Dutton, 2012). A study among Facebook users indicated that being a regular user for many years, having a relatively large network size, and having a certain number of stories is not associated with users' awareness of Facebook's News Feed algorithm (Eslami et al., 2015). Instead, users who use Facebook frequently, post stories actively, and adjust their settings frequently are more likely to be aware of Facebook's algorithm's function in content filtering (Eslami et al., 2015). Thus, the extent of the use of algorithm-driven platforms could play certain roles between individuals' accumulation of knowledge and awareness of algorithms. For individuals with intensive use of online platforms, their usage would enrich their general knowledge about algorithms and contribute to the increase of their awareness of how algorithms works and the impact on their daily life (Blank and Dutton, 2012).

There have been evidences indicating that the level of breadth and depth of internet use are correlated with users' experiences of accumulating knowledge and increasing algorithmic awareness. The breadth of internet use refers to the diversity of internet use (e.g., online activities, online applications), whereas the depth of internet use refers to the extent of users' engagement online. Users who use Facebook more frequently tend to correlate with more knowledge and greater awareness of the platform's news feed ranking algorithms and its working process (Eslami et al., 2015; Rader and Gray, 2015). The frequency and breadth of internet search on search engines are positively related with their knowledge and understanding about algorithms in online search (Cotter and Reisdorf, 2020). Online entrepreneurs and content creators, who are more motivated to engage deeply with specific platforms to promote their products or content, their online experiences relate to their knowledge and awareness of algorithms

(Klawitter and Hargittai, 2018; Cotter, 2019). Drawing on the above discussions, we propose our third research question as follows:

> RQ3: Is there a moderating effect of the breadth of internet use between previous knowledge and algorithmic awareness?

Materials and methods

Participants and procedures

The participants were recruited online using mixed methods. The first method used was an online crowdsourcing platform in mainland China (wjx), which provides functions equivalent to Amazon Mechanical Turk. Participants recruited through this platform (560) tend to be young and well educated, and most are between 20 and 40 years old and have a college degree. Furthermore, we used China's popular social media platform WeChat to recruit participants. The demographic features of participants who are recruited on this social media platform (301) tend to be more diverse, covering age groups ranging from 10 to 19 years old to 60 years old and above and education levels ranging from primary and secondary to a college degree. Each respondent from WeChat groups received 5-10 Chinese yuan for his or her participation, which was paid by WeChat's red packet function. In addition, as the link to the questionnaire was also available on an app targeting young internet users from across the whole country, we also received a small group of respondents (24) from the users of this platform.

The demographic characteristics of the participants are shown in Table 1. Among the participants, 43.5% were male, and 56.5% were female. More than half of the participants were from the 20–29 (34.1%) and 30–39 (35.3%) age groups, followed by the 40–49 (13.4%), 50–59 (8.7%), 10–19 (4.6%), and 60 and above (3.8%) age groups. Regarding the level of education, one-third of the participants had an undergraduate degree or above (70.2%), followed by a vocational college degree (18.2%), senior secondary level (8.1%), junior secondary level (3.1%), and primary level (0.5%). Considering that the Big Five personality scale adopted in this research consists of 60 complicated questions that require participants with a relatively higher level of education, the high percentage of participants with undergraduate and above degrees was crucial in ensuring the quality of personality trait-related data.

Measures

Previous knowledge of algorithm technology

Building on previous research on users' experiences with AI and practices of knowledge accumulation surrounding AI and algorithms (Charness et al., 2018), we included the variable 'Users' previous knowledge of algorithm technology'. Participants' previous knowledge was measured by their self-reported level of knowledge about algorithm technology from a more general perspective. More specifically, the question of 'Have you heard about algorithm technology and its usage in many popular online platforms?' was presented to the participants. The participants rated their level of previous knowledge about his question using a 5-point scale (1 = not at all aware, 5 = completely aware) (M = 3.32, SD = 0.850).

Big five personality traits

We assessed participants' personality traits using the Chinese version of the Big Five Inventory-2 (BFI-2) (Zhang et al., 2021), which has been tested to show good reliability, structural validity, convergent/discriminant validity, and criterion-related validity at the domain level. The BFI-2 consists of a total of 60 items nested within 5 12-item domains. Each of the items start with 'I am someone who' and end with a personality characteristic (e.g., 'I am someone who: is outgoing, sociable'). Participants rated themselves on each item using a 5-point scale (1 = disagree strongly, 5 = agree strongly). The survey produced a score for each of the Big Five personality traits for respondents: extraversion (M = 3.259, SD = 1.017, α = 0.850), agreeableness (M = 3.936, SD = 0.741, α = 0.848), conscientiousness (M = 3.823, SD = 0.883, α = 0.877), negative emotionality (M = 2.472, SD = 0.963, α = 0.886), open-mindedness (M = 3.493, SD = 0.935, α = 0.856).

TABLE 1 Demographic profiles.

Demographic Variable	Item	Frequency	Percentage (%)	Cumulative percentage (%)
Gender	Male	385	43.5	43.5
	Female	500	56.5	100.0
Age	10–19	41	4.6	4.6
	20–29	302	34.1	38.8
	30–39	312	35.3	74.0
	40–49	119	13.4	87.5
	50–59	77	8.7	96.2
	≥ 60	34	3.8	100.0
Education	Primary	4	0.5	0.5
	Junior secondary	27	3.1	3.5
	Senior secondary	72	8.1	11.6
	Vocational college	161	18.2	29.8
	Undergraduate and above	621	70.2	100.0
Total		885	100.0	100.0

Breadth of internet use

Building on previous studies on internet users' online experiences and engagement with algorithms (Eslami et al., 2015; Cotter and Reisdorf, 2020), we included the variable 'the breadth of users' internet use'. Respondents' breadth of internet use was measured by their self-reported level of the breadth of online applications usage. More specifically, the question of 'How many online applications do you use frequently in your daily life?' was presented to the respondents. The respondents rated their level of the breadth of internet use using a 5-point scale (1 = less than 10, 5 = 40 and above) (M = 1.73, SD = 0.792).

Algorithmic awareness of online content

We adopted the AMCA-scale, developed by Zarouali et al. (2021) to measure Chinese users' awareness of the algorithm's role in selecting and presenting online content. The AMCA-scale is designed to measure internet users' 'awareness of the usage and consequences of algorithms for the media content' on online platforms such as Netflix, YouTube, and Facebook (Zarouali et al., 2021, p. 9). The scale consists of 13 items that specifically measure users' level of awareness regarding the usage of algorithms in content filtering, automated decision-making, human-algorithm interplay, and the related ethical considerations. Each of the items is a statement indicating the role of algorithms in media content (e.g., Algorithms are used to recommend online content to me). Participants rate themselves on each statement using a 5-point scale (1 = not at all aware, 5 = completely aware) (M = 3.539, SD = 1.033, α = 0.913).

Statistical analysis

In this study, we utilized SPSS (version 26, IBM Corp.) and PROCESS (version 4.0, Hayes) software applications to examine the effect of the mediating and moderating factors. We first present descriptive statistics for our control variables and variables of interest, followed by bivariate associations among these variables. Second, we presented the results of regression analysis of the dependent variable. Third, we used PROCESS to examine the mediating effect of previous knowledge between open-mindedness and algorithmic awareness, and the moderating effect of the breadth of internet use between previous knowledge and algorithmic awareness.

Results

Descriptive statistics and correlation analysis

The descriptive statistics of and correlations between the study variables are presented in **Table 2**. There were positive correlations between extraversion and algorithmic awareness (r = 0.270, $p < 0.01$), agreeableness and algorithmic awareness (r = 0.221, $p < 0.01$), conscientiousness and algorithmic awareness (r = 0.211, $p < 0.01$), and open-mindedness and algorithmic awareness (r = 0.357, $p < 0.01$), whereas there was a negative correlation between negative emotionality and algorithmic awareness (r = –0.228, $p < 0.01$). Similarly, extraversion, agreeableness, conscientiousness, and open-mindedness had a positive correlation with previous knowledge (r = 0.246 ∼ 0.361, $ps < 0.01$), whereas negative emotionality had a negative correlation with previous knowledge (r = –0.231, $p < 0.01$). Previous knowledge was positively correlated with algorithmic awareness (r = 0.568, $p < 0.01$). The breadth of internet use was positively correlated with previous knowledge (r = 0.218, $p < 0.01$) and algorithmic awareness (r = 0.183, $p < 0.01$).

TABLE 2 Descriptive statistics and correlation analyses for each research variable.

	1	2	3	4	5	6	7	8	9	10	11
Open-Mindedness	–										
Negative Emotionality	−0.520**	–									
Conscientiousness	0.515**	−0.704**	–								
Agreeableness	0.454**	−0.615**	0.675**	–							
Extraversion	0.608**	−0.678**	0.606**	0.469**	–						
Previous Knowledge	0.361**	−0.231**	0.246**	0.276**	0.306**	–					
Breadth of Internet Use	0.199**	−0.178**	0.146**	0.149**	0.224**	0.218**	–				
Algorithmic Awareness	0.357**	−0.228**	0.211**	0.221**	0.270**	0.568**	0.183**	–			
Gender	0.076*	−0.178**	0.107**	−0.018	0.133**	0.076*	0.082*	0.071*	–		
Age	−0.089**	−0.063	0.112**	−0.033	0.004	−0.177**	−0.101**	−0.242**	0.051	–	
Edu	0.195**	−0.107**	0.138**	0.153**	0.120**	0.238**	0.136**	0.327**	−0.009	−0.288**	–
M	3.49	2.47	3.82	3.94	3.30	3.32	1.73	3.54	1.44	3.99	4.55
SD	0.60	0.65	0.61	0.53	0.63	0.85	0.79	0.71	0.50	1.16	0.81

Sample size = *885*; * $p < 0.05$ **; $p < 0.01$.

Control variables

Gender and level of education had positive effects on users' algorithmic awareness, whereas age had a negative effect on algorithmic awareness. More specifically, male participants ($\beta = 0.082$, $p < 0.01$) and those with a higher level of education ($\beta = 0.280$, $p < 0.001$) tended to be more aware of the roles of the algorithm in the content they encountered online; in addition, with an increase in age, the level of algorithmic awareness decreased ($\beta = -0.165$, $p < 0.001$).

Regression analysis

Table 3 shows the results of the regression analysis of algorithmic awareness as the dependent variable. First, the control variables were included in the regression, and then five dimensions of Big Five personality traits were included in the regression model (Models 1 and 2). The third step was to add previous knowledge to the regression model (Model 3). The fourth step added breadth of internet use and the interaction item to the regression model (Model 4). The results of model 2 indicated that among the five dimensions of Big Five personality traits, only the dimension of open-mindedness was significantly correlated with the dependent variable. Thereby, the first research question is answered: open-mindedness is positively correlated with algorithmic awareness. Furthermore, the results presented in model 3 and 4 have demonstrated the correlations between previous knowledge, the breadth of internet use with algorithmic awareness. Drawing on these results, we will analyze the mediating effect of previous knowledge between open-mindedness and algorithmic awareness, and the moderating effect of breadth of internet use between previous knowledge and algorithmic awareness. We propose the theoretical model shown in Figure 1.

TABLE 3 Hierarchical regression results for the level of algorithmic awareness.

Variable	Dependent variable: Level of algorithmic awareness			
	Model 1	Model 2	Model 3	Model 4
Constant	2.649***	1.608***	1.596***	1.031*
Gender	0.082**	0.052	0.023	0.026
Age	−0.165***	− 0.160***	− 0.108***	− 0.102***
Education	0.280***	0.221***	0.160***	0.154***
Open-mindedness		0.229***	0.132***	0.127***
Negative emotionality		− 0.021	− 0.057	− 0.048
Conscientiousness		- 0.009	− 0.010	− 0.004
Agreeableness		0.039	− 0.023	− 0.020
Extraversion		0.071	0.007	0.012
Previous knowledge			0.455***	0.624***
Width of internet use				0.356**
Int: breadth of use*width of internet use				− 0.419**
F	46.650***	32.098***	62.963***	52.945***
R^2	0.137	0.227	0.393	0.400
Adjusted R^2	0.134	0.220	0.387	0.393
ΔR^2	0.137	0.090	0.166	0.007

*$p < 0.05$; **$p < 0.01$; ***$p < 0.001$.

The mediation effect of previous knowledge between open-mindedness and algorithmic awareness

In this study, we investigated the mediating effect of previous knowledge between open-mindedness and algorithmic awareness. Tables 4, 5 presented the relationship between these variables in the mediating effect. Table 4 demonstrated the direct

TABLE 4 The mediation effect of previous knowledge between open-mindedness and algorithmic awareness.

Open-mindedness	Previous knowledge		Algorithmic awareness	
	β	Boot SE	β	Boot SE
Constant variables	1.2281***	0.2532	0.7003*	0.2693
Open-Mindedness	0.4508***	0.0472	0.1741***	0.0334
Previous knowledge			0.5231***	0.0588
Gender	0.1011	0.0537	0.0495	0.0388
Age	−0.0805**	0.0250	−0.0592**	0.0194
Education	0.1527***	0.0388	0.1359***	0.0292
R^2	0.1735		0.3987	
F	46.1836***		83.0701 ***	

*$p < 0.05$; **$p < 0.01$; ***$p < 0.001$.

TABLE 5 Direct effects, indirect effects and overall effect.

	Effect	Boot SE	Boot LLCI	Boot ULCI
Overall effect	0.3494***	0.0361	0.2786	0.4203
Direct effect	0.1741***	0.0334	0.1065	0.2378
Mediation effect: low internet use	0.1961***	0.0260	0.1485	0.2490
Mediation effect: Medium internet use	0.1671***	0.0217	0.1270	0.2117
Mediation effect: High internet use	0.1357***	0.0220	0.0954	0.1809

*$p < 0.05$; **$p < 0.01$; ***$p < 0.001$.

effect of open-mindedness on algorithmic awareness and the indirect effect of open-mindedness on algorithmic awareness through the mediating effect of previous knowledge. Table 5 presented the specific indexes of the mediating effect's total, direct and indirect effects.

Data analysis (as shown in Tables 4, 5) demonstrated that: open-mindedness significantly and positively predicted previous knowledge (β = 0.4508, p < 0.001); open-mindedness significantly and positively predicted algorithmic awareness (β = 0.1741, p < 0.001); previous knowledge significantly and positively predicted algorithmic awareness (β = 0.5231 p < 0.001); and open-mindedness indirectly and positively predicted algorithmic awareness through previous knowledge (β = 0.1719, p < 0.001). Table 5 presented the total, direct, and indirect effects of the mediated model, and the analysis indicated that effects above are within the 95% confidence interval, and the upper and lower bounds of the effects do not include 0, suggesting that the model is a mediating model. Thus, the second research question is answered as follows: there is a mediation effect of previous level of knowledge between the personality dimension of open-mindedness and algorithmic awareness.

The above results suggested that those with higher level of open-mindedness were more likely to be aware of the operations of algorithms in online platforms. Furthermore, level of open-mindedness indirectly affected level of algorithmic awareness through users' amount of previous knowledge relating to algorithms. When users' level of open-mindedness increased, they were more likely to obtain greater amount of algorithm related knowledge, thus increasing their level of awareness on the functions of algorithms in their daily life.

The moderation effect of the breadth of internet use between previous knowledge and algorithmic awareness

Table 6 showed the moderation effect of the breadth of internet use between previous knowledge and algorithmic awareness. It was found that the breadth of internet use was significantly and positively predicted algorithmic awareness (β = 0.3404, p < 0.01) and then negatively moderated the correlation between previous knowledge and algorithmic awareness (β = –0.0886, p < 0.01); the mediating model index after adding the moderating variable was –0.0397 [SE = 0.0140, 95% CI = (-0.0675, –0.0134)]. Thus, research question 3 was answered: there is a statistically significant moderation effect of the breadth of internet use between previous knowledge and algorithmic awareness.

To further explore the moderation effect of internet use, Figure 2 demonstrated the changes in the influence between previous knowledge and algorithmic awareness moderated by

TABLE 6 The moderation effect of breadth of internet use between previous knowledge and algorithmic awareness.

IV	Algorithmic awareness	
	β	Boot SE
Constant	1.0747 ***	0.2575
Previous knowledge	0.5618 ***	0.0596
Width of internet use	0.3404**	0.1123
Int: breadth of use*width of internet use	– 0.0886**	0.0306
Gender	0.0587	0.0398
Age	– 0.0587**	0.0196
Education	0.1499 ***	0.0289
R^2	0.3805	
F	89.8834***	

*p < 0.05; **p < 0.01; ***p < 0.001.

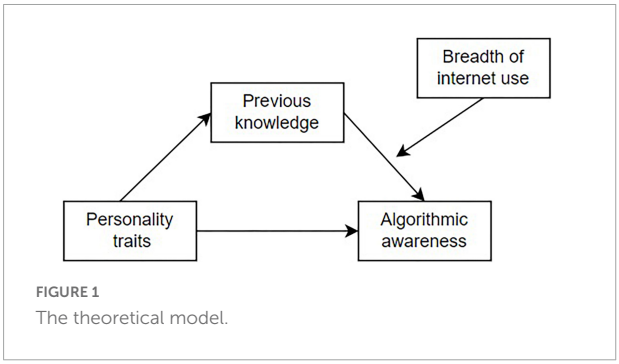

FIGURE 1
The theoretical model.

different levels of the breadth of internet use. As shown in the figure, the slope increased from the high (M + 1SD) to low (M–1SD) breadth of internet use group. When the level of breadth of internet use is high, the positive relationship between previous knowledge and algorithmic awareness is significant (β = 0.3385, t = 9.8782, p < 0.001). The positive relationship between previous knowledge and algorithmic awareness was significant when the level of breadth of internet use was low, and the effect of previous knowledge on algorithmic awareness was more significant (β = 0.4732, t = 15.9778, p < 0.001).

The results suggested that for respondents who use the internet with higher level of breadth, their level of algorithmic awareness increased with increased level of internet use breadth, while at the same time, the effect of previous knowledge on their increased level of algorithmic awareness is relatively weaker [SE = 0.0343, 95% CI = (0.2712, 0.4057)]. Whereas for participants with lower level of internet use breadth, the increase in amount of previous knowledge was correlated with a more significant increase in the level of algorithmic awareness [SE = 0.0296, 95% CI = (0.4151, 0.5313)]. Figure 3 presents the tested theoretical model and standardized regression coefficients.

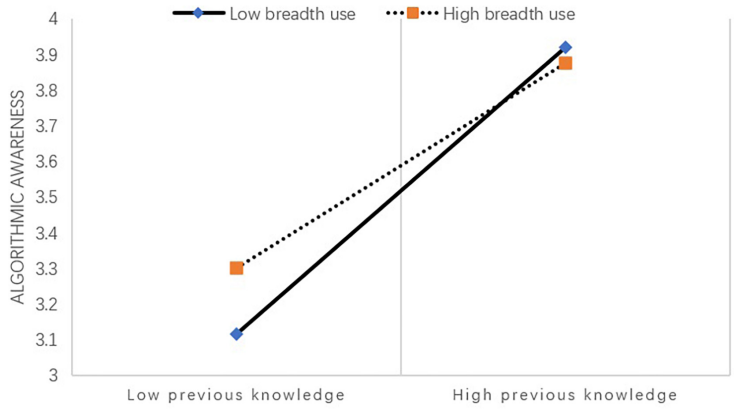

FIGURE 2
The moderation effect.

Conclusion and discussion

Theoretical implications

In the pandemic era, it seems that there's a mismatch between the increasing integration of algorithms in online platforms and users' awareness of the operations of algorithms. In this study, we investigated the effect of personality traits on algorithmic awareness; more specifically, we examined the mediating role of previous knowledge regarding algorithms between open-mindedness and algorithmic awareness, as well as the moderating role of the breadth of internet use between previous knowledge and algorithmic awareness. Our results have demonstrated that among the five dimensions of Big Five personality traits, only open-mindedness is positively correlated with users' awareness of algorithms; furthermore, previous knowledge plays a mediating role between open-mindedness and algorithmic awareness, and the breadth of internet use has a moderating effect between previous knowledge and algorithmic awareness. Our findings contribute to the literature on the personality traits and internet users' algorithmic awareness in several ways.

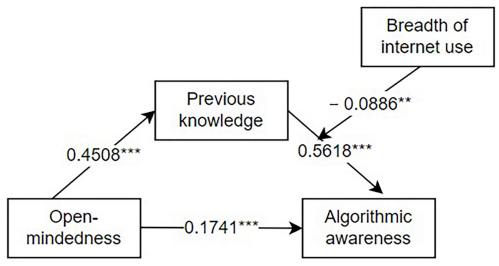

FIGURE 3
Model with coefficients. *$p < 0.05$; **$p < 0.01$; ***$p < 0.001$.

First, our results indicate a limited effect of Big Five traits on users' level of algorithmic awareness. In other words, among all the five dimensions of personality traits, only open-mindedness is the predictor of whether internet users are aware of algorithms' usage and impact on their online content. This finding suggests that personality traits as a whole may not predominantly predict the gap in algorithmic awareness between internet users. But the positive correlation between the dimension of open-mindedness and algorithmic awareness is worth noticing. The more open-minded users are more likely to gain knowledge related to algorithms. As addressed earlier, users' algorithm knowledge acquisition involves extant resources such as news reports, social networks, and direct interactions with algorithms through online engagement (Eslami et al., 2015; Rader and Gray, 2015; Klawitter and Hargittai, 2018; Cotter and Reisdorf, 2020). For individuals with a higher level of openness to experience, their willingness to try new things and engage in imaginative and creative activities seems to contribute to their accumulation of algorithmic knowledge through their experiences of online exploration. Furthermore, results of this study do not support the correlation between the other four dimensions of personality traits, including negative emotionality, conscientiousness, agreeableness, and extraversion, and algorithmic awareness. These four dimensions of personality traits, though have been shown to be related to issues like time spent online (Swickert et al., 2002; Landers and Lounsbury, 2006), internet addition (Kayiş et al., 2016), cyberbullying (Zhou et al., 2018), these amount of time and practices online do not necessarily relate to awareness of how algorithms operate. As addressed earlier, the awareness of algorithms, which are experience technologies (Blank and Dutton, 2012), requires active practices of exploring with curiosity than passively time spent online on algorithm-driven platforms (Eslami et al., 2015).

Second, this study emphasized the importance of previous knowledge in increasing the public's awareness of algorithms in today's algorithm-driven society. Results of this study indicate the mediating effect of users' previous knowledge between open-mindedness and their level of algorithmic awareness. This finding is consistent with previous studies on the positive relationship between open-mindedness and the acceptance, trust, and adoption of new technologies (e.g., Huo et al., 2022). This suggests that people with a high level of openness would be more likely to try new things while using the internet. Furthermore, their rich experience accumulated through active engagement online would help to increase their awareness of the roles of algorithms in the platforms they frequently use. The results of several previous studies on algorithmic awareness, despite not paying attention to personality traits, have indicated that users' level of engagement online is positively correlated with their awareness of the roles of algorithms in social media platforms such as Facebook (Rader and Gray, 2015). This finding seems to provide further implications for the current debates on improving users' algorithmic awareness and furthering algorithmic literacy. In the research on this issue, early studies have emphasized users' awareness of how a specific algorithm operates on specific media platforms such as Facebook or Google (Rader, 2014; Rader and Gray, 2015), whereas scholars from another line of research have proposed that users need to only have a general awareness of the use of algorithms in many domains of life (Hargittai et al., 2020). The results of the correlation between users' mainly general and fragmented knowledge and their awareness of algorithms' use and impact on a special domain of internet use (e.g., dynamics of online content) in this study suggest the integration of the above two lines of research. In other words, the increase in user knowledge of algorithms can help to deepen the understanding of the operations and impact of algorithms in users' daily life.

Third, this study demonstrates the moderating effect of the breadth of internet use between previous knowledge and algorithmic awareness. That is, the breadth of engagement with online applications moderates the transition of users' general algorithm knowledge into the specific awareness of how algorithms operate. This result is consistent with previous studies exploring the relationship between internet use, algorithmic knowledge accumulation and algorithmic awareness. For instance, for search engine users, the increase of frequency and bread of use contribute to greater level of knowledge of and understanding of how search engine works (Cotter and Reisdorf, 2020). Similarly, research conducted among social media users have also revealed that those having high usage frequency of Facebook (more than 20 times daily), are more likely to accumulate knowledge regarding algorithms; and the further exploration on this platform has increased their awareness of the functions and impact of news feed algorithms used by Facebook (Eslami et al., 2015).

Practical implications

This study provides practical implications for improving people's level of algorithmic awareness and increasing their autonomy in the new pandemic world. First of all, it is worth noticing that respondents in this study display a higher percentage of algorithmic awareness compared to those participants from many other studies. One possible explanation can be the societal features relating to AI in China. As the development of AI has become an essential step for realizing China's dream of a cyber-superpower, both official narratives reflected on mainstream media and public discussions on social media surrounding AI have been similar, focusing on AI's economic potential mainly from positive perspectives (Zeng et al., 2022). These positive evaluations of AI could to some extent increase the recognition of algorithms among the public. Another explanation could be the increase integration of AI in society that have sparked discussions about ethics relating to AI on social media platforms among scholars, journalists, IT industry actors, and the general public (Mao and Shi-Kupfer, 2021). In particular, since the start of the pandemic in China, the rapidly increasing news reports and public discussions on algorithm use distributed across popular social media have made the term 'algorithm' widely acknowledged among many internet users. For instance, in September 2020, an investigative report from China's 'People' magazine entitled 'Delivery drivers stuck in the system' went viral on China's popular social media platform WeChat within hours. This article elaborated how food delivery platforms utilize stringent algorithms to maximize profits at the cost of putting food deliverers and the public's lives at risk. Moreover, this report caused a moment of national reckoning regarding the harm that algorithms present to people, partly because food delivery drivers are nearly omnipresent in Chinese cities. Through events such as these, members of the public in China, especially in cities, can accumulate knowledge on algorithms' use and increase their awareness of algorithmic content production. Another explanation of the high level of awareness may be rated to the increasing number of users who have been using algorithm-driven online applications. According to a recent CNNIC report, by the end of June 2021, the number of China's online video application users had reached 944 million (CNNIC, 2021). The most popular online video platforms in China, such as Douyin (TikTok), Kuaishou, and Bilibili, use algorithms to provide personalized content to their users. Thus, through their engagement on these platforms, users have accumulated knowledge relating to algorithms, which has led to their increased level of algorithmic awareness.

Second, in recent years, particularly since the start of the COVID-19 pandemic, widely adopted algorithm-driven applications have increased efficiency at both the individual and societal levels on the one hand but have also caused new concerns for both the government and the public on the other hand. Our findings have important policy

implications for increasing the public's algorithm awareness to enhance users' autonomy in regard to encountering online content. In the context of China, 'Internet information service algorithm recommendation management regulations' were officially implemented on 1 March 2022. A noticeable included guideline is that users should be given the option to easily turn off algorithm recommendation services. Moreover, this guideline has the potential to shape the global landscape of algorithm regulation. Recently, many online platforms that are widely used in the domains of online shopping, entertainment, etc., have started providing options for users to turn off the algorithms used by their platforms following this regulation. This change is especially important for individuals living in an algorithm-driven world, as they can have a relatively high level of autonomy in deciding what content they encounter online and make decisions about the information they gather based on their own choices. However, the precondition for users to turn off the algorithms is that they are aware of the algorithms used in the platforms and the impact that these algorithms have on their daily life. Therefore, increasing users' algorithm awareness is the crucial first step for policy-makers and organizations who aim to improve users' online autonomy.

Limitations of the study

There are several limitations of the present study. First, our sample tended to be drawn from well-educated, young and middle-aged groups. On the one hand, the characteristics shared in these groups of respondents helped to guarantee the quality of the personality data collected through a 60-question scale. However, on the other hand, the level of algorithmic awareness of those drawn from the less-educated and older age groups was less likely to be represented in our sample. Considering that many of these individuals are also users who are influenced by algorithms, in the future, we need to conduct studies among these groups using methods suitable for them to gain an awareness of algorithms. Second, the measures of algorithmic awareness and the Big Five personality traits were based on respondents' self-reports. We recommend that future studies either use different methods or conduct studies among different groups to better replicate our findings. Third, although the adapted Algorithmic Media Content Awareness Scale (AMCA-scale) has been tested on three different online platforms, namely, Facebook, Netflix, and YouTube, among U.S. respondents (Zarouali et al., 2021), there has been a lack of validation of this scale on platforms outside the Western context. Therefore, future studies in this field should be conducted to further verify the generalizability of this scale using samples of online platforms used in different countries.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Ethics statement

Ethical review and approval was not required for the study on human participants in accordance with the local legislation and institutional requirements. Written informed consent for participation was not required for this study in accordance with the national legislation and the institutional requirements.

Author contributions

WF contributed to the research idea, literature review, and data analysis and model. JJ contributed to the analysis with constructive discussions of the study. Both authors contributed to the article and approved the submitted version.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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Supplementary material

The Supplementary Material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fpsyg.2022.953892/full#supplementary-material

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Social media interactions between government and the public: A Chinese case study of government WeChat official accounts on information related to COVID-19

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The concept of a *public energy field* is central to public administration discourse theory. Its main idea is the facilitation of dialog between government and the public, on the basis of equality, to construct a public policy consensus. In contemporary society, social media provides new and distinctive channels for such interactions. Social media can, therefore, be conceived as a novel type of *public energy field*. Since the outbreak of the COVID-19 pandemic, interactions between the Chinese government and the Chinese public (whether located in China or abroad) have been acutely reflected through WeChat official accounts. This article focuses on the COVID-19 pandemic and, through social media text mining and processing, analyzes the text topics and emotions covered. Basic principles of discourse validity, regarding this public energy field and two guarantee conditions, are applied to analyze the information exchange and dialog between the government and the public on COVID-19 through WeChat official accounts. It was found that the government's WeChat official accounts have not yet formed a harmonious dialog space to balance the public energy field, and that the interaction between the government and the public has to be improved. The government's social discourse had a significant influence on the public's social discourse. Using text analysis, the study found that the government has published information on 11 topics related to the prevention and control of the pandemic. It can be argued that the public energy *field* presented by both the government and the public effectively portrayed and reflected the actual situation of the pandemic in China.

KEYWORDS

public energy field, COVID-19, social media, social discourse system, WeChat official account, text analysis

Introduction

Since the outbreak of COVID-19, the Chinese government has taken a series of measures to combat the pandemic. The rapid development of information technology has increased the complexity of social and political discourse, and given the government unprecedented challenges. This crisis posed risks for the government that public trust might erode if confidence in the handling of the pandemic, and or faith in the accuracy and/or timeliness of official information, declined. One strategy to forestall such an outcome was to involve the public more intensively in the policy debate (Halvorsen, 2003). Such an enhancement of public participation (Barnes et al., 2003) has also been widely recognized as a route to facilitate genuine improvements in policy outcomes and can be interpreted as a method to improve the efficiency of government and the quality of public services (Nayak and Samanta, 2014; Hue and Sun, 2022). Interaction between government and the public is increasingly conducted through social media; a trend that was acute concerning the COVID-19 pandemic, given the social-distancing restrictions.

Social media has been playing an increasingly significant role in our modern society (Yang et al., 2020). "Sina Weibo" and "WeChat" are two of the most popular and important social media platforms in China (Carvajal-Miranda et al., 2020). Some of their features and services overlap (Gan, 2018), for instance, functions including chatting, sharing, commenting, and so on. Many government departments have been using Sina Weibo or WeChat to interact with the public and achieving remarkable results.

However, WeChat, regarded as an efficient instant messaging tool, also can be used to publish information and provide services. Moreover, more than 1.2 billion users from WeChat ensures that information is widely disseminated (Jiang et al., 2021); hence it increases the diversity of the user groups, the richness of user groups, and the engagement of the users. In addition, Sina Weibo is more likely to be threatened by a discourse monopoly, while the discourse center of WeChat is more multidimensional (Ma, 2014).

Nowadays, the public and institutions are more inclined to use WeChat official accounts or WeChat applets. For instance, Zhang et al. (2018) demonstrated that hospitals are more likely to use WeChat than Weibo. During the pandemic, the Health QR Code and Travel Card, which were widely used, were all based on the WeChat platform. Therefore, the article selected WeChat as the research object.

In China, WeChat official accounts form a vital interactive platform for the government and its agencies to disseminate information on time, and for the public to engage in political and social debates. Such interactions form the *public energy field* where public policies can be formulated and modified through social discourse, which, at least occasionally, challenges governmental agendas and practices (Fox and Miller, 1994).

This article contributes to our understanding of interactions between government and the public during the COVID-19 pandemic in China. During the severe period of the pandemic, information related to the emergency released by the government and media was eagerly received by the public and there was a widespread desire to engage in debates about the pandemic (Lu and Zhang, 2020). Most of this informational exchange occurred *via* WeChat official accounts. We deploy four principles and two guarantee conditions to study the *public energy field* contained within the social media discourse. Discourse analysis is undertaken on the interactive information flow between the government and the public, through WeChat official accounts, for the COVID-19 pandemic. We consider both governmental and public perspectives to evaluate this discourse.

Literature review

Discourse systems in social media

The concept of social discourse reflects oral or written communication that has a social purpose or a distinctive social component (Addams and Proops, 2000). With the rapid development of the Internet, social media has been increasingly adopted as a core mechanism for social discourse on central aspects of contemporary political and public policy debate. Social media provides channels for information release and social interchanges and establishes a platform for political discourse, thereby facilitating the reconstruction of social/political relations, blurring the boundaries between the real and the virtual (Trilling, 2014), and creating their *public energy field.*

The Internet offers the potential of an approximately equal space for individuals and organizations. Social media creates new challenges and opportunities for public administrators (Knox, 2016), such as the enhancement of policy information (Gong et al., 2022), and increases the capacity of the public to participate in public debates (Mossberger et al., 2013). People's active participation establishes a unique political/social discourse system in cyberspace covering a variety of media formats (including text, audio, image, and video). By mining the discourse within these media, the contribution of this communication to public debates can be identified, the importance of such forums highlighted, and the capacity to improve government policies specified (Kavanaugh et al., 2012). Such methodologies have also enabled scholars to develop overarching conclusions about the impact of social media, for instance, Li et al. (2019) observed that interactions between the public and governments in China reflected specific and changing social–political discourse and political values. In terms of three separate self-identities – individualism, relational collectivism, and group collectivism – expressed through such

discourses, those authors found that the Chinese government was more inclined to respond to demands articulated through relational collectivism. That is, the government was most responsive to agendas emerging from networks constructed through interpersonal relationships, rather than a wider sense of belonging to a collective entity (Kreuzbauer et al., 2009). Dialog and discourse in social media can, thus, have a positive influence on promoting interaction between the public and government, and improving relationships between them. Such an outcome is normally specified as a core goal of digital governance (Chadwick, 2009).

Nevertheless, encouraging the public to actively participate in such social media interaction remains a core challenge for policy-makers (Mossberger et al., 2013). Perhaps the most effective strategy has involved government extensively promoting dialog on issues that were of immediate relevance to a wide social segment, rather than broader organizational interests or marketing-related matters (Bonsón et al., 2015).

Public energy field

The idea of a *public energy field* is central to discourse theory (Fox and Miller, 1994), which represents an interdisciplinary application of postmodern discourse to contemporary international society. *A public energy field* is a political term formed by the combination of the field theory of modern physics and phenomenological methodology. Its purpose lies in the creation of a distinctive discourse system, which emphasizes the public voice and advocates independent expression. *Public* is a field composed of action and discourse, which confronts elite authority and is open to all citizens. *Energy* refers to the internal force and the collision force, while *Field* concerns the synthesis of forces acting on the situation. The structure of a field is not a fixed formula but depends on what is happening (Fox and Miller, 1994).

Discourse legitimacy

The access mechanisms of discourse platforms provided by social media are open and free. However, scholars such as Fox and Miller (1994) suggested, constructed through Habermas' specification of valid conditions for ideal speech and authentic communication, four practical claims (warrants) for valid discourse – sincerity; situation-regarding intentionality; willing attention; and substantive contribution. Sincere discourse required mutual trust to safeguard the public interest, which is undermined through the proliferation of disingenuous arguments (Fox and Miller, 1993). Situation-regarding intentionality reflects requirements that the dialog concerns an issue that is "contextually situated" and that "speakers will take into account the context of the problem, the lives of those affected, and the public interest" (Fox and Miller, 1994, p. 123). In other words, those deliberations need to be grounded in the real world context rather than have an abstraction from reality. Requirements for willing attention relate to aspirations for "a spirit of vigorous, active even passionate engagement" (Fox and Miller, 1994, p. 125). Finally, the substantive contribution warrant recognises the requirements for informed dialog, for instance, through "offering a unique viewpoint, specific expertise, generalized knowledge, or pertinent life experience, or by being able to express the concerns of groups or classes or citizens" (Fox and Miller, 1994, p. 125). To secure the legitimacy of the discourse, Fox and Miller (1994) also specified two guarantee conditions. First, equality between the participants and, second, the dialog culture term *some people*, which reflected inclinations to avoid dialog restricted to elite participation or a dialog overwhelmed through a multiplicity of voices. One central aim was the avoidance of monologues and the facilitation of meaningful arguments and refutation. Public administration discourse should also avoid the one-way interaction between the administrators and the public.

Public energy fields can be contrasted with discourse structures prevalent within organizations and policy networks. Organizations have formal relational structures, while policy networks normally exhibit relatively stable relationships (Kickert et al., 1997; Sørensen and Torfing, 2011). *Public energy fields* also have a much greater level of openness of access than organizations or policy networks (Schaap, 2007). A diverse range of protagonists with contrasting agendas, intentions, and perspectives thus clash, debate, and argue, often with a repetitious favor as ingrained perspectives and interests are regurgitated. This active dialog between governance and the public thus represents a departure from the official monologues (Farmer, 1995) and restricted enthusiasm for public participation (Cole, 2004) that has traditionally characterized bureaucratic behavior.

Public crisis events and social media

For major public crisis events, the government must efficiently inform the public about the crisis (Chen et al., 2020). Social or electronic media often plays a crucial role in the rapid dissemination of information. For example, during the Haiti earthquake in January 2010, CNN's website saw a significant increase in page views (about 240%) in 1 day (Bunz, 2010). When public crisis events occur, discourse in such media can reflect official attitudes and public feedback quickly, which assists in the dissemination of information to the public and the government, in terms of shifting public attitudes. Social media text analysis can be utilized to establish a link between informatics and disaster management (Gründer-Fahrer et al., 2018). Text analysis in social media brings new opportunities for crisis management. For instance, Laudy et al. (2017) introduced

a series of text analysis tools, such as the tweet locator, to support the management of social media in a public crisis. These tools might be deployed to classify and manage the text, thus avoiding information overload as a consequence of a deluge of data.

Many scholars have used text analysis to study crisis events. For example, Mollema et al. (2015) studied relationships between the amount of social media information and measles reports during the measles outbreak among orthodox Protestants in the Netherlands, finding that data extracted from social media facilitated understanding of public attitudes. This information enabled public health institutions to respond to public concerns immediately. Similarly, Gründer-Fahrer et al. (2018) used natural language processing to mine relevant texts, and extract topics from Facebook, during the 2013 floods in China and Europe, thereby specifying the public's emotional and wider response to that natural disaster and official measures. In the case of the Malaysian Airlines MH17 disaster, Jong et al. (2016) evaluated the response of local authorities in the Netherlands through social media and newspaper articles, finding that mayors could use social media to achieve crisis communication goals and operate as chief mourners for their communities.

Some studies have explored the weakness of government in social media interactions. Lachlan et al. (2016) discussed the use and content of Twitter in the pre-crisis stage of Storm Nemo, which hit the North Eastern United States and the Atlantic coast of Canada in 2013, finding that social media provided an opportunity to inform and motivate the public in the crisis events. Furthermore, those scholars asserted that emergency management officials should continue to search for specific and more general social media audiences, and consider the search strategies that affected audiences might deploy to facilitate information dissemination. Similarly, Chen (2012), through the analysis of social media coverage of the *Yongwen* railway accident in Wenzhou, China, concluded that social media played a crucial role in crisis communication. However, governmental inexperience with the technology meant that its communication appeared passive and lacking in adequate preparation.

Conceptual framework

WeChat official accounts enable a dialog between followers and government-sponsored accounts through *comments* and facilitate the expression of emotions through *thumb-ups*. Texts published or the information released by the WeChat official accounts can be shared with others by the readers/followers. These interactive processes constitute social discourse, while the sheer volume and complex dynamics of these social discourses imply an interpretation as a *public energy field*.

Taking the COVID-19 pandemic as an example, the government supplied relevant information through the official account platforms. The government sought, therefore, to satisfy public demands for information about the pandemic and diminish unease about how the officials were handling the crisis. Furthermore, it might be argued that the dialog between the government and the public followed the principles of sincere interaction, the situation intentionality, willing attention and substantive contribution. Sincere interaction might be assumed given the widespread trust in the government among Chinese public opinion (Zhai, 2016), while the other principles might be credible assumptions given the immediacy of the emergency, the participatory enthusiasm, and the scale of the interaction.

To evaluate these debates about COVID-19, we thus designed a *public energy field* with proxies for the four principles and guarantee conditions of discourse legitimacy (see **Figure 1** and **Table 1**).

For the government, "Associated with COVID-19," "Position of text" and "Guide to Reading the full text" were selected to indicate governmental sincerity in releasing information related to the pandemic. While for the public, the "Active followers" indicator was selected to specify the public's sincerity in engaging those government accounts and, by implication, trust in the credibility of the government's information on COVID-19 more generally.

For situation of interactive participation (or situation regarding intentionality), our government proxies were "Original content," "Number of videos," and "Additional audio," to reflect government editing and "improving" the text quality. For the public, "Number of readings" was selected to indicate public participatory engagement with material directly affecting their lives.

In terms of participatory willingness (or willing attention), for the government "Average daily number of texts" and "Number of words in the text" were selected to describe texts and contents released by the government autonomously. Alternatively, for the public, this principle was proxied through "Number of thumb ups," "Number of comments," and "Number of thumbs up comments." Thumb up behavior indicating active participation following receipt of the information.

To measure substantive contribution, "Importance of text," "Topic category fo text," and "Emotion of text" were chosen to describe how the government released information of varying importance, categories and emotions, and guides the public to read the contents. For the public, the "Number of lookings" indicator was selected as indicative of the scale of their engagement.

To evaluate the equality of the social media dialogue, "Number of comment replies" was selected to proxy official attitudes towards the status of public engagement, i.e. the seriousness or equality with which they interpreted public reactions. For the public, "Number of thumbs up comment replies" was selected to indicate to what extent the public sought to participate in a roughly equal dialogue with official sources.

Partial interaction, the *some people* idea espoused by Fox and Miller (1994), was proxied through "Government response

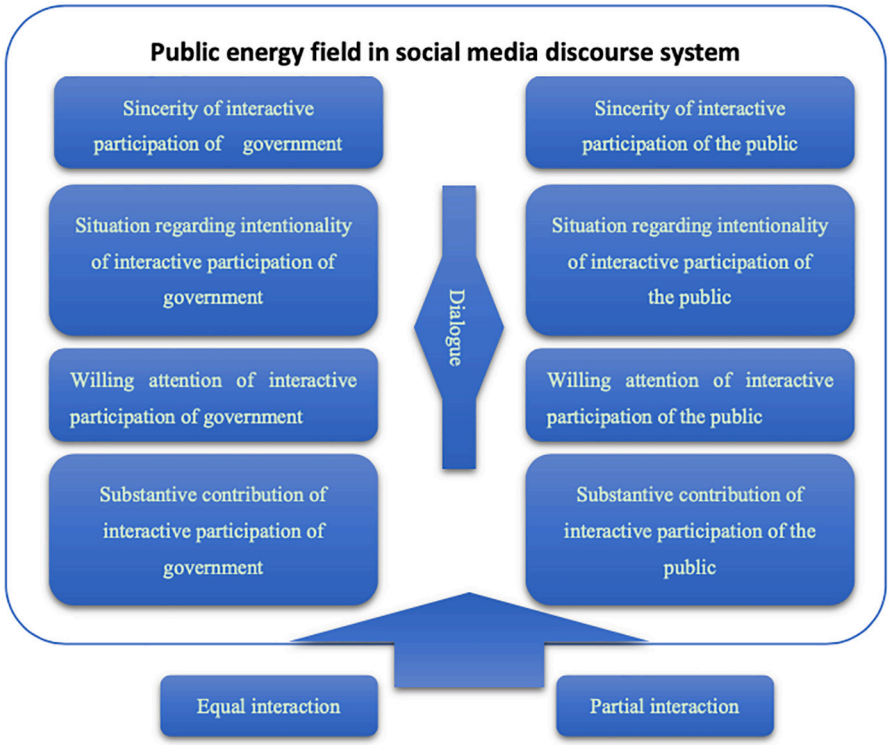

FIGURE 1
Research framework.

TABLE 1 Measurement index design of discourse legitimacy.

Practical claims for valid discourse (Fox and Miller, 1994)	Proposed framework (By authors)		
(a) sincerity		Measurement index	
(b) situation-regarding intentionality	Elements	Government	The public
(c) willing attention	(a) Sincerity of interactive participation	Associated with COVID-19 Position of text Guide to reading the full text	Active followers
(d) substantive contribution	(b) Situation regarding intentionality of interactive participation	Original content Number of videos Additional audio	Number of readings
	(c) Willing attention of interactive participation	Average daily number of texts Number of words in the text	Number of thumb ups Number of comments Number of thumb up comments
	(d) Substantive contribution of interactive participation	Importance of text Topic category of text Emotion of text	Number of lookings
The conditions for legitimate discourse (Fox and Miller, 1994)	(e) Equal interaction	Number of comment replies	Number of thumb up comment replies
(f) equality of discourse (g) some people's discourse	(h) Partial interaction	Government response rate = Number of comment replies/Number of comments	Participation rate of the public = Number of comments/Number of readings

rate" (Number of comment replies/ Number of comments), which identified willingness of the government to respond to public comments. In contrats, public participation was proxied through the Number of comments/the Number of readings.

Public crisis events selection, research methods, and data

Event selection and data collection

To evaluate social media communication surrounding the COVID-19 pandemic in China, and with reference to the influence ranking list of the government official account of "Xinbang" ([1]China's most authoritative content industry service platform), we selected 10 influential government WeChat official accounts. Those sources were the China Government Network, the Communist Party Member, the Communist Youth League Central Committee, Beijing Release, Shanghai Release, Guangdong Release, Hubei Release, Wuhan Release, the Beijing Center for Disease Control and Prevention, and the Hubei Center for Disease Control. A total of 13,723 items of data for 114 days (from 8 January 2020 to 30 April 2020) were collected, incorporating basic data information, text information for the title and body, and information about government–public interactivity in relation to the text. Among the data collected, 3,988 items of information were not directly related to COVID-19, but mainly related to local economies and were largely collected in April, when the pandemic had been brought under control. Since the article aimed to describe the whole interaction situation between the government and the public during this period, all this data was analysed.

The timeframe reflected that, on 8 January 2020, the National Health Commission confirmed the new coronavirus as the source of the pandemic. On 20 January, Zhong Nanshan, the leader of the high-level expert team at the National Health Commission, clarified that the spread occurred through human-to-human transmission. After late January 2020, COVID-19 thus became a matter of acute public and governmental concern. However, after 30 April 2020 official data indicated that, in China, the pandemic was under control with few new infections and industry operating again. This period was, therefore, the critical phase in China's domestic fight against the pandemic, and it was also the timeframe within which government, media, and public opinion were most concerned about the outbreak in China.

When the outbreak in China became relatively severe, the government and the media issued timely reports on pandemic-related information. The public exhibited acute concern about this information, and thus intensive willingness to participate in online interaction. Government official online social media, thus, provided rich research data and observation samples for studying the discourse system. Basic information about the 10 government WeChat official accounts is outlined in Table 2.

The basic data items obtained through research and capture, calculation analysis, and manual reading judgments were classified as G (interactive behavior by the government) or P (interactive behavior by the public). The specific government categorization was as follows G1, Associated with COVID-19; G2, Position of text; G3, Guide to reading the full text; G4, Original content; G5, Number of videos; G6, Additional audio; G7, Average daily number of texts; G8, Number of words in the text; G9, Importance of text; G10, Emotion of text, G11, Number of comment replies; and G12, Government response rate. Similarly, for the public the categories were, P1, Active followers; P2, Number of readings; P3, Number of thumb-ups; P4, Number of comments; P5, Number of thumb-up comments; P6, Number of lookings; P7, Number of thumb-up comment replies; and P8, Participation rate of the public.

G1 and G4 were evaluated through manual reading (three people made initial judgments; after data correction, the data was finally determined, and a 100% consistency pass rate was obtained). G7, G12, and P8 were calculated and analyzed to obtain the final data. G9 and G10 were the final data of the text analysis of the title and body using Python. The remaining items were derived from the webpage data of the official accounts. G2 assigned data according to the importance of the text's publication position (the headline is the most important, and so on). Finally, we studied the dimensionless processing of the data, so that the data mapping interval of all items is [0–100].

Text processing and analysis

Next, we outline the Python processes for textual analysis.

(i) Word segmentation and cleaning:

We deployed the *jieba word segmentation database* to perform word segmentation; using Chinese stop vocabulary, Harbin Institute of Technology stop vocabulary, Baidu stop vocabulary, and Sichuan University Machine Intelligence Laboratory stop vocabulary. The aim was to clean the word segmentation results.

(ii) Text content analysis:

(1) The title:

We identified the 100 highest frequency words in title texts and assigned a weight to each of those words. Each high-frequency word had an average weight.

The importance of $Text_i$ is calculated as follows:

$$TitleImportance_i = \sum_w w \times Weight_w \times TimesInTitle_w.$$

where i refers to the i-th text, w stands for the $TimesInTitle_w$-th high-frequency words, $Weight_w$ represents the weight of w, and all weights are taken as 1, and $TimesInTitle_w$ denotes the appearance of w in the title text frequency.

(II) Title and body:

1 https://www.newrank.cn/

TABLE 2 Basic information of WeChat official account.

Name of official account	Wechat certification authority	Estimated number of active followers (Data from "Xinbang" and "Xi Gua Data")	Number of texts/Average daily number of texts (The reference time period is 08 January 2020 to 30 April 2020)
China Government Network	China Government Network Operations Center of the General Office of the State Council	1691950	1137/10
Communist Party Member	Organization Department of the CPC Central Committee's Party Member Education and Cadre Evaluation Center	1038150	952/8
Communist Youth League Central Committee	Central Committee of the Communist Youth League of China	3028900	1557/14
Beijing Release	The Information office of the Beijing Municipal Government	124183	1303/11
Shanghai Release	The Information office of the Shanghai Municipal Government	1244750	2499/22
Guangdong Release	The Information office of the Guangdong Municipal Government	3028900	945/8
Hubei Release	The Information office of the Hubei Municipal Government	162367	2287/20
Wuhan Release	The Information office of the Wuhan Municipal Government	110302	2334/20
Beijing Center for Disease Control and Prevention	Beijing Center for Disease Control and Prevention	113545	468/4
Hubei Center for Disease Control and Prevention	Hubei Center for Disease Control and Prevention	84042	241/2

We identified the 100 highest frequency words appearing in titles and the main body of the analysis, and assigned a weight to each high-frequency word (see Table 3).

The title and body text importance analysis data was assigned to the variable G9, Importance of text.

The importance of $Text_i$ is calculated as follows:

$$G9_i = TextImportance_i$$

$$= \sum_w w \times Weight_w \times TimesInTitle_w$$

$$+ \sum_w w \times Weight_w \times TimesInContent_w$$

where i represents the i-th text and w refers to the w-th high-frequency words. $Weight_w$ stands for the weight of w. All weights are taken as 1, $TimesInTitle_w$ denotes the number of times w appears in the title, and $imesInContent_w$ refers to the number of times w appears in the text.

The longer the text, the higher the probability of containing high-frequency words, which would diminish the importance of shorter texts and so bias our analysis. To overcome, this problem, we, therefore, scaled the importance of the text with a length, specifically,

$$G9_i = TextImportance_i$$

$$= \sum_w w \times Weight_w \times TimesInTitle_w$$

$$+ Sacle\left(\frac{\sum_w w \times Weight_w \times TimesInContent_w}{Length_i}\right)$$

where $Scale(W_i) = W_i \times \frac{TitleImportance_{max}}{W_{max}} \times 2$ is equivalent to mapping the distribution interval of the importance of the text to the distribution interval of two times the importance of the title, thereby reflecting the importance of the text.

(iii) Text clustering:

The Latent Dirichlet Allocation topic modeling method was used for cluster analysis. Then the k-means clustering method was used to iterate 20 times, and the clustering results and topic words of each category were calculated. The resulting text topic categories are shown in Table 4.

(iv) Sentiment text analysis:

We use the *Sogou Sentiment Dictionary* as the basis of word classification. We give sentiments scores to each sentence according to sentence patterns and the frequency of emotional words, adverbs, negative words, and so on. Then we take the average of all sentence scores as the sentiment score of the text. The sentiment scores of all the texts were then linearly mapped to the interval of [−100, 100] to obtain G10. Daily average sentiment scores (see Figure 2) are within the range of [−0.26, 16.04]. The sentiment tends to be neutral and

TABLE 3 The first 100 high-frequency words statistics.

Word	Frequency	Word	Frequency	Word	Frequency	Word	Frequency
pandemic	75240	Related	11897	Discharged	8263	Policy	6493
Prevention and control	51411	Development	11840	People	8138	Area	6474
Job	40954	Country	11740	Support	8115	Center	6458
Wuhan	27276	Shanghai	11647	Construction	8108	WeChat	6450
pneumonia	26820	New	11418	Reporter	8080	Influence	6368
enterprise	24929	Infection	11149	Disinfect	8031	Way	6362
Case	24082	Measure	11001	Platform	7879	Ensure	6350
Hospital	23908	Beijing	10674	Unit	7831	Severe	6283
Personnel	20574	Source	10644	Grand total	7765	News	6150
COVID-19	18025	Coronavirus	10407	Department	7547	City	6124
Service	17409	Management	10370	Report	7512	Abroad	6046
Patient	17255	Add	10080	Produce	7374	Resume production	5999
China	16171	Information	9771	Treat	7274	Student	5958
Health	15990	Supply	9645	Treatment	7241	Meeting	5949
Confirmed	15717	Provide	9587	First line	7166	Advance	5940
Community	15662	Release	9566	Hubei province	7105	Fever	5906
Do well	14118	Period	9512	Activity	6952	Risk	5825
Time	14009	Organization	9467	pandemic prevention	6916	Community	5686
Situation	13692	Medical treatment	8983	Virus	6856	The masses	5648
Hubei	13629	Nationwide	8879	Protection	6794	School	5628
Mask	12617	Detect	8850	Xi Jinping	6727	Youth	5533
Isolation	12583	Implement	8670	Society	6710	Find	5454
Wuhan city	12230	Focus	8559	Citizen	6600	Further	5450
Guarantee	12214	Edit	8322	Enter	6545	Residents	5413
Resume work	12109	Life	8321	Hygiene	6541	Introduction	5316

TABLE 4 Results of text clustering.

Category	Words
The Global COVID-19 Pandemic	China, Pandemic, Country, COVID-19, America, Rumor, Virus, Global, International, Nationwide, Time, Organization, Vaccine, World, Pneumonia, My country, Cooperation, Media, Netizen, Anti-pandemic
Resumption of Work and Production	Enterprise, Pandemic, Resume work, Service, Policy, Support, Resume production, Produce, Related, Prevention and control, Influence, Employment, Guarantee, Provide, Handle, Period, Unit, Department, Funds, Development
Economic construction	Development, Construction, Job, Advance, Xi Jinping, Innovation, Promote, City, Get rid of poverty, Economic, Meeting, Industry, Project, Accelerate, Center, Promote, Tack, Perfect, System, Governance
Transportation and Travel	Shanghai, Reservation, Time, Open, Restore, Traveler, Information, Citizen, Traffic, Tourist, Park, Travel, Tourism, Service, Vehicle, Scenic spot, Passenger, Culture, Railway, Health
Pandemic Prevention and Control	Pandemic, Prevention and control, Gob, Personnel, Beijing, Pneumonia, Do well, Health, Measure, COVID-19, Management, Community, Implement, Guarantee, Hubei, Situation, Isolation, News, service, Focus
Pandemic Information Release	Case, Confirmed, Patient, Hospital, Pneumonia, Wuhan, Add, Discharged, COVID-19, Grand total, Hubei, Enter, Abroad, Report, Treatment, Severe, detect, Isolation, cure, new
Market Supervision	Consumption, Market, Sale, Vegetable, Price, Distribution, Case, Weather, Agriculture, Supermarket, Wildlife, Legal, Commodity, Consumer, Food, Illegal, Party, Store, Product, Release
Anti-Pandemic Measures	Mask, Disinfect, Health, Protection, Contact, Wear, Suggest, Symptom, Infection, Ventilation, Place, Coronavirus, Prevention, Virus, Do well, Pneumonia, Beijing, Period, Disease, New
The Front Line of the Battle Against the Pandemic	Pandemic, Wuhan, Hospital, First line, Medical Team, Gob, Time, People, Anti-pandemic, Child, Player, Volunteer, Doctor, Medical Personnel, Life, Nationwide, Party member, Hubei, Hope, Fight
Community Pandemic Prevention	Wuhan, Community, Hubei, Residents, Supplies, Community, Pandemic, Personnel, Mask, Service, Gob, Staff member, Street, Company, Introduction, Group, Prevention and control, Volunteer, Employee
Resumption of Classes and Employment	School, Student, Start of school, Time, Education, College, Back to school, Gob, Examination, Enrollment, Sign up, Recruitment, Study, Graduate, Candidate, Profession, Post, Related, Middle school, Information

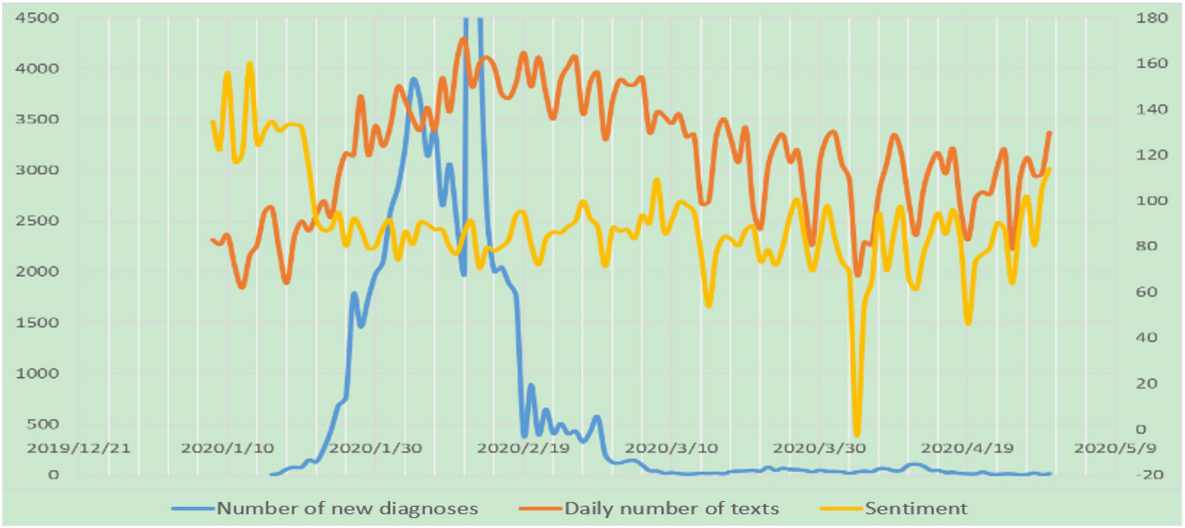

FIGURE 2
The trend of three sets of data.

positive, but fluctuations can be observed at some important time nodes, such as a significant drop for the national day of mourning on 4th April.

Data description and visual presentation

Data description

Of the 13,723 items of textual information incorporated within this study (see above), 9,735 (70.94%) elements were related to the pandemic. After 20 January, 12,765 items were posted, of which 9,705 (76.03%) concerned the pandemic. Here, we make preliminary observations on the collected and calculated data.

The data source for the number of newly confirmed cases was the official website of the National Health Commission of the PRC. For the period 16 January 2020 to 30 April 2020, we collected information on the daily number of newly confirmed cases in China (31 provinces, autonomous regions, and municipalities; and Xinjiang Production and Construction Corps). On 12 February, the 15,152 newly clinically confirmed cases (including 13,332 clinically confirmed cases in Hubei province) were recorded. However, to facilitate observation of the overall trends, we set the upper limit of the scale of the spindle axis at 4,500, thus data for 12 February could not be shown.

It can be observed from the graph that starting from 22 January, with the intensification of the outbreak in China and the closure of Wuhan on 23 January, the sentiment score of the texts published on the WeChat official account exhibited a substantive downward trend. On 4 April, the national day of mourning, the sentiment score was at its lowest negative. After 27 April, the sentiment score experienced an upward trend. The sentiment expressed in the texts of the WeChat official account was, therefore, closely related to the severity of the pandemic.

From 23 January, the number of daily texts on the WeChat official accounts began to increase. This trend continued until 14 March, when the quantity started to decline. A development that might be interpreted through success in starting to control the spread of COVID-19. Information released through government WeChat accounts was closely associated with the stage of the pandemic. Overall, the government succeeded in spreading information and emotional guidance during the critical period of the pandemic.

Data subject category analysis

Python performed a cluster analysis on the text of the title and body, and 11 categories were generated; specifically (C1) The Global COVID-19 Pandemic; (C2) Resumption of Work and Production; (C3) Economic Construction; (C4) Transportation and Travel; (C5) Pandemic Prevention and Control; (C6) Pandemic Information Release; (C7) Market Supervision; (C8) Anti-Pandemic Measures; (C9) The Front Line of the Battle Against the Pandemic; (C10) Community Pandemic Prevention; and (C11) Resumption of Classes and Employment (see Table 5).

There were interesting differences in the coverage and the topics published by the various government WeChat official accounts. As the official account of the central government, *China Government Network* focused more on C2, with emphasis on restarting the domestic economy. *Communist Party Member* and *Communist Youth League Central Committee*, as official CP accounts, focused more on C9, emphasizing progress in

TABLE 5 Distribution of text categories in different official accounts.

	The global COVID-19 pandemic	Resumption of work and production	Economic construction	Transportation and travel	Pandemic prevention and control	Pandemic information release	Market supervision	Anti-pandemic measures	The front line of the battle against the pandemic	Community pandemic prevention	Resumption of classes and employment	Total
China Government network	87	422	46	21	248	173	25	61	17	18	19	1137
Communist Party Member	60	50	128	13	118	122	15	36	376	29	5	952
Communist Youth League Central Committee	454	37	24	10	65	30	35	46	689	27	140	1557
Beijing Release	8	131	110	112	604	146	19	66	40	27	40	1303
Shanghai Release	35	242	166	637	255	314	236	209	131	50	224	2499
Hubei Release	20	131	168	54	773	462	75	71	154	355	24	2287
Wuhan Release	20	126	88	137	418	509	139	92	182	585	38	2334
Beijing Center for Disease Control and Prevention	5	1	3	6	76	124	2	228	15	0	8	468
Hubei Center for Disease Control and Prevention	5	0	1	1	12	13	0	197	11	0	1	241
Total	731	124	759	1027	2676	2173	608	1098	1745	1118	547	13723

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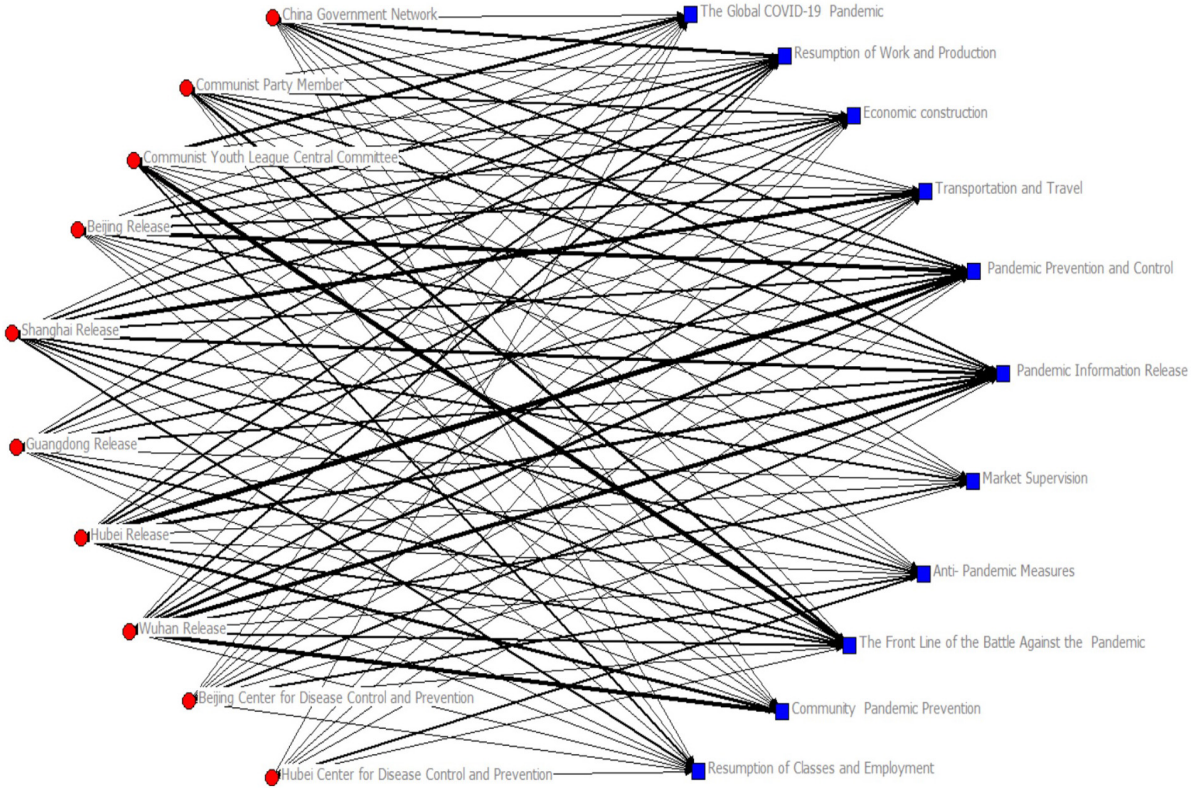

FIGURE 3
Distribution of text categories in different official account.

the frontline flight against COVID-19. The *Communist Youth League Central Committee* stressed information about the global pandemic (C1). Five local government official accounts – *Beijing Release, Shanghai Release, Guangdong Release, Hubei Release,* and *Wuhan Release* mainly considered C5 and C6, namely, prevention and control themes and information release. This selection reflected the functions of local government in controlling the spread of the outbreak and disseminating information about the pandemic in their locality. For such functional reasons, *Shanghai Release* paid particular attention to C4. Alternatively, at the epicenters of the Chinese outbreak, *Hubei Release* and *Wuhan Release* both stressed C10, specifically the role of the local community in pandemic prevention. Focusing on control and management of the pandemic and, of most importance, effective grassroots prevention activities. The local outbreak prevention departments also have their own verified WeChat official accounts, although the number following such accounts was low. As the WeChat official accounts, the *Beijing Center for Disease Control and Prevention* and the *Hubei Center for Disease Control and Prevention* stressed C8, reflecting the remit of those departments.

Next, a social network analysis of the matrix data was outlined. *Ucinet* software was deployed to analyze the network structure of the data matrix (see **Figures 3, 4** and **Table 5**).

Based on the matrix data of "data-category," the network diagram of two-mode is generated to analyze the focus of the government WeChat official accounts across our timeframe (see above).

During January, the 10 official accounts paid little attention to C1, C2, C7, or C11, which covered global, regulatory, and employment-production themes. Conversely, in January discussion about COVID-19 coalesced around themes such as C4 or C9. In particular, the arrival of the Spring Festival accounted for the emphasis on travel and transport matters, while reports about the initial spread of the virus in Wuhan explained the emphasis on C3 in the first half of the month, However, in the second half of January, with the outbreak in its early stages, the official accounts focused on themes such as C5, C6, C8, or C10, especially dissemination of information about COVID-19 and efforts to limit its spread.

It can be seen, from the network diagram for February, that the overall network density was significantly higher than in January. With the worsening of the severity of the outbreak, the focus on related themes intensified. The 10 official accounts barely focused on C3 or C11, both economic themes. At the end of the month, there was little attention paid toward global issues C1 or C4 or C7, transport, travel, and regulatory matters. This reflected the fact that China

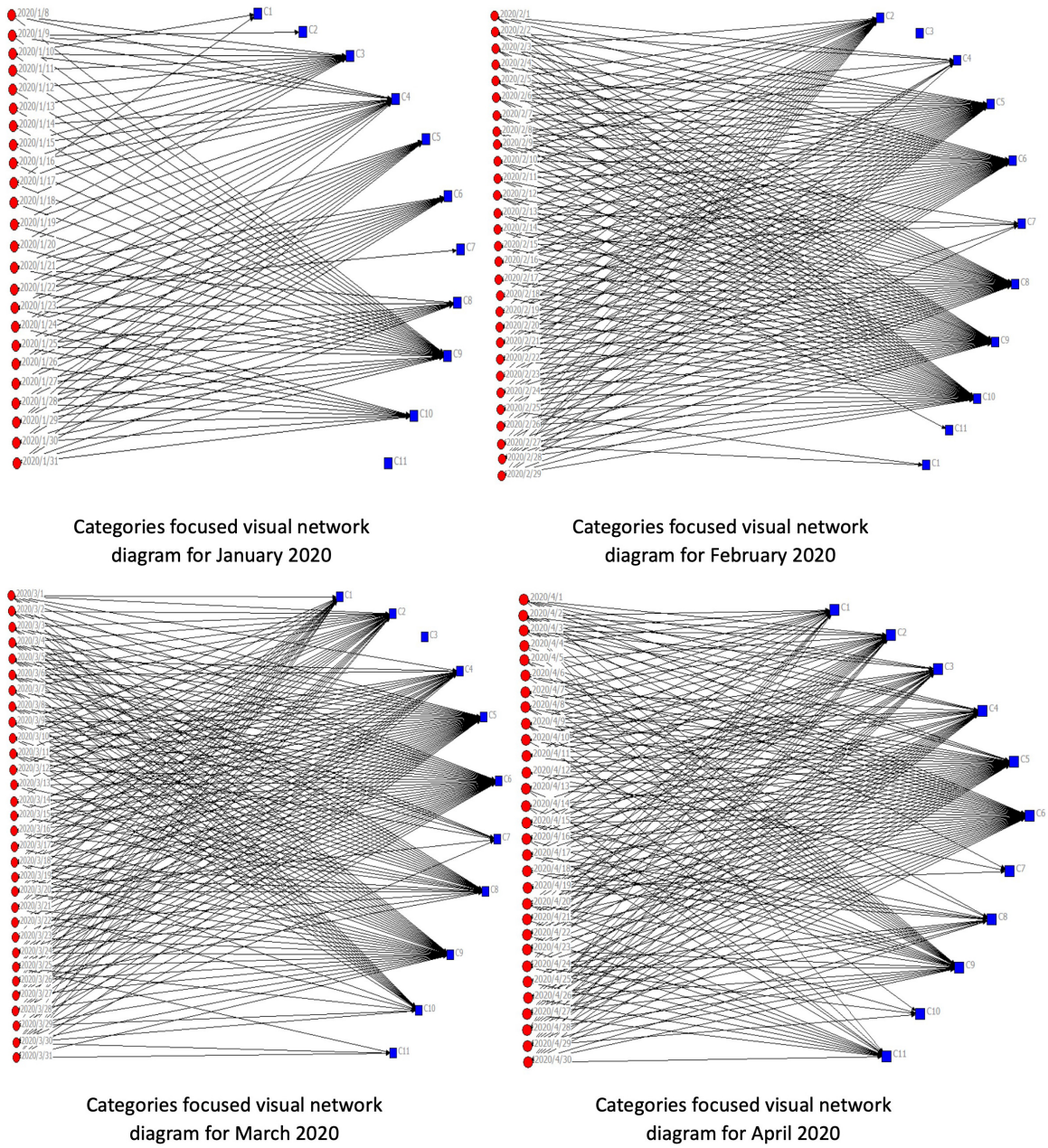

FIGURE 4
Categories focused visual network diagram for January 2021.

was at a crucial juncture in handling the medical emergency. Substantive parts of business and society were not functioning, and the state had issued instructions to prevent gatherings and reduce population movement. Throughout February, the emphasis was on C2 (resumption of work and production). C5 (pandemic prevention and control), C6 (pandemic information release), C8 (anti-pandemic measures), C9 (the front line of the battle against the pandemic), and C10 (community pandemic prevention). Most Chinese regions were at a high or the highest-level of public health emergency response. Government official accounts released a large amount of outbreak-related information on time, reflective (in part) of public hunger for information about the crisis. After the Spring Festival, and the peak period of the outbreak, the state aimed for an orderly resumption of work and production in different sectors, while fighting the pandemic.

As can be observed, from the network diagram, in March the 10 official accounts seldom focused on C3. At the start

of the month, official accounts stressed C10 (community pandemic prevention), although this focus declined as control measures became more effective. From mid-to-late March, there was relatively little emphasis on C7 (market supervision). Meanwhile, the emphasis on transportation and travel (C4) increased as travel restrictions were liberalized. Simultaneously, the global spread of the pandemic was reflected in renewed stress on C1. At the end of March, increased attention was directed at C11 (resumption of classes and employment), reflective of expectations of the re-emergence of a more normal lifestyle. Throughout March, the pandemic remained an important topic on social media. There was an intensive focus on five themes – C2 (resumption of work and production); C5 (pandemic prevention and control), C6 (pandemic information release), C8 (anti-pandemic measures), and C9 (the front line of the battle against the pandemic). In March, China began to resume work and production in multiple industries, and, at the same time, the country was also in a critical period for pandemic preventive work.

In April, emphasis on C10 (community pandemic prevention) substantively diminished, reflecting the fact that the community prevention work was near its completion, although there was still a limited focus on C7 (market supervision). The restarting of the economy was reflected by a renewed emphasis on C3 (economic construction), in comparison with February and March. Official accounts also focused on C2 (resumption of work and production) and C11 (resumption of classes and employment). However, the emphasis on C8 (anti-pandemic measures) decreased significantly. This trend reflected two factors, first, the extensive media campaign meant that basic protective measures, such as increased ventilation, wearing masks, frequently washing hands, fewer social gatherings, and social distancing, had already been widely implemented. Second, evident progress made in containing the pandemic in China meant that some strict pandemic prevention measures were liberalized or cancelled. Furthermore, throughout April, the official accounts kept focusing on the five themes – C1, C4, C5, C6, and C9, reflecting, for instance, the global spread of COVID-19 and continuing attempts to control the pandemic.

Data analysis and results

Drawing on Fox and Miler's (1994) specification of warrants and guarantee conditions for discourse legitimacy, we developed six elements for both government and the public. First, for the government, we had Ga, Sincerity of interactive participation," "Gb, Situation of interactive participation," "Gc, Willing attention of interactive participation," "Gd, Substantive contribution of interactive participation," "Ge, Equal interaction," and "Gf, Partial interaction." Second, at the public level we specified "Pa, Sincerity of interactive participation," "Pb, Situation of interactive participation," "Pc, Willing attention of interactive participation," "Pd, Substantive contribution of interactive participation," "Pe, Equal interaction," and "Pf, Partial interaction."

The formulas for calculating the score of each element were as follows,

$$Ga_{Score} = \frac{G1 + G2 + G3}{3}; \quad Gb_{Score} = \frac{G4 + G5 + G6}{3};$$

$$Gc\_Score = (G7 + G8)/2;$$

$$Gd_{Score} = \frac{G9 + G10}{2}; \quad Ge_{Score} = G11; \quad Gf_{Score} = G12 = \mathrm{G11/P4}.$$

$$Pa_{Score} = P1; \quad Pb_{Score} = P2; \quad Pc\_Score = (P3 + P4 + P5)/3;$$

$$Pd_{Score} = P6; \quad Pe_{Score} = P7; \quad Pf_{Score} = P8 = P4/P2.$$

First, the objective was to measure the *public energy field* of selected WeChat official accounts at both government and the public levels. Second, the *public energy field* was used to explore interactions between the various elements comprising the field. The government deployed its WeChat official accounts to publish and disseminate information and give the public a secure online interactive platform. Since the government controlled the screening, editing, and publishing of information, we assumed that the government-level *public energy fields* in the government WeChat public accounts were larger than the public-level energy fields. Of course, our study had been contextualized through the reality that, during the relatively severe stage of the pandemic outbreak, the degree of attention and interaction to incident information in cyberspace would be much greater than usual.

This study also assessed the interaction between government and the public. *Gf*, *Partial interaction* and *Pf*, *Partial interaction,* reflecting the *partial* public participation and the government's response to this *partial* interaction. Since the values of these two elements were calculated through data from other indicators, they also reflected that *some people* were involved in the interaction. Gf and Pf were, therefore, excluded from our analysis to avoid multicollinearity when calculating the interaction of various elements.

TABLE 6 Descriptive statistics for Ga, Gb, Gc, Gd, Ge, and Pa, Pb, Pc, Pd, Pe.

	Minimum	Maximum	Average	Standard deviation	ADF test statistic	*P*-value
Ga	0	1	0.5006	0.1894	−11.2932	0.01
Gb	0	1	0.0883	0.1601	−22.1334	0.01
Gc	0	0.9854	0.3692	0.1522	−26.6127	0.01
Gd	0	0.7215	0.3454	0.0913	−17.9018	0.01
Ge	0	1	0.0077	0.0351	−22.8365	0.01
Pa	0	1	0.2707	0.3195	−28.2438	0.01
Pb	0	1	0.4327	0.4241	−28.9700	0.01
Pc	0	0.5994	0.0448	0.0764	−25.5811	0.01
Pd	0	1	0.0130	0.0356	−23.1734	0.01
Pe	0	1	0.0052	0.0401	−23.2137	0.01

TABLE 7 The Granger causality test between Ga, Gb, Gc, Gd, Ge, and Pa, Pb, Pc, Pd, Pe.

Null hypothesis	Test statistic	*P*-value	Null hypothesis	Test statistic	*P*-value
Ga Granger causes Pa	14.2549	0.00	Pa Granger causes Ga	10.1460	0.00
Gb Granger causes Pb	7.1564	0.00	Pb Granger causes Gb	6.7218	0.00
Gc Granger causes Pc	22.8300	0.00	Pc Granger causes Gc	8.0561	0.00
Gd Granger causes Pd	22.5712	0.00	Pd Granger causes Gd	8.9893	0.00
Ge Granger causes Pe	3.8649	0.01	Pe Granger causes Ge	0.6075	0.61

Social discourse between public and government

Summary statistics for Ga, Gb, Gc, Gd, Ge, and Pa, Pb, Pc, Pd, Pe were tabulated (see Table 6). This data indicated that Ga, Gb, Gc, Gd, Ge, and Pa, Pb, Pc, Pd, Pe were stationary. Results that allowed us to build a vector autoregression (VAR) model, and conduct likelihood ratio tests to detect whether interactions between government and the public were statistically significant.

The model is based on the following formula:

$$y_t = c + \Phi_1 y_{t-1} + \Phi_2 y_{t-2} + \cdots + \Phi_p y_{t-p} + \varepsilon_t, \qquad (1)$$

where y_t refers to the $13,728 \times 10$ matrix, and p stands for the order of VAR, which is selected based on Akaike information criterion (AIC). Here $p = 3$. The VAR model can be estimated by using the maximum likelihood (ML) method. If there was no significant interaction between the government and the public (H_0), the coefficient matrices Φ_i would be block-diagonal, namely,

$$\Phi_i = \begin{bmatrix} \Phi_{i,G} & 0 \\ 0 & \Phi_{i,P} \end{bmatrix}, \qquad (2)$$

where Φ_i refers to the 10×10 matrix, and 0's stand for the 5×5 zero matrices. Based on the restriction, we could obtain the restricted likelihood ($\mathcal{L}_0^*$). If there was social discourse between government and the public, all off-diagonal entries for Φ_i would be free to deviate from zero, and the corresponding likelihood function would be referenced as the unrestricted likelihood ($\mathcal{L}_1^*$). In general, we expect $\mathcal{L}_0^* \leq \mathcal{L}_1^*$, because $\mathcal{L}_0^*$ is obtained under restriction. However, if H_0 is valid, we would expect that $\mathcal{L}_0^*$ and $\mathcal{L}_1^*$ were close to each other. Based on this intuition, we formulated the likelihood ratio test based on $\mathcal{L}_0^*$ and $\mathcal{L}_1^*$, which, under the null, follows χ^2 distribution with 150 degrees of freedom, therefore, $2\left(\mathcal{L}_1^* - \mathcal{L}_0^*\right) = 1364.63$. It can be seen that the statistic was highly significant, and H_0 was rejected at even the 1% significance level. Thus, we could safely conclude that there was a significant social exchange between the public and the government.

We also considered the Granger causality test (Granger, 1969), which is a statistical concept of causality based on predictability. Here, we appraised the influence of the public and the government regarding our five dimensions (see the start of section "Social discourse between public and government"). Considering Ga and Pa, if the public's sincerity of interactive participation did not affect that of the government, we would expect that the inclusion of Pa in the regression analysis would not improve the predictive power of a time series model based on Ga only. If the inclusion of Pa could improve the predictive power in a significant fashion, we might conclude that the sincerity of interactive participation from the public (Pa) influenced that of the government. These results are tabulated in Table 7.

The government's social discourse, in terms of sincerity, situation, willing attention, substantive contribution and equal interaction, had a significant influence on the public's social discourse. However, equal interaction on the public side (Pe) did not Granger cause that of the government, or equivalently, it did not have predictive power over the *Ge*, *Equal interaction*.

The Granger causality tests are only beneficial for determining whether the influence was significant, not the direction of influence. To remedy this deficiency, we deployed the orthogonal impulse response function. The results are summarized in **Figure 5** and the red lines indicate a 95% confidence interval.

In general, the plots from **Figures 5A–E** implied that the public first reacts negatively to "Ga, Sincerity of interactive participation" in a significant fashion; "Gb, Situation of interactive participation" had no significant influence on the public; "Gc, Willing attention of interactive participation" first enhanced public interaction significantly; "Gd, Substantive contribution of interactive participation," and "Ge, Equal interaction" also had no significant effect initially on the public. Furthermore, the plots from **Figures 5F–J** suggested that Pa, Pb, Pc, Pd, and Pe lead immediately and significantly to the changes in Ga, Gb, Gc, Gd, Ge; and that it is worth noting that the situation of interaction, the willing attention of interaction and the equality of interaction were reduced in a significant fashion with the increase in those government indicators. To some extent, therefore, the government's social discourse weakens that of the public. In general, the analysis based on the orthogonal impulse response function suggested that social discourse between the government and the public was unbalanced, with each of the five indicators implying that the government took the lead. The imbalance in dialog also reflected governmental control over the information released in WeChat official accounts. The amount of information posted by the public on those accounts was relatively small. However, it did not affect the equal dialog, because the government's WeChat official account supplied the channel for interactive dialog.

Social discourse analysis based on principal components

Principle Component Analysis (PCA) was undertaken on Ga, Gb, Gc, Gd, Ge, and Pa, Pb, Pc, Pd, Pe to further refine the analysis. We hypothesized that these principal components might explain 80% of variations in Ga, Gb, Gc, Gd, Ge and Pa, Pb, Pc, Pd, Pe, respectively. Three main components were extracted from the government dimension, namely, *Fac*1.*Government*, *Fac*2.*Government*, and *Fac*3.*Government*. Two main components were extracted from the public dimension, namely, *Fac*1.*Public* and *Fac*2.*Public*. Referring to the component score coefficient matrix, the calculation formula for each component score was obtained as follows:

$$Fac1.Government = 0.142Ga + 0.580Gb - 0.562Gc - 0.192Gd + 0.044Ge$$

$$Fac2.Government = 0.551Ga - 0.016Gb + 0.073Gc + 0.679Gd - 0.005Ge$$

$$Fac3.Government = 0.080Ga + 0.201Gb + 0.181Gc - 0.073Gd + 0.938Ge$$

$$Fac1.Public = 0.445Pa + 0.411Pb + 0.197Pc + 0.173Pd - 0.220Pe$$

$$Fac2.Public = -0.249Pa - 0.123Pb + 0.289Pc + 0.247Pd + 0.802Pe$$

*Fac*1.*Government* was mainly composed of "Gb, Situation of interactive participation," which reflected context and relevance of governmental social media interaction and its emphasis on the originality and design of information release. *Fac*2.*Government* primarily comprised "Ga, Sincerity of interactive participation" and "Gb, Situation of interactive participation" and reflected the government's sincere and effective participation in social media interaction as well as generation of relevant content. *Fac*3.*Government* was largely comprised of "Ge, Equal interaction," reflective of the equal dialog in social media, with the government paying attention and responding to public comments.

*Fac*1.*Public* overwhelming comprised "Pa, Sincerity of interactive participation" and "Pb, Situation of interactive participation." This outcome reflects the public's sincerity and the relevance of the public's communication with the government on social media. If the public become active followers, they will pay attention to the information released by the government. *Fac*2.*Public* mainly reflected "Pe, Equal interaction," which was derived from the social media dialog. The public notice governmental feedback on comments, while the content of texts released by the WeChat official accounts stimulated dialog and opinion exchanges between the parties. The five components of *Fac*1.*Government*, *Fac*2.*Government*, *Fac*3.*Government*,*Fac*1.*Public*, and *Fac*2.*Public* were used to assess each WeChat official account in each month and so evaluate the relevant *public energy field.* Results are shown in **Table 8**.

The scores obtained through using PCA were relative values. To further understand the data, we used an accumulation scale graph. The distribution of the diagram of the components was, therefore, constructed through those scores (see **Figure 6**).

Overall, the government's *public energy field* was reflected through *Fac*1.*Government* and *Fac*2.*Government*, while the public's *public energy field* was reflected in the *Fac*1.*Public*. However, the proportion of *Fac*3.*Government* and *Fac*2.*Public* were very low. Since the government controlled the release

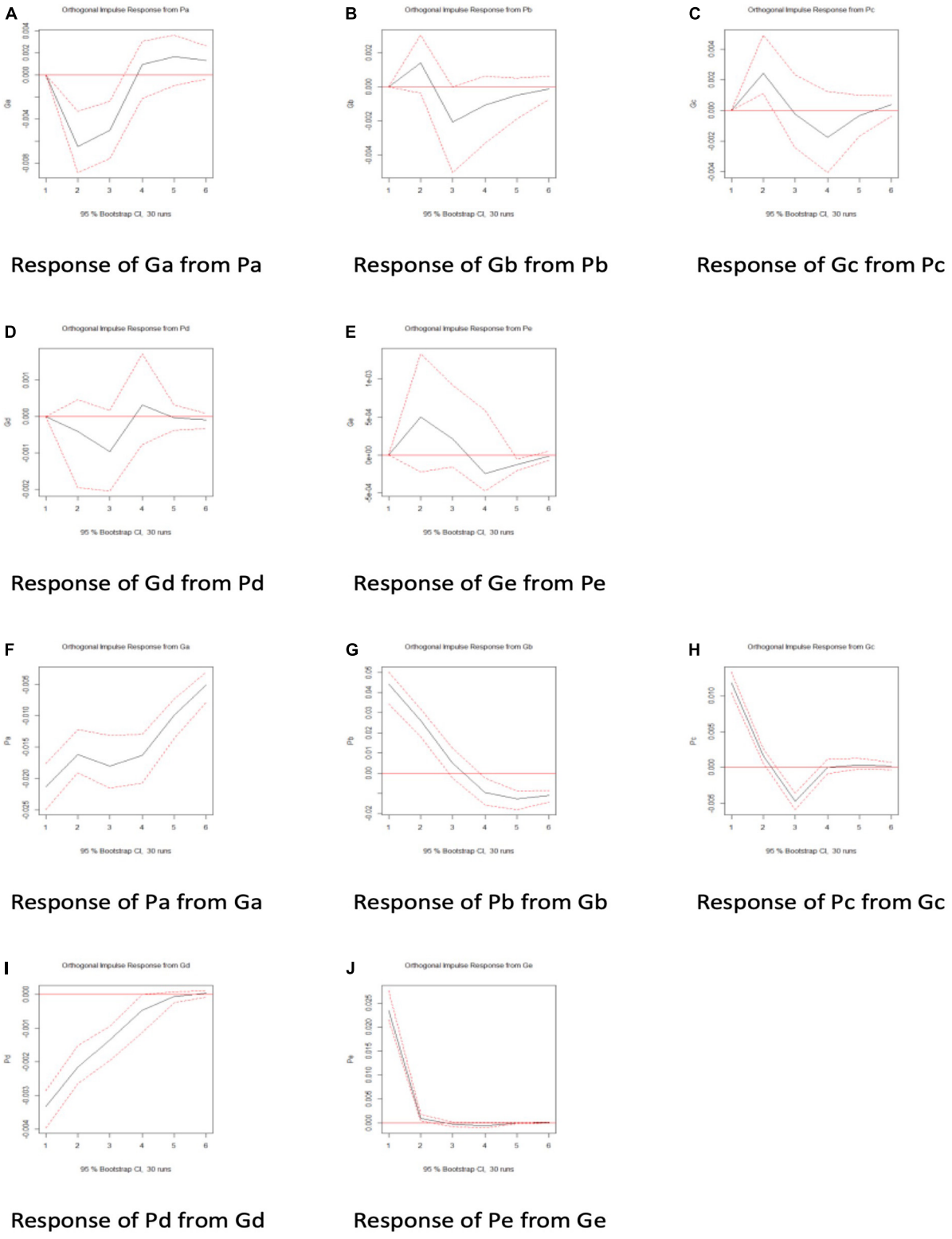

FIGURE 5
(A–J) The impulse response functions between Ga, Gb, Gc, Gd, Ge, and Pb, Pl, Pc, Pd, Pe.

TABLE 8 Principal component scores.

	Fac1.Government Gb	*Fac2.Government* Ga & Gd	*Fac3.Government* Ge	*Fac1.Public* Pa & Pb	*Fac2.Public* Pe
Total	5534.964	6166.774	461.777	4498.014	585.154
China Government Network	666.847	543.126	32.298	466.779	29.121
Communist Party Member	481.526	407.876	17.602	345.221	37.458
Communist Youth League Central Committee	657.286	629.708	55.666	758.845	53.381
Beijing Release	675.181	661.314	34.02	329.785	53.95
Shanghai Release	710.815	955.673	160.413	931.244	151.586
Guangdong Release	474.71	434.807	18.146	309.246	38.273
Hubei Release	662.457	1080.404	61.103	571.104	92.571
Wuhan Release	709.472	1154.171	65.817	604.877	99.797
Beijing Center for Disease Control and Prevention	312.146	203.83	10.086	120.393	19.031
Hubei Center for Disease Control and Prevention	184.525	95.864	6.357	60.545	9.986
January	868.989	916.037	63.105	767.929	95.993
February	1740.512	2111.143	140.488	1405.243	185.391
March	1596.912	1790.629	149.149	1258.323	174.372
April	1328.552	1348.965	109.034	1066.519	129.397

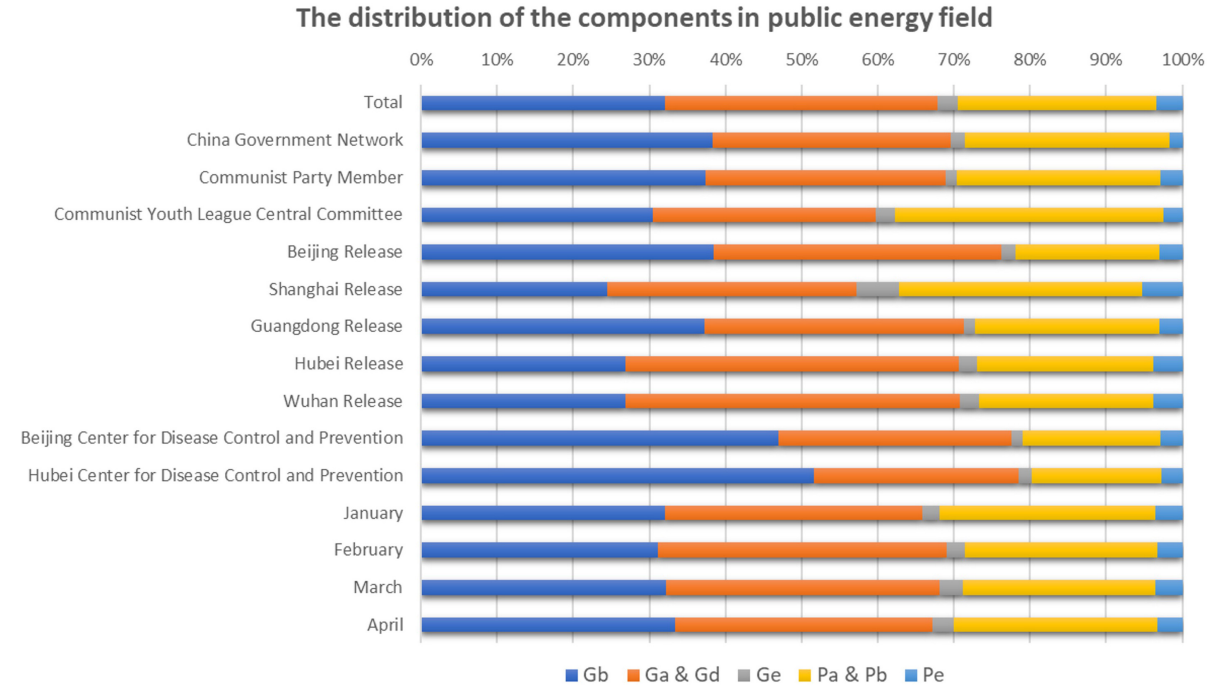

FIGURE 6
The distribution of the components in public energy field.

of information and the public was merely the recipient of information, the government ranked above the public in terms of discourse energy. The scores for *Fac*1.*Government* and *Fac*2.*Government* were, therefore, higher than those registered for *Fac*1.*Public*.

We observed and analyzed the data in Table 6. Comparatively, the number of followers for *Shanghai Release* was substantive and the public paid much attention to the information released by the municipal government. Overall, the public had a high degree of participation in interactive dialogs. The *Communist Youth League Central Committee* also had a large number of followers, and the public paid considerable attention to the information released. However, the public's participation in interactive dialogs was slightly

TABLE 9 The Granger causality test between Principle Component Analysis (PCA) results.

Null hypothesis	Test statistic	*P*-value	Null hypothesis	Test statistic	*P*-value
Fac1.Government **Granger causes** *Fac1.Public*	168.5707	0.00	*Fac1.Government* **Granger causes** *Fac2.Public*	27.50891	0.00
Fac2.Government **Granger causes** *Fac1.Public*	7.6425	0.00	*Fac2.Government* **Granger causes** *Fac2.Public*	22.5199	0.00
Fac3.Government **Granger causes** *Fac1.Public*	8.0188	0.00	*Fac3.Government* **Granger causes** *Fac2.Public*	6.1151	0.00
Fac1.Public **Granger causes** *Fac1.Government*	1.0125	0.39	*Fac2.Public* **Granger causes** *Fac1.Government*	4.6090	0.00
Fac1.Public **Granger causes** *Fac2.Government*	11.6780	0.00	*Fac2.Public* **Granger causes** *Fac2.Government*	41.9244	0.00
Fac1.Public **Granger causes** *Fac3.Government*	10.0071	0.00	*Fac2.Public* **Granger causes** *Fac3.Government*	15.7424	0.00

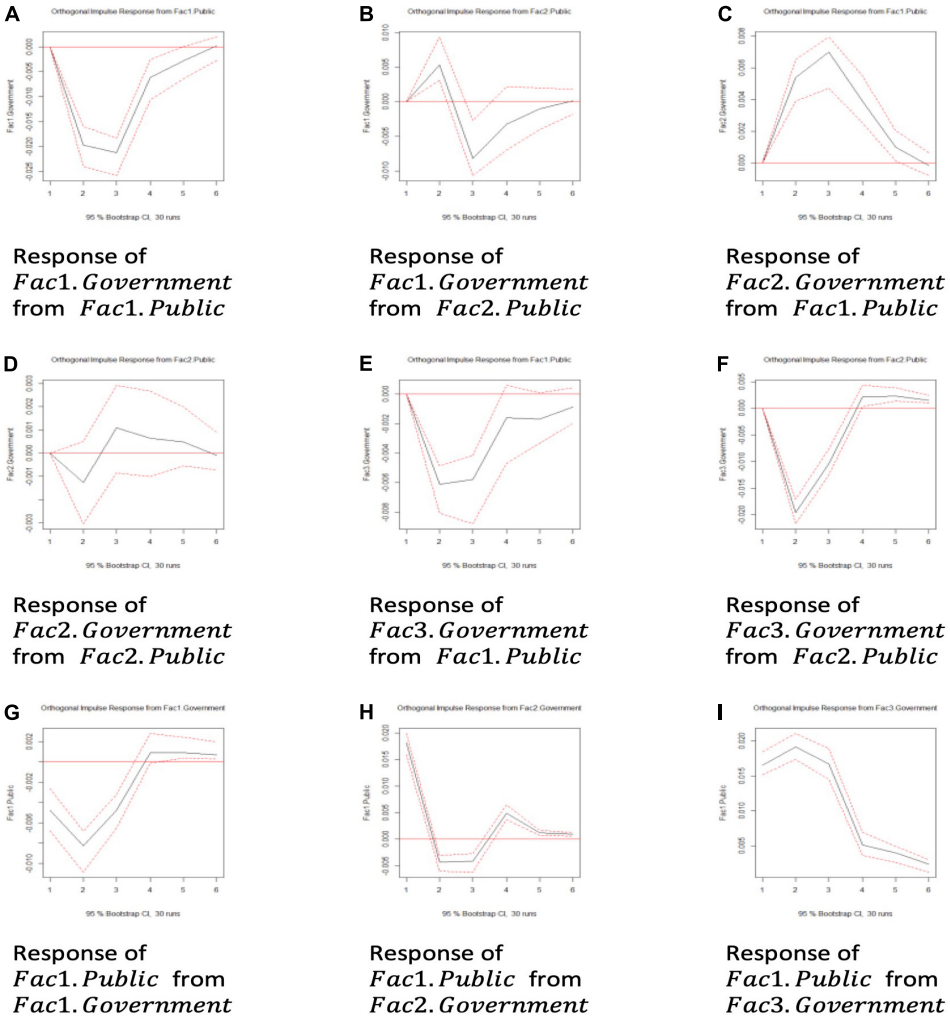

FIGURE 7
(A–I) The impulse response function between principle components.

lower than for *Shanghai Release*. Because Wuhan and Hubei were seriously affected by COVID-19, the *public energy fields* for the government and the public registered for *Hubei Release* and *Wuhan Release* were higher than those of other local government WeChat official accounts. This finding implied that both the Wuhan government and the Hubei government were

working hard to achieve timely release and disclosure of the information about the pandemic and that the public's yearning for such information and interaction exceeded that of other localities. The *Beijing Center for Disease Control and Prevention* and the *Hubei Center for Disease Control and Prevention*, as well as the WeChat official account of the regional *Center for Disease Control and Prevention* (CDC), failed to register high scores for either *public energy field*, The low score for the public's *public energy field* reflecting the modest number of followers, which was a consequence of public reading habits. The public concentrated on WeChat official accounts, as indicated by the large number of followers, of central, provincial, and municipal governments. The domestic pandemic information released through those accounts broadly satisfied public requirements, thus the public neglect of the CDC accounts. Given that the peak of the outbreak occurred in February and March, all *public energy fields* in February and March were higher than in January or April.

We also observed and analyzed the data in Figure 6. For the *Beijing Center for Disease Control and Prevention* and the *Hubei Center for Disease Control and Prevention*, the performance of *Fac*1.*Government* was outstanding. Those WeChat official accounts were performing effectively regarding "Gb, Situation of interactive participation." The government's inclination to participate in social media interaction was very strong – the proportion of *Fac*1.*Government* was significantly high.

For *Shanghai Release* and the *Communist Youth League Central Committee*, the performance of *Fac*1.*Public* was, again, outstanding. Those WeChat official accounts performed effectively concerning "Pa-Sincerity of interactive participation" and "Pb-Situation of interactive participation." The number of followers and text readings on those WeChat official accounts was substantive, ensuring good public interaction. For *Wuhan Release* and *Hubei Release*, the performance of *Fac*2.*Government* was outstanding. Those two WeChat official accounts were effective for "Ga, Sincerity of interactive participation" and "Gd, Substantive contribution of interactive participation" As the epicenter of the epidemic, *Wuhan Release* and *Hubei Release* indicated that the government's participation in such social media interaction was sincere and effective and that the government had made substantive efforts to edit content and release information about the disaster.

Next, we conducted a Granger causality test on the PCA results. The bivariate Granger causality test results are summarized in Table 9.

This analysis showed that the *Fac*1.*Public* did not Granger cause *Fac*1.*Government*. This finding confirmed the result of the orthogonal impulse response analysis, that government leads the social discourse process and the public follows. Moreover, given that the rest of the Granger causality tests are statistically significant, and that each of the PCA components comprised all five dimensions, these Granger causality results implied complex interactive relationships involving the government and the public.

We generated impulse response functions based on these principle components. The significance level was again set to 95%; and, for simplicity, we only incorporated significant results, when the confidence intervals did not contain zero during five periods.

As can be observed from Figure 7, all the impulse response functions were significant, apart from Plot (d). *Fac*2.*Government* reflected the government's efforts in editing the released information; while *Fac*2.*Public* concerned the equality of social media dialog – whether WeChat official accounts had generated dialogs and genuine opinion exchanges between the government and the public. The insignificant result obtained from Plot (d) (see Figure 6) implied, however, that the interaction between the public and the government was unbalanced with the government prevailing and that the government should improve information release to balance the *public energy field*.

Has China delayed dissemination of COVID-19-related information

Since the outbreak of the COVID-19 pandemic, the Chinese government has faced increasing criticism for its transparency in relation to the emergency. We, therefore, estimate whether the Chinese government delayed the release of vital information. We make the following three assumptions. First, it is not reasonable or even possible for China to withhold such details

TABLE 10 Can government social discourse Granger cause the new diagnosis?

Null hypothesis	Test statistic	*P*-value
Ga Granger causes new diagnosis	125.3506	0.00
Gb Granger causes new diagnosis	125.3506	0.00
Gc Granger causes new diagnosis	7.949397	0.00
Gd Granger causes new diagnosis	22.68522	0.00
Ge Granger causes new diagnosis	30.53451	0.00
*Fac*1.*Government* Granger causes new diagnosis	0.7621662	0.52
*Fac*2.*Government* Granger causes new diagnosis	69.52285	0.00
*Fac*3.*Government* Granger causes new diagnosis	1.5368	0.20

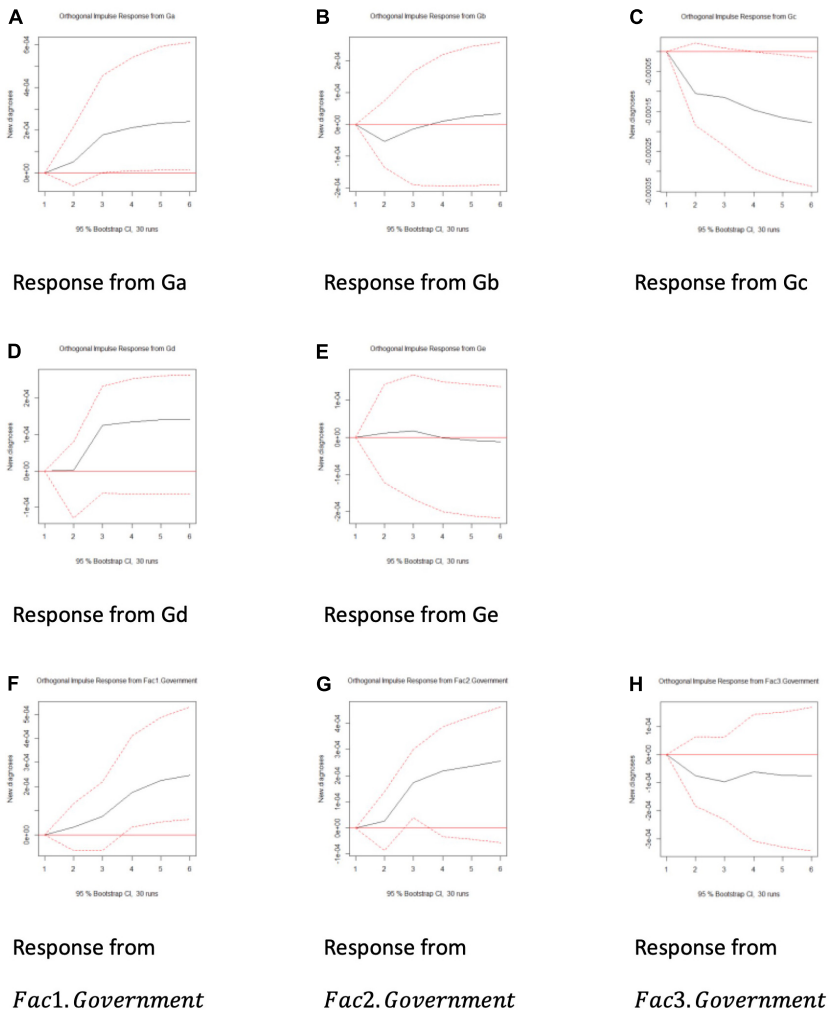

FIGURE 8
(A–H) The impulse response function of various factor on the number of new diagnosis.

permanently; this information would be gradually disseminated to the public. The Chinese government might risk serious repercussions if the public eventually discovered that official information had been misleading. Second, delays in the release of information about COVID-19 might be interpreted through aims to prevent a public overreaction and allow the government to prepare its response. Third, these WeChat official accounts would be among the first sources to disseminate such information.

If these three assumptions held, we should find that some of Ga, Gb, Gc, Gd, and Ge; or alternatively, *Fac*1.*Government*, *Fac*2.*Government*, and *Fac*3.*Government* have predictive power over new COVID-19 cases. We establish two VAR models, the first of which comprised Ga, Gb, Gc, Gd, Ge, and new COVID-19 cases; while the second comprised *Fac*1.*Government*, *Fac*2.*Government*, *Fac*3.*Government*, and new COVID-19 cases; the Granger-causality test results are summarized in **Table 10**.

These results implied that the government's social discourse Granger causes the number of new diagnoses, namely, the government's social discourse has predictive power over new diagnoses. This finding indicated that there might have been a time lag in releasing the information related to the COVID-19 pandemic. The Granger causality tests based on the principle components suggested that only *Fac*2.*Government* was statistically significant, whereas *Fac*1.*Government* and *Fac*3.*Government* were insignificant. Those results implied that the government dialogue lacked sincerity and contemporary relevance, which was consistent with the insignificant result of Plot (d) in **Figure 6**. The sincerity and situation of interactive participation from the government (*Fac*2.*Government*) were not affected by the public dialog (*Fac*2.*Public*).

If the government delays information dissemination, we would expect the relationship to be significant and positive. To explain the causal direction of this relationship, we generated

orthogonal impulse response functions for various factors on the number of new diagnoses (see **Figure 8**).

The plots from (a) to (e) concerned the orthogonal impulse response functions of the number of new COVID-19 cases from Ga to Ge, while the plots from (f) to (h) were the impulse responses for three principle components: Fac1.Government, Fac2.Government, and Fac3.Government.

Arguably, if the government had delayed the dissemination of vital information, we should be able to observe significant and positive impulse response functions, indicating that an enhancement in social discourse on the government's side increased new COVID-19 cases. From Plot (a) it can be observed that Ga has significant and positive impulse responses over a new diagnosis, implying potential information withholding. However, Plot (c) suggested that across a longer timeframe, the influence of Gc on new diagnoses was negative; therefore, perhaps the government's interaction across a longer period might reduce the number of new COVID-19 cases.

Unfortunately, the first two principal components (Fac1.Government and Fac2.Government) suggested significant positive influences, with the third being negative, *albeit* it was insignificant. This finding implied that, perhaps, the negative influence in Plot (c) might be marginal, given that those three principal components explained 80% of the data variations.

Although this analysis implied that the government might have slowed the release of vital information about COVID-19, it did not exclude the possibility that the government might have supplied a reasonable prediction about the future course of the pandemic and, therefore, reacted proactively to combat the pandemic. The Chinese government might have adopted the predictions from the National Health Commission about future trajectories of the pandemic and moved in response to probable future trajectories. Of course, it might be explained through a time lag in CDC's statistics on the new COVID-19 cases.

Conclusion

Social media is being incorporated as an important governing tool (Bonsón et al., 2012; Mergel and Bretschneider, 2013), a process that, for instance, has occurred in China, principally through the establishment of official social media accounts. The importance of this new media has been seen through global trends to regulate social media communications (Al-Aufi et al., 2017) and growing governmental awareness of the importance of effectively engaging with public opinion through social media discourse. In particular, social media has the potential to increase governmental responsiveness to public attitudes and agendas (Al-Aufi et al., 2017). We have shown that the Chinese government and the public interact online to deal with major emergencies. Meanwhile, the establishment of proper discourse systems and *public energy fields* is required to create effective dialog interactions in social media, so that government and the public both benefit from these network platforms.

The conclusions generated through this study are as follows. First, analysis of (e) equal interaction and (f) partial interaction implied that the discourse system embodied through the government official accounts had legitimate conditions for *equal* and *some people* dialog. In such an equal space for dialog, both the government and the public can be energized and influence each other, conditions that assist the government in supplying public services and encourage the public to participate in shaping the public policy agenda. Nevertheless, our results show that the current dialog is unbalanced in favor of the government; circumstances derived from the fact that the public has relatively little information to disseminate. The government's influence is, therefore, significant, as a consequence of its capacity to disseminate information through those accounts. Intensive public discussion of such details (of course) increases governmental influence regarding those nuggets of information, the converse public reaction diminishes such government influence.

Second, from the analysis of (a) sincerity of interactive participation, (b) situation of interactive participation, (c) willing attention of interactive participation, and (d) substantive contribution of interactive participation, we found that the government's WeChat official accounts struggled to achieve good results in all four aspects simultaneously. Overall, our findings implied that the government should focus more on "situation of interactive participation," "sincerity of interactive participation," and "substantive contribution of interactive participation." In response, the public should increase its emphasis on "sincerity of interactive participation" and "situation of interactive participation." In summary, the government's social discourse had a significant influence over the public's social discourse, thus illustrating the potential of those WeChat official accounts as influential *public energy fields*.

Third, government official accounts with more followers had more energy and dialog interactions. Those WeChat official accounts, such as the *China Government Network*, *Communist Party Member*, the *Communist Youth League Central Committee*, the *Shanghai Release,* and the *Guangdong Release*, have many active followers and enhanced *public energy fields*. Overall, WeChat official accounts exhibited substantive virtual social capital (through many active followers), which facilitated information dissemination and government–public interaction. The accumulation of virtual social capital will intensify the influence of WeChat official accounts. Our study also suggested that WeChat official accounts should consider the influence of the followers, as well as the active interaction with the public and the continuous increase of the number of active followers, to increase their influence.

Fourth, in response to the COVID-19 outbreak in China, the government's WeChat official accounts released comprehensive and timely information on 11 themes (see above). The number of posts, the emotional context of the texts, the topics of concern, and the number of readings were altered to reflect contemporary circumstances. It can be argued that the *public energy fields* presented by both the government and the public effectively portrayed and reflected the actual situation of the pandemic in China. However, the Granger causality tests revealed that the information content of the government accounts had predictive power over new COVID-19 cases, findings perhaps implying that there was a lack of transparency over the timeliness of the release of the information related to COVID-19. However, those results did not exclude the possibility that the government acted proactively in response to its predictions about the course of the pandemic. This outcome might also reflect the time lag in summarizing the new COVID-19 cases.

In general, those government WeChat accounts released information in a timely, comprehensive, and accurate manner, thereby meeting at least some of the public's information requirements. Those accounts can guide and alter public behavior to assist with the resolution of social problems. Different WeChat official accounts have different *public energy fields* and concerns, reflecting contrasting organizational responsibilities and the accumulation of virtual social capital. Regarding the COVID-19 pandemic, although the *public energy field* of the government, reflected through the public accounts, was slightly larger than that of the public, the government had managed to generate substantive interaction with the public and assist the public in handling the pandemic. When the *public energy fields* of the government and the public approached equality, discourse power was more proportionate, and better communication and interaction were achieved. The government, therefore, has to further focus on the public's social media requirements and enhance its promotion of active participation by the public. In summary, government WeChat accounts exist to provide information and conduct dialog with the public, thus facilitating wider participation in decision making. We need to translate online participation driven by social media into government behavior (Bertot et al., 2010).

Data availability statement

The original contributions presented in this study are included in the article/**Supplementary material**, further inquiries can be directed to the corresponding author/s.

Author contributions

CS and XG contributed to the ideas, manuscript architecture design, and manuscript writing. JS contributed to the application of statistical and mathematical to synthesize study data. MC performed the theoretical analysis. GL did the data crawling and cleaning. All authors contributed to the article and approved the submitted version.

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Publisher's note

Supplementary material

The Supplementary Material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fpsyg.2022.955376/full#supplementary-material

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Exploring factors that influence COVID-19 vaccination intention in China: Media use preference, knowledge level and risk perception

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Vaccine is one of the most effective means to deal with the COVID-19 pandemic in many countries, but vaccine hesitancy has been always widespread among people due to individual differences in access to vaccine information. This research aims to empirically investigate the relationship between media use preference (video-based and text-based), knowledge level, risk perception and willingness to vaccinate among Chinese residents. A cross-sectional survey of a Chinese sample (N=885) was carried out to explore factors that influence the COVID-19 vaccination intention of Chinese residents. The empirical results show that the knowledge level and risk perception of Chinese residents positively contribute to vaccination intention. People with video-usage preference have lower levels of knowledge about the COVID-19 vaccine than those with text-usage preference. People's risk perception of the COVID-19 pandemic is not influenced by their media use preference or knowledge level, as COVID-19 is a global pandemic and a significant social risk. The current study yields health-related implications for the role of media use preference in vaccination intention.

KEYWORDS

COVID-19 vaccine, media use preference, knowledge level, risk perception, vaccination intention

Introduction

The COVID-19 pandemic is sweeping the world, causing more than 245 million infections and more than 4.98 million deaths by October 2021 (Worldometers, 2021). Vaccine development is hailed as a long-term solution to the prevention and control of global health crises (Marwah et al., 2021). However, it is not a sufficient basis for many individuals to receive the vaccination without protest. Residents have experienced vaccine hesitancy, indicating that people doubt the benefits of vaccines, worry about their safety, question the need for vaccination, and always associate the vaccine with certain diseases (Shelby and Ernst, 2013). The coverage of vaccination

has been estimated to probably reach 75–80% when the COVID-19 vaccine is going to stop a pandemic (Bartsch et al., 2020). As a consequence, the unvaccinated population can lead directly to disease outbreaks.

Communication and media environments are considered to be potential drivers of vaccine hesitancy. In China, the communication environment is somewhat different from that in western countries. First, there are more vaccination-promoting messages on Chinese social media and official media. The Chinese government is much stricter in controlling false information about vaccines on social media (Ouyang et al., 2022). Second, Chinese residents' opinions on vaccines are largely influenced by their trust in media rather than content (Zhang et al., 2022). They prefer to believe in traditional media channels (Wu and Shen, 2021) and are more influenced by official media (Chen et al. Chen et al., 2021). Third, information access channels for Chinese residents vary greatly (Yu et al., 2021).

Existing studies have investigated the relationship between attitudes, intentions, and behaviors of COVID-19 vaccination based on the communication environment in western countries (Chen et al., 2021; Mir et al., 2021; Thaker and Subramanian, 2021). Some focused on how the interaction of attitude and cognition affects willingness to vaccinate (Carcelen et al., 2021; Mir et al., 2021); some focused on how information features affect risk perception and willingness to vaccinate, such as risk information (Ansari-Moghaddam et al., 2021) and misinformation (Thaker and Subramanian, 2021). However, most studies on COVID-19 vaccine hesitancy only examined these factors separately, which ignored the media use preference as a potential factor influencing vaccination intention. In China, there is a divergence in people's information access channels. Some studies have found that people always use their media repertoires built by different media choices and preferences to form perceptions (Hasebrink and Popp, 2006). In other words, there is not a clear answer to the relationship between media use preference and vaccination intention.

Literature review and model development

Theoretical background

Health behavior refers to actions taken by individuals to avoid risky behaviors and lead to health improvement (Weinstein, 1993; Conner and Norman, 2005). Up to now, there has been a considerable body of studies that recognize the critical role played by social cognitive factors in predicting health behavior (Bandura, 1998; Schwarzer and Renner, 2000; Conner and Norman, 2005). Cognition in psychology is generally considered an information-processing pattern of people's psychological function (Sternberg and Sternberg, 2016). Some scholars defined cognition as a collection of all mental processes and abilities associated with knowledge, memory, perception and even decision-making (Neisser, 1976; von Eckardt, 1995). According to the theory of social cognition proposed by Bandura (1986), cognition, vicariousness, self-reflection and self-regulation play a central role in processing information. He believes that psychosocial functioning can be explained by triadic reciprocal causation. From the transactional perspective of self and society, environmental events, personal factors and behavioral patterns all serve as interacting determinants that influence each other bidirectionally (Bandura, 2001). Most external effects, the environmental factors he conceptualized, influence behavior through cognitive processes. In addition, cognitive factors exert an in-depth influence on which environmental information is observed, what meaning is given to them, and whether they have a lasting impact.

Results from earlier studies suggest a positive association between cognition and behavioral intention (Dunkley et al., 2011; Winter, 2012). In the context of COVID-19 vaccine information and dissemination, the environmental factors that influence behavior refer to the access to COVID-19 vaccine-related information in the media form of video or text. Moreover, the cognitive output refers to individuals' level of knowledge, that is, to evaluate their ability to correctly identify misinformation and measure the percentage of people's correct answers and risk perception. This lays the foundation for a contemplation process early in the motivation phase (Schwarzer and Renner, 2000). Behavioral intention factors refer to individuals' intention to receive the COVID-19 vaccine. In this theoretical framework, three groups of variables were proposed, which contribute to information processing and decision-making, namely, environmental factors, cognitive factors, and behavioral intention factors.

Media use preference

Communication scholars have been prompted to speculate on the influence of abundance on choice behavior since the number of information and entertainment choices available to media users has rapidly increased in the last decade (Panek, 2016). Users have a wealth of choices and unprecedented control over where, how and when to obtain news according to their preferences (Mangold and Bachl, 2018). Thus, today's media users may show more different modes of using news compared to earlier work. Previous studies have identified that social media platforms contribute significantly to the production and diffusion of misinformation (Allcott and Gentzkow, 2017; Shin et al., 2018; Apuke and Omar, 2021). In terms of media format, online fake news research related to COVID-19 showed that the combination of video and text accounts for the largest percentage of fake news content, followed by the combination of text and photo (Al-Zaman, 2021).

A growing number of published studies also provide evidence that people of a higher social class use video media such as television less frequently (Mangold and Bachl, 2018). People who play the role of an opinion leader prefer media with high-quality information, such as investigative reporting and news commentary (Shah and Scheufele, 2006). Instead, research has proven that people who have lower political interests but more media options may cut down their news consumption and spend more on entertainment in video channels (Huang and Yang, 2022).

There are also differences in Chinese residents' access to information about the COVID-19 pandemic. Some tend to use traditional channels such as newspapers and television to get information. Some people prefer to use audio and video approaches to share information in a private circle *via* social media (Tang and Zou, 2020).

Therefore, it is assumed that there are preferences and divergences in people's media use, showing reliance on a certain type of information forms, such as TikTok (video media) and news apps (text media). The present study does not explore all the media forms, but focuses on the most important media forms—video media use preference and text media use preference.

Based on the above discussion, it can be hypothesized:

> *H1*: People's media use habit has shown an obvious divergence between video-preference and text-preference.

Media use preference and knowledge level

Existing literature suggests that information forms can influence an individual's comprehension ability and then knowledge level. Some studies have concluded that video does not improve people's learning ability. When learning from videos, learners' preference for videos over texts does not transfer to better comprehension (Caspi et al., 2005). In addition, evidence supports that comprehension cannot be guaranteed by using videos to communicate scientific information (Mayer et al., 2005). This may be because audiovisual media can put people in a passive state of acceptance, unable to make people initiative and creative (Merkt et al., 2011).

Moreover, media use preference can lead to differences in the quality of the information received, which further affects the level of knowledge. Compared with some text-based reports written by mainstream media, there is information overload combined with gate-keeping failures in video media (Garrett, 2011). A study analyzed user-generated videos about the HPV vaccine on YouTube, finding that most of these videos were negative in tone and disapproved of the HPV vaccine (Briones et al., 2012). As media technology empowers each person, any information can be diffused on the Internet, which dissolves the role of traditional gatekeepers, and a large amount of uncensored misinformation enters the channel. People use the information of uneven quality as a basis for decision-making, further increasing the possibility of misleading information dissemination (Miles et al., 2000; Kata, 2010; Pandey et al., 2010).

Based on the above discussion, it can be proposed:

> *H2*: Video media use preference is negatively correlated with the knowledge level of vaccine information.
>
> *H3*: Text media use preference is positively correlated with the knowledge level of vaccine information.

Media use preference and risk perception

People develop risk perception by receiving the corresponding risk information from media channels, so the risk perception of individuals will vary with media use. Previous studies have concluded that media is a risk amplifier (Kasperson et al., 1988). According to the social learning theory proposed by Bandura (1973), people learn through both action and observation. This means that all the experience we have gained, even second-hand, can lead us to learn about the world. So when it comes to the relationship between risk perception and media use, Bandura says that the mimetic environment created by television distorts the real environment and gives us unrealistic fears. This is because the content of many programs is much more serious than in the real world.

In recent years, many studies have found that media channels and information forms have an important impact on risk perception, which is a key factor affecting vaccination intentions (Renn et al., 1992; Brewer et al., 2007; Kahan et al., 2008; Liao et al., 2013). A study compared individuals' perception of the risk of eating contaminated fish using pamphlets and classroom lectures, showing that those who received information in the form of classroom lectures perceived higher risks than those who read pamphlets (Burger et al., 2003). It implied that scenario-based and visual information forms could increase the level of risk perception. Moreover, many studies on anti-smoking advertising have also found that anti-smoking warnings in the form of pictures or videos are much more effective than those in the form of texts to inspire risk perception (Evans et al., 2016; Nagelhout et al., 2016).

According to the Dual Coding Theory (DCT), the human mind has two types of mental representations, namely, verbal and visual information (Paivio, 1978). Textual information can generally only mobilize individuals' mental representation of verbal information, while video information can activate these two mental representations. Considering the involvement and participation of information processing, videos are more likely to increase people's perception of risk through activating visual mental representation.

Based on the above discussion, it can be put forward:

> *H4*: Video media use preference is positively associated with risk perception on COVID-19 virus information.
>
> *H5*: Text media use preference is negatively associated with risk perception on COVID-19 virus information.

Knowledge level, risk perception and vaccination intention

People are always selectively exposed to some media and content in a wealth of information environments, leading to different levels of health knowledge and a series of disease risk perceptions generated in media and information environments.

In terms of vaccination intention, studies have concluded that it is important to disseminate information about vaccines to increase people's willingness to vaccinate (Betsch and Wicker, 2012). Thus, personal health knowledge is an important basis for health-related behaviors (Wood et al., 1985). Those with lower levels of knowledge are more likely to associate vaccines with negative events and doubt the safety of vaccines, which may reduce their willingness to get vaccinated (Reyna, 2012; Zheng et al., 2021). A survey reported that 89.2% of health care workers with a high level of vaccine knowledge chose to get vaccinated in the first place after the vaccine became available in China (Li, 2021).

Researchers mentioned that risk perception is a non-negligible predictor. For example, Zhang et al. (2011) found that the possibility of spreading influenza to patients, the mortality risk of H1N1, the vulnerability of people to influenza or H1N1 and other risk perception items were predictors of vaccination. Schwartz et al. (1995) found that the overestimation of ovarian cancer risk can lead women to take positive actions to cope with the disease, such as self-learning and seeking medical treatment. Yaqub et al. (2014) reviewed 34 research articles by meta-analysis, including 15,988 subjects, finding that public vaccination behavior can be significantly predicted by the effect sizes (es) of risk perception.

It is also found that there is a correlation between individual knowledge level of pandemic diseases and perceived risk. Knowledge is often used as an explanatory variable for public attitudes, with an implicit subtext that knowledge can be used as a proxy variable for cognitive ability. The Accessibility/Diagnosticity Theory suggests that there are different information-processing strategies existing between consumers with high-and low-knowledge information. When people are in ambiguous situations, it will be difficult to make judgments, which increases the perceived decision risk (Chiou et al., 2002). More precisely, people with higher levels of knowledge about a particular vaccine are more likely to be aware of the consequences of pandemic and therefore they will perceive a higher risk of environment (Zhang et al., 2011). Conversely, lack of knowledge can interfere with people's ability to extract the basic meaning or gist of information, which may reduce the perceived risk of pandemic (Reyna, 2012; Rozbroj et al., 2019). In addition, Pew Internet data also showed that 75–80% of users seek health information online (Pew Internet & American Life Project, 2008), indicating that improving the level of knowledge through information-seeking behavior is an effective way to deal with the anxiety of risks. Zhong et al., (2021) found that risk perception can be influenced by knowledge of the disease in a growing pandemic.

In summary, people's willingness to get vaccinated is the result of the combined effect of knowledge level and risk perception. However, existing studies have been conducted in specific contexts, including SARS (Brug et al., 2004; Smith, 2006) and Ebola (Sell et al., 2017). There is a lack of relevant data on the COVID-19 vaccine currently. Therefore, this study aims to provide new data evidence in the context of the COVID-19 vaccine.

Based on the above discussion, it can be put forward:

> *H6*: Knowledge level is positively correlated with risk perception.
>
> *H7*: Risk perception is positively correlated with vaccination intention.
>
> *H8*: Knowledge level is positively correlated with vaccination intention.

On this basis, the research model is proposed, as shown in Figure 1.

Research method

For the purpose of verifying our framework, empirical research was carried out to test the proposed hypotheses. First of all, a questionnaire was designed for the Chinese residents on the basis of the previous literature and the extant research context. Secondly, we conducted an online investigation by using the Tencent questionnaire platform. Finally, when both the investigation reliability and validity were validated, the got data was explored by using the Structured Equation Modeling through the Amos23.0 and SPSS26.0 tools.

Measures

To build our research, multi-item scales were produced in accordance with the prior literature. In addition, the survey questionnaire sought data related to the media use preference, knowledge about the COVID-19 vaccine, perception of the risk of the COVID-19 virus and vaccination intention, as well as demographic information.

Media use preference

Based on a survey of the media use report of Chinese residents, the top 10 Apps were selected from a total of 50 Apps that Chinese residents use most frequently to obtain information (Yu et al., 2021), including 5 textual media products (i.e., WeChat subscription, Weibo, Zhihu, New Clients, Baidu, and Jinri Toutiao) and 5 video media products (i.e., TikTok, Kwai, Bilibili, Huoshan video, and Xigua video). Besides, by using seven points Likert scale (1 = never, 7 = very often), respondents were asked to select the frequency that they used each of these Apps to obtain the COVID-19 vaccine-related information.

Knowledge level

It referred to the total number of right answers to the 12 items. The questionnaire was adapted from the articles on rumors and truths about the COVID-19 vaccine published by the Chinese Center for Disease Control and Prevention in Guangdong (2021). In addition, a total of 12 questions were selected, within which 6 are true and 6 are false. All of these

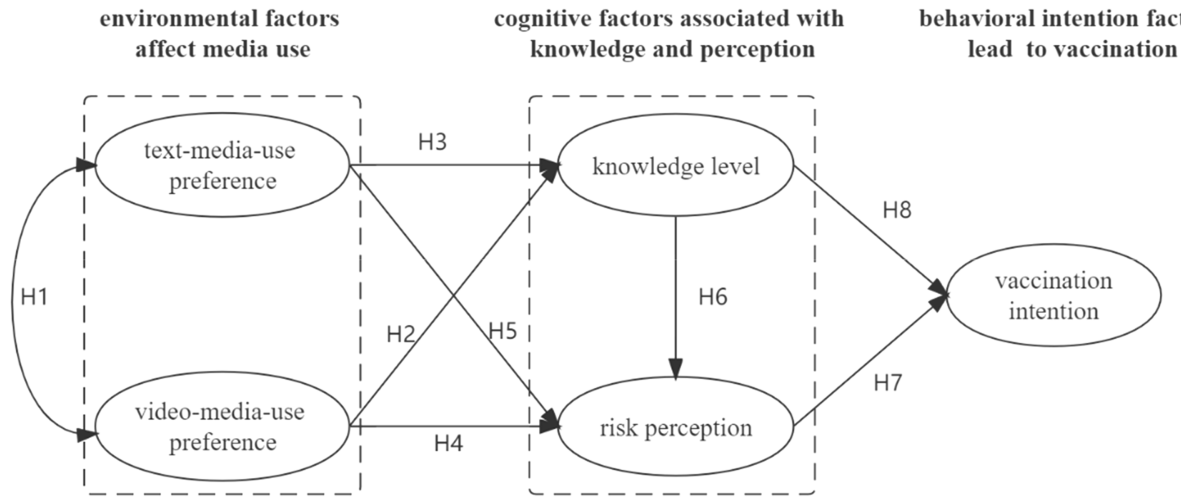

FIGURE 1
The research model.

questions served as the measure items to evaluate individuals' level of knowledge of the COVID-19 vaccine, and the obtained minimum and maximum scores from the scale were 0 and 12, respectively, (in which the correct answer = 1 and the incorrect or unsure answer = 0). Among the, a higher score indicates a higher level of knowledge.

Risk perception

The questionnaire was adapted from the scale of Rosenstock (1974). By using seven points Likert scale (1 = strongly disagree, 7 = strongly agree), five items assessed people's perception of the risk of the COVID-19 pandemic. The risk perception degree was counted as the average value ticked for every item to obtain the risk perception score ranging from 1 to 7.

Vaccination intention

The questionnaire was adapted from the well-established research scales of Chien (2011) and Nan and Madden (2012), containing 3 items that assessed people's vaccination intention by using the 7-point Likert scales (1 = strongly disagree, 7 = strongly agree). Besides, the vaccination intention degree was counted as the average value ticked for every item to generate the risk perception score ranging from 1 to 7.

Data collection

Through random sampling of Chinese residents, an electronic questionnaire link was posted to people to invite them to attend the online survey. The sampling process was conducted from September 15, 2020, to November 10, 2020. A total of 885 responses have returned, and 885 valid responses remained when the incomplete responses were eliminated. Table 1 shows the respondents' demographics.

TABLE 1 Demographic information (*N*=885).

Variable	Category	Numbers	Percentage
Gender	Male	379	42.8
	Female	506	57.2
Area	Urban	514	58.1
	Rural	371	41.9
Marriage	Married	200	22.6
	Unmarried	685	77.4
Age	<16	10	1.1
	16–24	583	65.9
	25–34	223	25.2
	35–50	58	6.6
	>50	11	1.2
Education	High school and below	222	25.1
	Post-secondary	275	31.1
	College and above	388	43.8
Income	<1,000 *yuan*	224	25.3
	1,000–3,000 *yuan*	223	25.2
	3,000–5,000 *yuan*	220	24.8
	5,000–10,000 *yuan*	174	19.7
	>10,000 *yuan*	44	5

Data analysis and results

Reliability and validity

Table 2 examines the convergent validity of constructs in our study. The Cronbach's alpha of the concerned factors had a range between 0.779 and 0.873, which surpassed the 0.6 threshold (van Griethuijsen et al., 2014). The composite

reliability (CR) of latent variables was from 0.784 to 0.876, all more than 0.6, which was the suggested critical value suggested by Ryu (2014). As a result, the results pointed out that there was not only a good internal consistency but also a satisfactory reliability level. The convergent validity was verified through the examination of not only the average variance extracted (AVE) but also the standardized factor loadings. Within Table 2, it could be seen that the majority of AVE values were higher compared to the recommended 0.5 threshold (Fornell and Larcker, 1981). In Table 3, the results of the correct identification of knowledge level were indicated.

TABLE 2 Results of confirmatory factor analysis.

Constructs and Items	Factor loadings
Text-media-use preference (Cronbach's α = 0.779, AVE = 0.440, CR = 0.784)	
TEX1.1: Wechat	0.32
TEX1.2: Zhihu	0.70
TEX1.3: News Clients (including Tencent News, NetEase News, and so on)	0.84
TEX1.4: Baidu	0.58
TEX1.5: JinRi TouTiao	0.75
Video-media-use preference (Cronbach's α = 0.837, AVE = 0.557, CR = 0.854)	
VID2.1: TikTok	0.42
VID2.2: Kwai	0.66
VID2.3: Bilibili	0.65
VID2.4: Huoshan video	0.95
VID2.5: Xigua video	0.92
Risk perception (Cronbach's α = 0.873, AVE = 0.588, CR = 0.876)	
RIS4.1: Living and working with people every day increases the likelihood of contracting the COVID-19 virus.	0.70
RIS4.2: Only people over 65 years can be infected with the COVID-19 virus.	0.87
RIS4.3: I have a high probability of contracting the COVID-19 virus.	0.79
RIS4.4: Healthy people can also be infected with the COVID-19 virus.	0.78
RIS4.5: I am worried that I will be infected with the COVID-19 virus.	0.68
Vaccination intention (Cronbach's α = 0.868, AVE = 0.700, CR = 0.875)	
INT5.1: I am willing to vaccination once a year in the future if needed.	0.80
INT5.2: If faced with a choice, I would still get vaccinated within a month.	0.86
INT5.3: I will encourage my friends and family to get vaccinated.	0.85

CR, construct reliability; AVE, average variance explained.

Model fit assessment

Generally speaking, the data offers a good model fit, which could be confirmed through the estimation of several model fit test statistics: comparative fit index (CFI) = 0.929, the standard root mean square residual (SRMR) = 0.06, $\chi^2 = (144, N = 885) = 743.249$, $p < 0.001$, the goodness-of-fit indices (GFI) = 0.914, adjusted goodness of fit index (AGFI) = 0.887, and the root mean square error of approximation (RMSEA) = 0.069. All of the results point out an excellent absolute match of the model.

Hypothesis testing

H1 to H8 were all tested through the examination of path coefficients between the different variables. Figure 2 shows the results.

In terms of accessing information about the COVID-19 vaccine, there is a significant correlation in people's media use preference between video-based and text-based ($\beta = 0.77$, $p < 0.001$), which supported H1. It was found that the preference for using video media to obtain information exerted a negative impact on people's knowledge level ($\beta = -0.39$, $p < 0.001$), and the preference for using text-based media to obtain information exerted a positive impact on people's knowledge level ($\beta = 0.41$, $p < 0.001$), supporting H2 and H3. However, H4, H5, and H6 were not supported since preference for using text-based media,

TABLE 3 Results of correct identification of knowledge level.

Items	Correctly identified (%)
1. The vaccine is not recommended to be given at the same time as other vaccines for the time being. (T)	74.9
2. Eating a full meal and drinking enough water before the vaccination can avoid adverse reactions. (F)	35.5
3. Nucleic acid test is not necessary before vaccination. (T)	13.7
4. The second dose must be given within 2 weeks to 3 weeks after the first dose. (F)	52.7
5. COVID-19 vaccination is recommended for people 60 years and older because of the health protection it provides. (T)	56.6
6. If in good health, it is recommended that people with chronic diseases also receive the vaccine. (T)	54.0
7. Cancer patients cannot receive the vaccine yet not because of the vaccine itself, but because of a lack of clinical data. (T)	49.8
8. People who work or study in medium or high risk countries or regions serve as a priority group for vaccination. (T)	79.2
9. COVID-19 vaccine may cause cancer. (F)	78.4
10. COVID-19 virus keeps mutating, so the vaccine is useless. (F)	78.8
11. COVID-19 vaccine can change human genes and make people genetically modified. (F)	85.6
12. You can take off the mask after the vaccination. (F)	90.4

The knowledgeable level referred to the total number of correct answers to the 12 items. It ranges from 0 to 12, with 12 indicating the highest level of knowledge of the COVID-19 vaccine and 0 indicating the lowest.

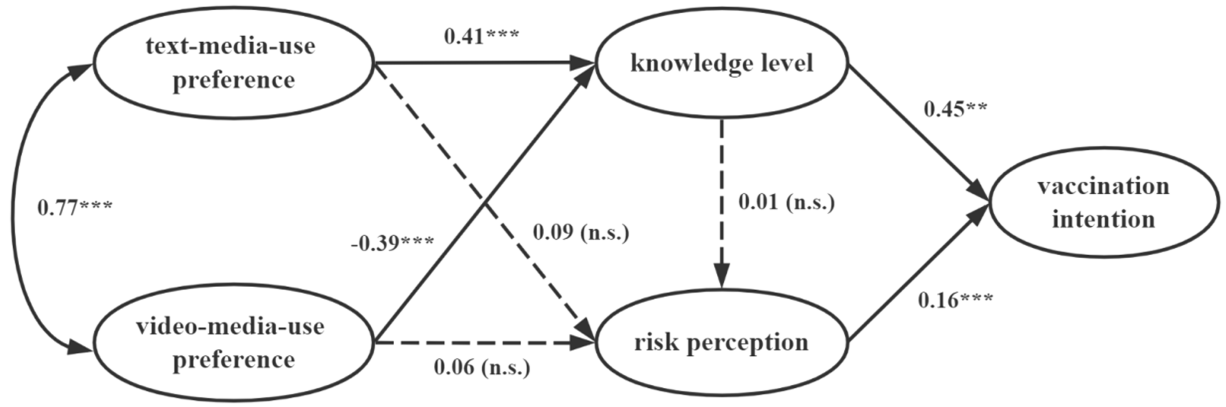

FIGURE 2
Results of the research model. *p<0.05, **p<0.01, ***p<0.001, n.s.: non-significant at 0.05.

preference for using video-based media and knowledge level was not associated with people's risk perception. Risk perception significantly and positively impacts vaccination intention ($\beta = 0.16$, $p < 0.001$), supporting H7. In addition, it was also verified that knowledge level had a positive and significant linkage to vaccination intention ($\beta = -0.45$, $p < 0.01$), thereby supporting H8.

Discussion and conclusion

Our hypotheses were verified by the empirical research results.

First of all, the findings showed that a significant positive correlation existed between the video-media-use preference and the text-media-use preference, thereby implying that people who frequently use textual media also use video media to access COVID-19 vaccine information. We assumed that citizens' media exposure diverges into two different camps, which were video-based and text-based, but the results of the study are contrary to our hypothesis. This might be a media repertoire that was created because media users combined different media contacts into one comprehensive contact pattern (Hasebrink and Popp, 2006). This suggested that people combined contacts with different media and different types of content instead of obtaining information from only one media channel. Furthermore, although not consistent with our hypothesis, the result of the study was in line with the previous studies. Taneja et al. (2012) found that there are more than three media repertoires powerfully tied to the rhythms of people's daily lives. Due to the selective media use, the media repertoires also cause multimethod approaches in converging media environments.

Secondly, we found that compared to individuals with video-media-use preferences, individuals with text-media-use preferences have significantly higher levels of knowledge about vaccines, hence supporting the static media hypothesis. Compared to video information, static text reduced extraneous processing and facilitated the processing of critical information (Mayer et al., 2005). According to Merkt et al. (2011), audiovisual media can not only leave people in a passive state of acceptance but also reduce their creativity. This confirmed the view of this study, which manifested that individuals might not think seriously about the meaning of the content when they received COVID-19 vaccine information through video channels, but the opposite is true for individuals who receive information through textual media. In addition, media use preference could reflect social class characteristics to some extent. To be specific, some people with higher comprehension tended to rely on textual media, while some people with lower comprehension tended to rely more on video media. Taking into account that the differences in information reception channels could further create cognitive and emotional stratification, it was implied that those who prefer text-based media are more capable to interpret vaccine information, while those who prefer video-based media are more easily misled by narrative and emotional fake news.

Thirdly, it was found that people's risk perception and knowledge level had a significant and positive linkage to vaccination intention. H7 confirmed a positive correlation between risk perception and vaccination intention, which was consistent with the result of the previous studies that risk perception served as an important factor influencing the public's behavior. People with higher risk perception of the pandemic are more likely to be vaccinated as their acceptance of COVID-19 was associated with the risk perception degree (Zeballos Rivas et al., 2021). In addition, the establishment of H8 suggested that they tended to make more positive vaccination decisions as the public becomes more knowledgeable about social risk events. This finding demonstrated that there were knowledge gaps between different groups. Risk communicators need to be more aware of the knowledge needs of vulnerable groups, which also conformed to the research results of other scholars (Zhong et al., 2021). Interestingly, in this study, people's perceived risk of the COVID-19 virus was taken as a research variable, but the study by Zheng et al. (2021) used the perceived risk of COVID-19 itself as a variable, and they also confirmed that people's knowledge level had no direct association with vaccination

intentions, whereas was positively and indirectly related to vaccination intentions by reducing the perception of vaccine side effects. Thus, our study extends their established findings and reveals new factors influencing people's willingness to vaccinate.

In summary, we confirmed in this study that when the public had more comprehensive knowledge about COVID-19 and a higher perception of risk in their social environment, they tended to be more willing to make vaccination decisions consistent with their health status.

However, our several propositions have not been confirmed following the results of the current data analysis.

Firstly, results demonstrated that media use preference and individuals' knowledge level did not affect their risk perception of COVID-19, which did not conform to our hypothesis. There was a widespread belief argues that the media represents the sources of vital importance for people's risk perception (Bastide et al., 1989). How and how much influence was another question even if we considered that media did influence people's risk perceptions. In addition, we found no difference in risk perception between individuals with video-media-use preference and those with text-media-use preference, which was also opposed to the finding of Anderson et al. (2013), that is, the more comprehensive and vivid the media information, the weaker the individual's risk perception. It was logical that as a *Hot medium* that reduces the cognitive load, video (compared to text alone) should evoke a stronger perception of the risk of COVID-19. However, this is not supported by our findings. This might be because their study focused on the impact of emerging technology (like nanotechnology) on individual risk perceptions, while our findings confirmed that as COVID-19 is a global pandemic, people's perceptions of significant social risk events do not change depending on their media exposure preferences or knowledge level.

In other words, a general perception had been formed in people's minds when the media broadcasted to the whole society that "COVID-19 is dangerous!" in China. This perception did not vary according to the media forms. In addition, people's risk perceptions depended heavily on their pre-existing views instead of being always influenced by media channels. Thus, individuals with a preference for either text or video media did not witness a significant difference in their perceived risk of COVID-19. This was consistent with the previous study that compared to other potential health threats, people had a higher level of risk perception for COVID-19, which was not altered by the habits of media use preference.

Secondly, as the previous discussion suggests, people's risk perception of the pandemic may not simply be influenced by media use preferences. Risk perception is a multidimensional construct (Wilson et al., 2019). Therefore, in our study, we further proposed H6 from the perspective of cognitive factors to clarify the impact of people's level of vaccine knowledge on the perceived risk of COVID-19 pandemic, but the results did not support our hypothesis. This may be because that this study defines and measures knowledge level in the context of objective knowledge, rather than subjective knowledge, which includes the perceptions of vaccine effectiveness, safety, and importance. Researchers have proposed that there are two categories of knowledge used in information consumers research, which are (a) subjective knowledge (or perceived knowledge), referring to the individual's perception of how much she/he knows; (b) objective knowledge (or measured knowledge), which is defined as a measure what an individual knows (Raju et al., 1995).

In this study, the objective knowledge we measured consisted mainly of the identification of COVID-19 vaccine rumors. Subjective knowledge, on the other hand, includes perceptions of vaccine effectiveness, importance, and safety. The level of people's subjective knowledge about vaccines is another issue regarding trust in vaccines, which may be an alternative interpretation of factors that play a role in the risk perception. In other words, people with higher levels of subjective knowledge about a particular vaccine may have a better understanding of its potential importance and effectiveness. This will strengthen their trust in vaccination and therefore they will perceive the environment as less risky (MacDonald et al., 2012; Liu and Yang, 2021). Future vaccine promotion initiatives should take the role of subjective knowledge of vaccine into account when addressing the negative consequences of risk perceptions of the pandemic.

In conclusion, understanding the factors that influence COVID-19 vaccination intention is a critical step in vaccine promotion initiatives. This study proposes a three-domain model: environmental factors that affect media use preference (video-based vs. text-based), cognitive factors that associated with knowledge level and risk perception, and behavioral intention factors that lead to vaccination. The empirical results show that risk perception was a positive predictor of COVID-19 vaccination intention. People's media use preference had an indirect effect on vaccination intention through high knowledge level, with video-based media use preference having lower level of knowledge and text-based media use preference having higher level of knowledge.

Limitations and future directions

Because of the chosen samples and the research context, some of the limitations are likely to impact the generalizability of the findings. First of all, the present study used an online platform to distribute the questionnaires during the survey, and thus the sample selection was inevitably limited to those having a chance to access the Internet, resulting in a large number of respondents in this study being young people. In this case, this group can only be researched at first, and this study can be considered a primary study focusing on this topic.

Secondly, when investigating the respondents' media exposure channels, we did not assess the quality of the information content they received. This is because the information quality can also

influence the public's willingness to act and is likely to have a negative impact. As a result, future research can make some efforts to use a content quality perspective to explore the impact of media use preferences on the public's knowledge level and risk perceptions, to identify elements that influence the public's vaccination intention.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Author contributions

XC, YL, and GY participated in the design of the study. XC performed questionnaire design, data analysis, and wrote the manuscript and edited. YL performed data collection and paper revision. GY contributed to the conceptualization of the manuscript, designed the questionnaire, and provided the supervision of the whole research and reviewed the content of manuscript. All authors contributed to the article and approved the submitted version.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Publisher's note

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Event history analysis of the duration of online public opinions regarding major health emergencies

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Based on event history analysis, this study examined the survival distribution of the duration of online public opinions related to major health emergencies and its influencing factors. We analyzed the data of such emergencies (N = 125) that took place in China during a period of 10 years (2012–2021). The results of the Kaplan-Meier method and Cox proportional hazards regression analysis showed that the average duration of online public opinions regarding health emergencies is 43 days, and the median is 19 days, which dispels the myth of the "Seven-day Law of Propagation." Furthermore, the duration of online public opinions can be divided into three stages: the rapid decline stage (0–50 days), the slowdown stage (51–200 days), and the disappearing stage (after 200 days). In addition, the type of event, and the volume of both social media discussion and traditional media coverage all had significant impacts on the duration. Our findings provide practical implications for the carrying out of targeted and stage-based governance of public opinions.

KEYWORDS

event history analysis, health emergencies, online public opinions, information lifecycle, emergency management

Introduction

The impacts of health emergencies can be generally measured and evaluated based on their spread, the extent of the impact, and their duration. The duration refers to the influential lasting time of health emergencies on social media, and reflects the degree of public attention on the events and while also reflecting the importance of the public health emergency. It also reflects the degree of severity of online public opinions (Lian et al., 2017; Dong et al., 2018). Typically, the longer the duration of a health emergency, the more attention it arouses and the greater the impact it asserts.

Duration is an important variable in the study of public opinions online regarding public health emergencies, and is one of the important mechanisms in terms of the evolution of online public opinion, which can affect both predictions and decision-making by governments, enterprises, and organizations, who often hope that online

opinions dissipate relatively quickly–as short as possible– so as to minimize its negative impacts.

The "Seven-day Law of Propagation" is a popular idea when it comes to information on the Internet. It refers to the belief that the life span of emerging events online is only 7 days (Zhang, 2019).

Kwak et al. (2010) used data from Twitter and concluded that the active period of any widespread public opinion lasts no more than a week, and with 31% of the lifespans found lasting for only one day.

This paper argues the assertion of ideas of duration is more a summary of personal experience, or just a subjective guess, lacking empirical data support and scientific rigor. The prevalence of such so-called laws instead cause misunderstandings which can impact the governance of public opinions by government officers, and can lead to improper judgments and wrongful management practices.

Kwak's study of duration focused on Twitter, not on public health events. Furthermore, the findings have yet to be verified on other social media platforms.

The detection and tracking of emerging hot topics or rumors on social media has been studied over the course of decades (Allan et al., 1998; Zheng and Li, 2009; Lu et al., 2013), and better algorithm explored is being applied to enhance its accuracy and efficiency (Yang et al., 2015; Alkhodair et al., 2020). There has been research done into the speed, scale, and scope of information propagation (Yang and Counts, 2010). However, current research on the duration of public opinion is very sparse.

Duration is a quantitative indicator and measurement of the life cycle of information. Defining the life cycle of public opinions regarding emergencies is derived from the concept of the life cycle of living things. Public opinions of emergencies have a beginning point as well as an end point where they are no longer discussed, and the evolution from start to finish appears to follow certain laws. From the emergence of a public opinion, to its stabilization and eventual extinction, public opinion can be divided into different stages, with Fink (1986) proposing four stages to the evolution of crisis communication in their theoretical framework.

Borrowing from the concept of the biological life cycle, American scholar Horton proposed the concept of an information lifecycle similar to the cyclical pathway of life, proposing four stages: birth, growth, decay, and death. Later scholars have proposed different online public opinion stage divisions, including a three-stage division (Zeng et al., 2014; Wang et al., 2020; Li and Shen, 2021), a four-stage division (Gu et al., 2014), a five-stage division (Xie et al., 2010), and finally a six-stage division (Zeng et al., 2014). However, many of these models are based on a subjective guess or qualitative perspectives, lacking empirical data. Even in the empirical studies, only a handful of cases were applied, while still lacking exact time divisions and a determination of the survival distribution of the duration.

Research on the life cycle of online public opinions not only reflects the evolutionary law of online public opinion, but also requires corresponding countermeasures at different stages of public opinions evolution. When an event receives less coverage or discussion both on- and offline, its impacts die away. Thus, because of the differences in their degrees of importance, public opinions about emergencies can have a variety of different life spans. For important emergencies, opinions' life spans could last for weeks, while for flash events, they might die out in just a few days (Kleinberg, 2003).

The theory of the information lifecycle provides a theoretical framework to help understand the duration of online public opinions of health emergencies. The next section of this paper puts forth our research questions while summarizing past studies and identifying gaps in research.

The evolution of online public opinion involves primarily the functions of various factors such as the attributes of the event and its participants. Event attributes include classification and grading; participants refer to various social actors, including non-professional social media accounts coming from a variety of social roles, as well as professional individual opinion leaders (Zhang et al., 2021). At present, research on the duration of online public opinion regarding emergencies have focused on the attributes of the event itself, as well as other factors including media participation, opinion leaders, and death toll.

Event attributes

Event attributes comprise classification and grading. The classification and grading of emergencies is one of the basic tasks for establishing an emergency management system (Yang et al., 2005). Xue and Zhong (2005) believe that different types of emergencies cause different situations of criticalities and social harms, and thus require different national emergency measures. Event type is an important independent variable when it comes to public opinion research. By crawling the data of five million YouTube user videos, Crane and Sornette (2008) divided social events into four different types: exogenous, endogenous, critical, and subcritical. Exogenous and endogenous refer to the type of disturbance, while critical and subcritical indicate the user's ability to influence others into action. Additionally, they created combinations of the four types, then classified into four popularity patterns: exogenous subcritical, exogenous critical, endogenous critical, and endogenous subcritical. Utilizing the patterns, Kwak et al. (2010) studied the duration of these four patterns on Twitter. Fujita et al. (2018) estimated the influence of exogenous and endogenous forces on events. Other studies have found that there are significant differences in the survival times of three types of incidents: terrorist attacks, mass incidents, and criminal cases (Chen and Li, 2016). Meanwhile, Chen (2014) analyzed the survival distribution of public opinion in health events,

disasters, and emergencies according to the different event types.

Media participation

Media participation considers both traditional media and social media. Media can have positive or negative impacts by affecting personal emotions and views (Ma et al., 2014). In times of emergencies, media is an important channel for the public to obtain information. Information spreads quickly through the media and can work to alleviate people's anxiety. In China, traditional media such as newspapers, radio, and television are still the primary media channels trusted by the public particularly when emergencies occur. Especially in these emergency cases, traditional media is perceived as being more authoritative. Compared to traditional media, social media have its own advantages and unique characteristics. When traditional media is unavailable, social media can serve as an important information channel in crises and emergencies (Macias et al., 2009) offering alternative views (Zhang et al., 2021). During emergencies, while social media has in the past been utilized by the general public to communicate, it is now becoming adopted by emergency responders, governments, and non-governmental organizations as an integral tool for disaster management (Simon et al., 2015). Social media accounts offer an opportunity to rapidly distribute critical information and, in doing so, to mitigate the impact of emergencies by influencing public reactions (Panagiotopoulos et al., 2016).

As of December 2021, the number of Internet users in China had reached 1.032 billion, and the Internet penetration rate had reached 73 percent (China Internet Network Information Center, 2022). Social media provides spaces for both officials and average citizens to seek to interpret emergency situations and intervene accordingly. Some studies have pointed out that active participation on social media prolongs the discussion time of network events.

Opinion leaders

Lazarsfeld and Katz (1955) formulated a breakthrough theory of public opinion formation that sought to reconcile the role of media influence with the growing realization that, in a variety of decision-making scenarios ranging from political to personal, individuals may be influenced more by opinion leaders than media. Opinion leaders have a large number of followers and loud voices (Ekmen and Altın-Kayhan, 2017), giving them a stronger ability to spread public health opinions (Zhao et al., 2022). They usually strengthen microblog users' subjective evaluations of events (Su, 2019), and thus have great influence on public sentiment (Zhao et al., 2014). This is more likely to trigger the emotional responses and emotional resonance/empathy of online groups (D'Ancona, 2017). Gao (2017) used survival analysis to conduct research on Weibo, and found that the number of opinion leaders voicing their thoughts has a significant impact on the duration of public opinions online. Li and Shen (2021) found that key nodes play important roles in spreading public opinion of animal epidemic emergency.

Number of deaths

The more deaths caused by an event, the more attention it will receive on social media, and the longer the duration of public opinions regarding the event (Duan et al., 2020). Thus, this is an important factor in the event rating and is also the focus of public concern.

In this paper, we selected public health emergencies within China as samples to analyze the distribution of the duration of public opinions, and further explore their influencing factors.

Research questions

The information life cycle provides a theoretical basis for the duration of public opinion, but this is only a speculative assumption lacking empirical findings when it comes to public opinions regarding health emergencies. As to the limited studies done examining Twitter, validation studies on other social media platforms are also needed to confirm the Twitter findings. All in all, there are currently very few empirical studies on duration. Therefore, while the information life cycle provides us with a theoretical framework, there is a lack of empirical research on duration. The present study then posed the two following research questions:

Research Question 1(RQ 1): What is the survival distribution of duration of online public opinions regarding health emergencies?

Research Question 2(RQ 2): What are the influencing factors of duration?

Materials and methods

Event history analysis

Event history analysis is a statistical method used to analyze the occurrence and timing of events within a given time, allowing some cases to be censored.

Event history analysis has different terminology in different disciplines. In sociology, it is called history analysis, such as the duration of a relationship from marriage to divorce, from unemployment to re-employment, etc. In medicine, it is called survival analysis, defining, for example, a patient's

survival time after the onset of a certain disease. In the field of engineering, it is called either reliability analysis and failure time analysis. Economics refers to duration analysis and transition analysis (Allison, 2010). Despite these differences in terminology, however, the concept is identical across disciplines. The current research analyzes the duration of public opinions regarding health emergencies (events), so we chose the term "event history analysis."

The focus of event history analysis is to determine a specific model that characterizes the survival distribution, and to make statistical inferences based on the model. Event history analysis can be used to solve two problems that traditional multivariate statistical methods cannot solve: censoring and time-dependent covariates (Allison, 2010). A hazard model is able to handle censored observations containing partial information and covariates that change dynamically during the observing period. These two distinguishing features differentiate it from other regression models (Vermunt, 2001).

Definition of key concepts

Event refers to the end point of an emergency. The outbreak of public opinions on social media regarding public emergencies is considered the starting point of an event, and the cessation of public opinions is called the end point.

The outbreak of an event refers to the appearance of a topic in a document stream which is signaled by a "burst of activity," with certain features rising sharply in frequency as the topic emerges (Kleinberg, 2003).

Duration is the time interval between the outbreak of an event and its end point, namely, the lasting time of online public opinions, which in this study is measured by days.

Censoring is a universal feature of event history analysis, with the most basic distinction being left censoring and right censoring (Allison, 2010).

The Kaplan-Meier method

The Kaplan-Meier (KM) estimator, also known as the product-limit estimator, is most widely used for estimating survivor functions rather than for demonstrating correlations. The cumulative distribution function estimates for the Kaplan-Meier model are as follows:

$$\hat{S}(t) = \begin{cases} 1, t < t_1 \\ \prod_{t_i \ll t} \left\{1 - \frac{d_i}{y_i}\right\}, t_1 < t \end{cases}$$

$$\hat{V}\left[\hat{s}(t)\right] = \left[\hat{s}(t)\right]^2 \sum_{t_i} \frac{d_i}{y_i\left(y_i - d_i\right)}$$

t_i is the time point when the i_{th} event occurs, d_i is the number of events that occurred at time t_i, y_i is the number of risks at time t_i, and $\hat{V}ar\left[\hat{s}(t)\right]$ is the variance estimation of the survival/persistence rate.

We also use the Log Rank test and Breslow to test the difference of the duration between and among the independent variables.

The Cox proportional hazards model

The semi-parametric proportional hazards model proposed by the British statistician D. R. Cox in 1972 is referred to as the Cox proportional-hazards model, the dependent variable of which is the hazard function. The Cox proportional-hazards model does not directly reflect the relationship between the survival function and the explanatory variables X_1, X_2,...X_p, but uses the hazard function Inh(t) as the dependent variable. The regression coefficient β_p reflects exp (β_p), the change in the risk ratio caused by per-unit change of X_p when other independent variables are fixed. Our study uses this model to evaluate the online influence of independent variables on the risk rate of deaths in public events. This model can be written as follows:

$$[h(t, X_i) = h_0(t)\, exp\left(\beta_1 X_1 + \beta_2 X_2 + \cdots \beta_p X_p\right)]$$

X_1,X_2,... X_p are risk factors, which are the related factors that affect survival time. Estimating from the sample, β_1, β_2, ... β_p are regression coefficients. $h_0(t)$ is the baseline hazard and represents the hazard when all of the predictors and independent variables are equal to zero. If β_1 is greater than 0, it indicates that the covariate is a risk factor. The higher the value, the shorter the survival time. If β_1 is less than 0, it indicates that the covariate is a protective factor.

Data collection

To keep our samples authoritative, we searched key words under "health emergency" and "public health event" at the official websites for the national and provincial Health Commissions, the Ministry of Emergency Management, and the provincial Emergency Management Departments of China as well as a global web search conducted on other search sites. Following the classification criteria of health emergencies according to the National Emergency Plan for Public Health Emergencies, we screened events deemed major (Grade III), significant (Grade II), and extremely significant (Grade I) that occurred between 2012 and 2021, and obtained a total of 125 events. We then entered the keywords for each event into the Sina Weibo platform and data collection was conducted by a web crawler in Python.

Dependent variable: Duration

Sina Weibo (hereafter Weibo) is a Chinese version of Twitter, launched by Sina Corporation in 2009. As one of the

leading and the most popular social media platforms in China, Weibo had 573 million monthly active users in March 2021 (NASDAQ, 2022). Referring to the operational definition of Zhao (2017) for event duration, the earliest posting time on Weibo was recorded as the starting time, the total number of posts on the earliest day recorded as N_0, and the highest daily posting volume recorded as the peak N_1. The death of the event was recorded as when the daily posting volume dropped to 10% of N_1. Therefore, duration refers to the lasting time for the number of posts to drop from N_0 to 10% of N_1 (Zhao et al., 2017).

Independent variables

Event types

According to the Regulations on Preparedness for and Response to Emergent Public Health Hazards, public health emergencies refers to "the sudden outbreaks of major infectious diseases, mass diseases of unknown cause, major food and occupational poisoning, and other events that seriously affect public health and cause or may cause serious damage to public health."

This paper classifies health emergencies into the following five categories according to their nature with reference to the classification of types of health emergencies listed in the Regulation on Responses to Public Health Emergencies formulated and promulgated by The State Council, Grading Standards for Public Health Emergencies, issued by The Chinese Center for Disease Control and Prevention.

Food safety accidents

According to the Food Safety Law of the People's Republic of China, a food safety accidents refers to "food-borne diseases, food contamination, and other food-derived accidents that are or may be harmful to human health" (The State Council of the People's Republic of China, 2020).

Occupational poisoning accidents

This refers to workers coming into contact with industrial poisons in the process of labor, which may result in likely multiple organ damage.

Infectious diseases

Infectious diseases are defined by the Chinese Center for Disease Control and Prevention as diseases caused by various pathogens that can be transmitted from person to person, animal to animal, or human to animal.

Environmental pollution

This refers primarily to sudden events caused by natural disasters or initiated by man-made factors that have destroyed or damaged the environment such that it then endangers human health.

Medicine and health care accidents

Such accidents may occur throughout the entire production and sales process of medical instruments and drugs. They may be caused by the failure of the parties responsible for complying with relevant national laws and regulations in the selection of raw materials and manufacturing process of the drugs, or the great potential safety hazard in the production process, in either case resulting in the production of drugs that do not meet national standards, and cause great harm to human health and negative impacts on society.

Covariates

We make a tentative claim that the following eight variables might affect the duration and distribution of health emergencies: social media discussion volume, coverage volume by traditional media, participation of opinion leaders, subject of liability, areas influenced, number of people involved, and size of the city where the incident occurs. See **Table 1** for coding of those independent and dependent variables.

Social media discussion volume

In this paper, the number of posts on relevant topics on Weibo has been selected as an indicator of social media discussion volume, a continuous variable, to measure the amount of discussion taking place on social media.

Traditional media coverage

We used WiseSearch as the data source, and analyzed the reports of news outlets found in the database to determine whether traditional media coverage can have an impact on public health emergencies. This independent variable is treated as categorical variable according to its coverage and divided into five groups: no coverage; 1 to 5 coverage; 6 to 50 coverage; 51–1,000 coverage; and coverage of more than 10,000.

Participation of opinion leaders

Opinion leaders on Weibo are influencer users, and are identified publicly as verified users known as "Big Vs," denoted by a verification badge, a capitalized letter "V" added alongside their account name (Wang et al., 2014). In this paper, the "Big Vs" on Weibo (with more than 500,000 followers) are taken as the dichotomous variable.

Subject of liability

This refers to the main body chiefly responsible for public health emergencies. It is divided into five categories: government, school, enterprise, individual, and mixed.

Influenced areas

This refers to the geographical areas affected by a particular public health emergency. According to the classification of health emergencies in the Regulations on Emergency Response to Public, Health Emergencies issued by the State Council of the People's Republic of China, the influenced scope of incidents

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TABLE 1 Variable coding.

Variable	Meanings	Coding
X_1	Event type	1. Food safety; 2. Occupational poisoning; 3. Infectious disease; 4. Environmental pollution; 5. Medicine and health
X_2	Social media discussion volume	Continuous variable
X_3	Traditional media coverage	1. 0; 2. 1–5; 3. 6–50; 4. 51–1,000; 5 More than 1,000
X_4	Opinion leader	1. Yes; 0. No
X_5	Subject of liability	1. Government; 2. Schools; 3. Enterprises; 4. Individual; 5. Mixed
X_6	Influenced areas	1. Single city and county; 2. Multiple cities; 3. Multiple provinces
X_7	Number of people involved	1. Extremely large; 2. Large; 3. Medium; 4. Small
X_8	City size	1. Extra large; 2. Large; 3. Medium; 4. Small
Time	Duration	Continuous variable
Event	Status	1. Death; 0. Censoring

falls into three tiers: a single city or county, multiple cities, and multiple provinces.

Number of people involved

This refers to the number of people affected by a health emergency, including both those who have died and those who are injured. According to the National Emergency Plan for Public Health Emergencies, the number of casualties are classified into four categories: extremely large (501and above), large (101 to 500), medium (31 to 100), and small (1 to 30).

Size of the city where the public health emergency occurs

This is usually rated by the number of its residents. Generally speaking, larger cities tend to attract more media and public attention. According to the Notice of the State Council on Adjusting the Standards for Categorizing City Sizes, cities in Mainland China are divided into: extremely large cities (a permanent urban population of more than 2 million), large cities (a permanent urban population of between 500,000 and 1 million), medium cities (a permanent urban resident population of between 200,000 and 500,000), and small cities (a permanent urban population of less than 200,000) (The State Council of the People's Republic of China, 2014).

Results

Duration of online public opinions regarding major health emergencies

The sample (N = 125) comprised 30 cases of food safety accidents, 31 cases of occupational poisoning, 42 cases of infectious diseases, 12 cases of environmental pollution accidents, and 10 cases of medical and health accidents. Meanwhile, six cases were censored, accounting for 4.8% of the total cases, as shown in **Table 2**.

Univariate analysis of duration

Overall, 32% of the online public opinions regarding health emergencies lasted for less than 7 days, 39.50% for 8–50 days, 12.61% for 51–100 days, 6.72% for 101–150 days, 3.36% for 151–200 days, and 9.24% for more than 200 days (see **Table 3**).

The overall mean of duration of public opinions was 43.50 days. The medical and health events topped the list with 99.30 days each, followed by environmental pollution events with 64.67 days. The duration of occupational poisoning

TABLE 2 Proportion of each event type.

Event type	Total	Number of events	Censored	
			N	Percent
Food safety	30	30	0	0.0%
Occupational poisoning	31	28	3	9.7%
Infectious disease	42	39	3	7.1%
Environmental pollution	12	12	0	0.0%
Medicine and health	10	10	0	0.0%
Total	125	119	6	4.8%

TABLE 3 Duration distribution.

Lifetime	Frequency number	Frequency (%)
0–7 days	40	32.00%
8–50 days	47	39.50%
51–100 days	15	12.61%
101–50 days	8	6.72%
151–200 days	4	3.36%
More than 200 days	11	9.24%

cases and infectious disease events was 45.71and 39.74 days, respectively. Food safety incidents showed an average duration of 19.26 days, the shortest of all five categories. The median of the five types of events was14, 13, 19, 36, and 65 days, respectively, as shown in Table 4.

Kaplan-Meier analysis of the influencing factors can estimate the survival functions of duration and demonstrate whether there is correlation between the different independent variables and duration. Log Rank test results showed that there is significant difference of duration between or among event types ($p = 0.012 < 0.05$). Log Rank test results also showed that traditional media coverage ($p = 0.019 < 0.05$) and city size ($p = 0.032 < 0.05$) had significant impacts on duration. Breslow test results showed that influenced areas had a marginal significant impact on duration ($p = 0.10 < 0.1$). Other variables, including subject of liability, number of people involved, and opinion leaders, were not significant, so we put all the independent variables into the Cox model for further analysis, as shown in Table 5.

Cox model results analysis

The three stages of duration

The three stages of duration can be outlined as follows: the first stage (0–50 days) is featured by a rapidly descending rate of survival function. It levels off at the second stage (51–200 days). At the third stage (more than 200 days after the event) the impacts of the events basically subsided (see Figure 1).

According to the results of the Omnibus Tests of model coefficients, –2 Log Likelihood = 870.784, and $p = 0.010$.

As we can see in the Cox model, event type and media participation including social media discussion volume and traditional media coverage have a significant effect on the observed duration of public opinions online.

Effect of event type

With other variables under control, at the 95% confidence level there were significant differences on the duration of event types ($p = 0.037 < 0.05$). Compared with the medical and health events group, the duration risk of food safety events increased by 332.1%, the duration risk of occupational poisoning events increased by 215.4%, and the duration risk of deadly infectious diseases increased by 499.6%. Meanwhile, the difference between medical and health events and environmental pollution was not found to be significant on duration risk (see Table 6 and Figure 2).

Effect of media participation

With other variables controlled, at the 95% confidence level, social media discussion volume ($p = 0.046 < 0.05$) and traditional media coverage ($p = 0.045 < 0.05$) both had significant effects on duration.

For social media, the β value of discussion volume was −0.017, which means it is a protective factor with a relative duration risk of 0.983. With every unit increase in the amount of social media discussion, the duration risk decreased by 1.7% [(1–0.983) × 100%], which also meant that its probability of prolonged duration was increased by 1.7% with every unit increase.

For traditional media, compared with the reference group with the highest coverage, the duration risk of no coverage increased by 187.9%, while the duration risk of coverage (1–5) increased by 176.7%. The duration risk of the rest of the two groups did not show significant difference between the reference groups.

Other variables such as the participation of Opinion leaders, subject of liability, influenced areas, number of people involved, and city size did not seem to be important factors in the duration of public opinions.

Discussion

Using event history analysis, this study examined the duration of online public opinions regarding major health emergencies in China occurring between 2012 and 2021. Results show that the mean duration of public opinion was 43 days, with a median of 19 days.

Online public opinions about major health emergencies follow a life cycle which runs through consecutive stages. In light of the law of public opinion evolution, our event history analysis revealed three stages. The first stage (0–50 days) is featured by a rapid decline in discussion, followed by a slowdown at the second stage (51–200 days), and finally the disappearance of impacts in the third stage (over 200 days).

Following our understanding of the survival distribution of duration, we analyzed the influencing factors and found that with other variables controlled and at the 95% confidence level, the variables of event type, media participation including social media discussion volume and traditional media coverage all had significant impacts on duration.

A Cox model showed that event type played the most important role in the duration of public opinions online. Of all the event types, food safety had the shortest duration with a mean of 19 days and a median of 14 days, while medicine and health lasted the longest time with an average of 99 days and a median of 65 days.

Media participation was shown to be an important factor in duration. Social media discussion volume and traditional media coverage both had significant effects on duration. With regards to social media, more discussion online increased the duration of public opinion.

Although opinion leaders do not show significant impact on duration in the Cox regression model, the variable nonetheless merits attention. Within our data, the β value of opinion

TABLE 4 Descriptive statistics of event type.

Event type	Mean				Median			
	Estimate	Std. error	95% Confidence interval		Estimate	Std. error	95% Confidence interval	
			Lower bound	Upper bound			Lower bound	Upper bound
Food safety	19.267	3.662	12.090	26.443	14.000	4.782	4.627	23.373
Occupational poisoning	45.714	11.888	22.413	69.016	13.000	5.953	1.332	24.668
Infectious disease	39.744	9.039	22.027	57.460	19.000	3.113	12.898	25.102
Environmental pollution	64.667	17.962	29.461	99.873	36.000	19.053	0.000	73.343
Medicine and health	99.300	32.248	36.093	162.507	65.000	43.481	0.000	150.223
Overall	43.504	5.538	32.650	54.358	19.000	3.354	12.427	25.573

Unit = day.

TABLE 5 Log Rank and Breslow tests.

	Log Rank (Mantel-Cox)			Breslow (Generalized Wilcoxon)		
	Chi-square	*df*	Sig.	Chi-square	*df*	Sig.
Event type	12.828	4	0.012	6.045	4	0.196
Traditional media coverage	11.741	4	0.019	16.493	4	0.002
City size	8.834	3	0.032	8.484	3	0.037
Influenced areas	1.862	2	0.394	4.612	2	0.100
Subject of liability	4.793	4	0.309	2.947	4	0.567
Number of people involved	2.546	3	0.467	1.92	3	0.589
Opinion leaders	1.907	1	0.167	2.136	1	0.144

leaderswas.224, and exp (β) was 1,252, which indicates that the duration risk of events with opinion leaders was increased by 25.2% compared to those with no engaged opinion leaders. Even though the number of people involved was not found to be significant, events with increased casualties also are deserving of particular attention.

We also explored the interactive effects of coverage of traditional media and discussion volume on social media in our model, however, the interactive term of coverage of traditional media discussion volume on social media was not significant ($p = 0.73 > 0.05$). The interactive term did not show significant impacts on duration of online public opinions. As the interactive effects did not exist, we excluded the interactive term in our model.

Theoretical and practical implications

This paper has important theoretical and practical significance for the study of duration and its influencing factors. With the theory of the information life cycle as our theoretical framework, we undertook an empirical study on the duration of online public opinions examining 125 major health emergencies that took place in China from 2012 to 2021. The finding of the three-stage model of duration as developed from our empirical data further expands information life cycle theory. Given that the literature is still very limited at present, we feel that this is a substantial contribution to this field. Furthermore, considering that duration and its influencing factors are rarely researched at present and that consideration of its variables in research is far from systematic, this paper marks a bold attempt to explore the factors that influence public opinion duration.

With regards to the practical implications of our findings, first, our research helps dispel the longstanding misconception of the "Seven-day Law of Propagation." Our research serves as a wake-up call for government and other officials who need to understand the duration patterns of online public opinions as they plan and manage public opinions in response to emergency events lasting for longer periods of time.

Events that continue over a long period of time can trigger discussion mechanisms of associated events. For example, online public opinion surrounding a medicine scandal that broke out in a nursery school in Xi'an, Shaanxi Province, was alive and active online for 291 days. Meanwhile, discussions surrounding the African Swine Fever epidemic in Mingshui, a county in China's northernmost province of Heilongjiang,

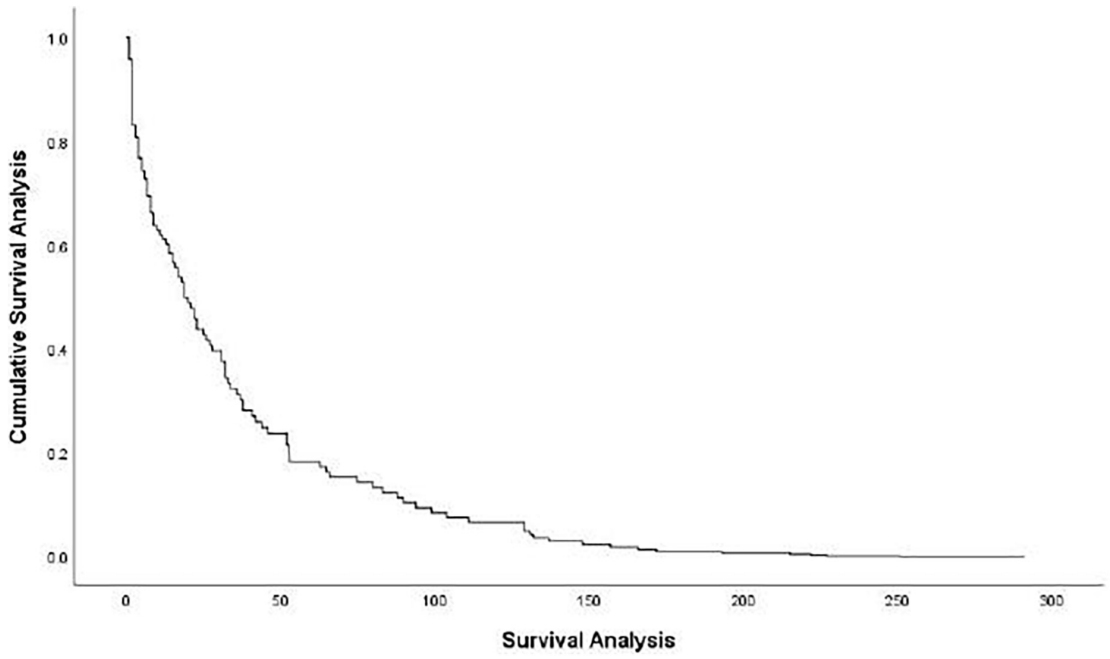

FIGURE 1
Survival function at mean of covariates.

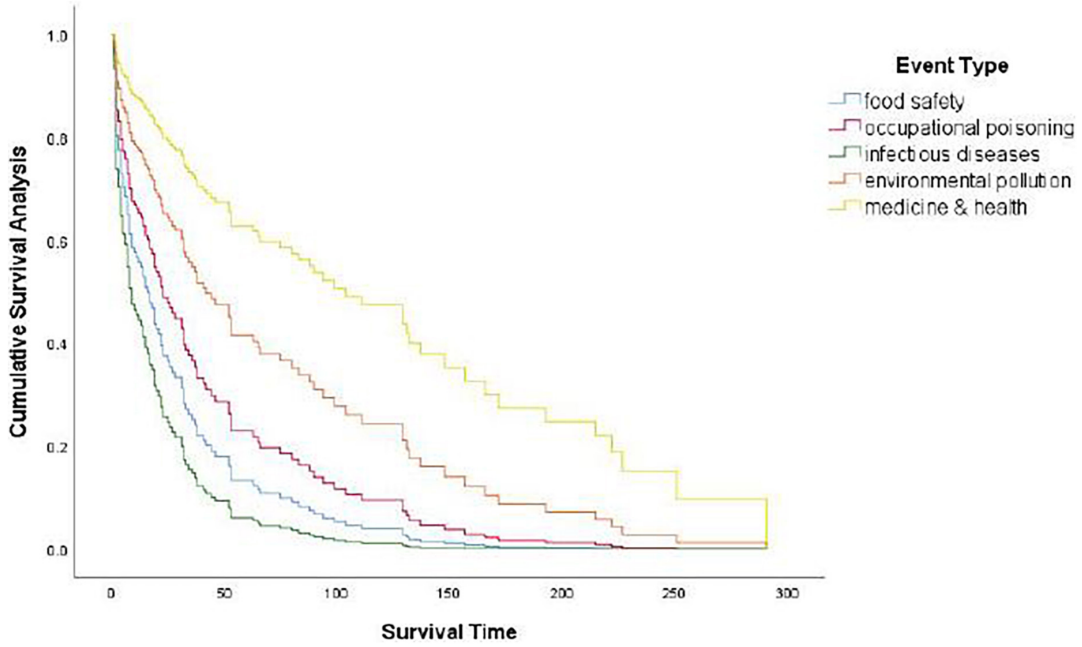

FIGURE 2
Survival function of event types.

sustained online presence for 251 days. Public opinions of an event do eventually subside, however, other events may evoke collective memory and prompt further online discussion about other ongoing related events. Halbwachs (1992) sees collective memory as something shared by a group that has spiritual meaning. Some health emergencies have significant

TABLE 6 Multivariate Cox regression analysis results.

Variable	B	*SE*	Wald	*df*	Sig.	Exp (β)	95.0% CI for Exp (β)	
							Lower	Upper
Event type								
Medical and health (=0)			10.197	4	0.037			
Food safety	1.463	0.517	8.001	1	0.005	4.321	1.567	11.910
Occupational poisoning	1.149	0.567	4.110	1	0.043	3.154	1.039	9.574
Infectious disease	1.791	0.709	6.390	1	0.011	5.996	1.495	24.042
Environmental pollution	0.633	0.602	1.106	1	0.293	1.884	0.579	6.131
Social media discussion volume	−0.017	0.009	3.969	1	0.046	0.983	0.966	1.000
Traditional media coverage								
More than 1,000 (=0)			9.721	4	0.045			
0	1.057	0.457	5.364	1	0.021	2.879	1.177	7.043
1–5	1.018	0.481	4.471	1	0.034	2.767	1.077	7.106
6–50	0.422	0.471	0.803	1	0.370	1.525	0.606	3.835
51–1000	0.239	0.417	0.330	1	0.566	1.270	0.561	2.876
Opinion leaders								
No opinion leaders (= 0)	0.224	0.245	0.835	1	0.361	1.252	0.774	2.025
Subject of liability								
Mixed (=0)			2.147	4	0.709			
Government	−0.016	0.717	0.001	1	0.982	0.984	0.241	4.015
School	0.201	0.697	0.083	1	0.773	1.223	0.312	4.793
Enterprise	0.441	0.641	0.473	1	0.492	1.554	0.442	5.464
Individual	0.603	0.650	0.863	1	0.353	1.828	0.512	6.532
Influenced areas								
Multiple provinces (=0)			0.567	2	0.753			
Single city or county	−0.344	0.476	0.523	1	0.470	0.709	0.279	1.801
Multiple cities	−0.274	0.456	0.362	1	0.547	0.760	0.311	1.857
Number of people involved								
Small (1–30) (=0)			4.129	3	0.248			
Extremely large (501and above)	0.745	0.382	3.799	1	0.051	2.107	0.996	4.457
Large (101–500)	0.483	0.386	1.570	1	0.210	1.621	0.761	3.454
Medium (31–100)	0.501	0.375	1.788	1	0.181	1.651	0.792	3.443
City size								
Small city (=0)			4.000	3	0.261			
Extremely large city	−0.281	0.277	1.028	1	0.311	0.755	0.439	1.300
Large city	−0.879	0.501	3.079	1	0.079	0.415	0.156	1.108
Medium city	−0.470	0.309	2.319	1	0.128	0.625	0.341	1.145

social impacts, and the recurrence of similar events tends to resonate with people and stimulate sustained discussions on social media.

Another example of public opinion leading to other tangential conversations is the "counterfeit vaccine." In 2013, there was the production and sale of an extremely large amount of a poor-quality rabies vaccine for human use. The online public opinion it triggered subsided in 2 days, however, the online public opinions triggered by two other events, a substandard diphtheria vaccine in 2017 and a problematic Chang Sheng vaccine in 2018, lasted 65and 166 days, respectively. Posts showed that the current event revived discussions over the previous related vaccine events, with some netizens even retweeting previous reports, which pushed online public opinions to explode from just one single event into a major event over multiple problematic vaccines. The duration of online public opinion was thus prolonged.

Second, we have proposed a three-stage division of online public opinions on health events based on scientific empirical research, which sheds light on the value of targeted phased management of public opinion by government managers.

Third, there were significant differences found on the duration of different types of events (see **Figure 2**). Medical and health events had the longest duration time with a mean of 99.30 days, followed by environmental pollution events with 64.67 days, occupational poisoning and infectious disease events with 45.71 and 39.74 days, respectively, and food safety having the shortest mean duration at 19.26 days. The median of the five types of events was 65, 14, 13, 19, and 36 days, respectively (see **Table 4**).

The duration of medicine and health events was relatively long with a slow decline rate, which corresponds to the complex causes of such events and the requirement of ongoing follow-up reports. Though online public opinions regarding infectious disease events experience a fast drop at their early stages, there is a subsequent long flat period, as infectious diseases recur and spread easily, generating a continuous series of new but related topics in online public opinions (see **Figure 2**).

It is therefore necessary to follow the law of the public opinion duration for each specific event, with differentiated public opinion management procedures used for the various types of events. Governments should pay more attention to events with longer public opinion duration. On one hand, they should realize that it is common for public health events such as medicine and health or environmental pollution to have an online duration that lasts for a longer period of time. On the other hand, governments should publish information openly and transparently from the start (Ma et al., 2014) so that the unnecessary longer duration of public opinion can be minimized. Subjects involved should be clear and those responsible should make their voices heard at the earliest moment, as an effective way of mitigating online public opinions. We recommend that concerned governments take corresponding countermeasures against runaway public opinion in a timely manner, which can keep rumors from spreading and reduce unwanted discussions on social media platforms from the early stages of an event.

The fake milk powder event from 2020, in which several infants and children were reported to develop "big-head" disease and contracted rickets after drinking the powder sold by local pharmacies and baby stores in Chenzhou, Hunan Province. Fearing that their children would be left with chronic conditions, many parents wrote a joint open letter to the Chenzhou Mayor on March 30 asking for a thorough investigation of the case. Strong emotions were aroused and information spread rapidly across social media, while people's memories of a similar event–the Sanlu Milk scandal of 2008 – were also recalled. This event sparked criticisms from netizens on social media, with people called for a thorough investigation into the case and tougher management over the formula industry. It wasn't until May 13th at the State Administration for Market Regulation of China published a notification urging local authorities in Hunan Province to conduct a thorough investigation. On May14, the People's Government of Hunan Province responded that local government would conduct a thorough investigation. Governments concerned about public opinion management should make full use of social media and respond immediately and effectively to prevent emotions going out of control or stopping the spread of rumors.

Fourth, media participation should be handled and managed properly. When public opinion was focused on violence toward medical staff in China, Duan et al. (2020) found that the more attention of the topic on Weibo, the more people participated in the discussion, and the longer the duration of public opinion. Our results also support this idea. Putting a focus on Weibo can be considered "discussion volume," as at the 95% confidence level, social media discussion volume was significant and is a protective factor of duration risk, which shows that the more discussion volume on social media, the longer an event's duration will last.

Traditional media, even now in the Internet Age, continues to have great social impact. The more traditional the media coverage, the more attention and interest it arouses in people, and the longer duration of public opinions shared online. Numerous reports may provide people with rich, detailed information, but they can also increase the uncertainty surrounding the event, leading to a continuous fermentation of public opinion. Furthermore, when serious consequences become the focus of traditional media attention, people's perception of threat will grow, which does not help to soothe online public opinion. Therefore, traditional media as well as social media need to provide timely comprehensive analyses that share accurate and reliable information and increase people's knowledge. At the same time, there is also need to control the quantity of traditional media coverage for the sake of enhancing quality. In addition to providing sufficient and accurate information to the public, media also need minimize redundant reporting lest such reports increase the public's perceived threat and cause panic.

Limitations

There are some limitations to this study. First, in terms of sample selection, given the absence of an authoritative database on public health emergencies, we derived our samples from extensive network search. Manual searches and subjective judgments may result in omissions of events, however. It is our hope that future researchers and relevant government agencies might initiate such a database to provide trustworthy data support for subsequent empirical studies. Second, there is room for discussion on the operational definition of time of death. This paper attempted to use the amount of reporting $N_0 = N_1$, but it was found to be not feasible in actual data observation. Therefore, this paper refers to the defining method of Zhao (2017), and more scientific research can be carried out on the operational definition of time of death in subsequent studies. Third, public health emergencies are often complicated, that

is, they are affected by multiple factors. In subsequent studies, we may study other possible variables and build effective models so as to discover further potential influencing factors. For instance, emotions are an important influencing factor on information diffusion on social media (Stieglitz and Dang-Xuan, 2013), where by the stronger netizens' emotions, the stronger the diffusion of social media (Zeng and Zhu, 2019). Future studies could collect data including emotions and test their influence on duration. Fourth, this paper found the initial signs of the correlation between topics, but time and study design prevented further discussion. In the future, empirical research should be carried out on the rules of propagation and correlation among topics. Fifth, there may be a few exceptions of events that involved only a small number of people yet had a long duration, but our data indicated that the more discussion online, the longer the topic's duration, which has also been previously supported by Duan et al. (2020). However, because of the limitations of the available data, we think this is worth considering in the future studies which may have access to more data. Finally, due to contextual constraints, we tried to explore the duration of online public opinions and its influencing factors, by focusing on 125 major health emergencies in China. The cases were only about China and examining Weibo. Future research could try to include more major health emergencies from across the globe, as well as explore data across other social media platforms.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Author contributions

XL and JZ originated and designed the research. All authors contributed to the statistical analysis, interpretation of the results, revision of the manuscript, involved in editing, reviewing, providing feedback for this manuscript, and approved the final version to be published.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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Personal space increases during the COVID-19 pandemic in response to real and virtual humans

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Personal space is the distance that people tend to maintain from others during daily life in a largely unconscious manner. For humans, personal space-related behaviors represent one form of non-verbal social communication, similar to facial expressions and eye contact. Given that the changes in social behavior and experiences that occurred during the COVID-19 pandemic, including "social distancing" and widespread social isolation, may have altered personal space preferences, we investigated this possibility in two independent samples. First, we compared the size of personal space measured before the onset of the pandemic to its size during the pandemic in separate groups of subjects. Personal space size was significantly larger in those assessed during (compared to those assessed before) the onset of the pandemic (all d>0.613, all p<0.007). In an additional cohort, we measured personal space size, and discomfort in response to intrusions into personal space, longitudinally before and during the pandemic, using both conventional and virtual reality-based techniques. Within these subjects, we found that measurements of personal space size with respect to real versus virtual humans were significantly correlated with one another (r=0.625–0.958) and similar in magnitude. Moreover, the size of personal space, as well as levels of discomfort during personal space intrusions, increased significantly during (compared to before) the COVID-19 pandemic in response to both real and virtual humans (all d>0.842, all p<0.01). Lastly, we found that the practice of social distancing and perceived (but not actual) risk of being infected with COVID-19 were linked to this personal space enlargement during the pandemic (all p<0.038). Taken together, these findings suggest that personal space boundaries expanded during the COVID-19 pandemic independent of actual infection risk level. As the day-to-day effects of the pandemic subside, personal space preferences may provide one index of recovery from the psychological effects of this crisis.

KEYWORDS

personal space, social distancing, COVID-19, virtual reality, public health, anxiety

Introduction

Personal space is the "comfort zone" surrounding the body that is typically maintained free of intrusions from others in order to protect the organism from harm (Hayduk, 1983; Graziano and Cooke, 2006). The monitoring and defense of this space is an evolutionarily conserved function of the brain across many species, from insects to mammals (Graziano and Cooke, 2006). In humans, the dimensions of personal space are moderately influenced by a number of situational, social, and psychological factors, including gender, age, social status, cultural norms, and psychological characteristics (Hayduk, 1983; Uzzell and Horne, 2006; Kennedy and Adolphs, 2014; Holt et al., 2015; Iachini et al., 2016). However, when many of these situational factors are controlled within a laboratory setting, the preferred distance that a given individual maintains from others remains remarkably stable over repeated measurements (Hayduk, 1981; Tootell et al., 2021).

Since early 2020, "social distancing" recommendations aiming to reduce transmission of the COVID-19 virus have influenced how far people stand from each other in many public settings. These consciously adopted distances (usually 6 feet in the US, and 2 meters elsewhere) are much larger than those generated by the intrinsic brain mechanisms involved in personal space regulation (e.g., 50–100 cm) (di Pellegrino and Làdavas, 2015). However, it is unclear whether the practice of social distancing, and other effects of the pandemic on social interactions (Killgore et al., 2020; Tull et al., 2020; Calbi et al., 2021), have broadly influenced personal space regulation. To examine this question, we measured personal space in two independent cohorts of subjects. In addition, in the second cohort, personal space size was measured with respect to both real people and avatars presented using virtual reality technology. With these data, we tested the prediction that the size of personal space, assessed in the laboratory using the well-validated Stop Distance Procedure (Hayduk, 1983; Kaitz et al., 2004), increased during the pandemic, even in a virus-free, virtual reality context.

Materials and methods

Participants

Cohort 1

A subset of the participants of a study of the mental health of college students (Burke et al., 2019; DeTore et al., 2022) underwent a comprehensive in-person clinical and cognitive assessment that included measurements of personal space size with human confederates (see details below). A total of 249 participants were assessed (65.1% female, mean age: 19.0), including (1) $n = 178$ in 2017–2019 (65.2% female; mean age: 19.0), (2) $n = 38$ in January and February of 2020, immediately prior to the beginning of the pandemic and the institution of the associated restrictions and mandates in Boston (68.4% female, mean age: 18.7), and (3) $n = 33$ after March 2020, during the pandemic (60.6% female, mean age: 19.3). There were no significant differences in age or gender across these three groups (see Supplementary Table S1 for additional demographic information about this cohort). The three groups were 100% independent of each other (with no common subjects). Also, the experimental procedures were identical across these groups, other than some additional precautions implemented during the pandemic (see below).

Cohort 2

A second cohort of healthy individuals ($n = 19$, 47% female, mean age: 30.6 ± 11.3 years) were recruited *via* online advertisement posted on the Massachusetts General Hospital (MGH) Rally Website[1] and initially assessed before the COVID-19 pandemic lockdown began in Boston, MA (during the period between September 2019 and early March 2020; the pandemic lockdown in Boston began on March 13, 2020). A subset of this same group of subjects ($n = 12$, 42% female, mean age: 33.3 ± 11.2 years) returned to complete a second assessment session, which was identical to the first (other than the addition of pandemic-related precautions, see below), during the initial surge of the COVID-19 pandemic in Boston (July–December 2020; see Supplementary Table S2 for additional demographic information about this cohort). All subjects of the baseline sample who were willing and able to return were enrolled in the second session. The two sessions were an average of 10.04 ± 1.6 months apart. Intrinsic personal space preferences have been shown to be stable and measured reliably over that length of time (Hayduk, 1983).

All research protocols were approved by the Mass General Brigham Healthcare Institutional Review Board. Written informed consent was obtained from all subjects prior to enrollment.

Overview of procedures

Throughout this study, we used a well-validated, highly reliable (kappa ~0.8) experimental procedure for measuring personal space size, the Stop Distance Procedure (SDP) (Hayduk, 1983; Kaitz et al., 2004). The SDP measures the distance from a subject at which the subject first becomes uncomfortable when another person (the experimental confederate) approaches them (passive trials), or when the subject approaches another person (active trials). Both types of trials measure the distance between the subject's body and their personal space boundary.

To control additional variables that could potentially influence personal space size (such as varying physical characteristics of the SDP confederates), in Cohort 2 we also collected personal space measurements using an immersive virtual reality (VR) version of the SDP, in addition to the conventional SDP. This VR procedure measures personal space in response to virtual simulations of humans ("avatars") but is otherwise identical to the SDP conducted with real humans. VR-based measurements of personal space with respect to

1 https://rally.massgeneralbrigham.org/

avatars have been shown to correspond closely to those measured to real humans *in vivo* (Iachini et al., 2016; Tootell et al., 2021).

In addition, in Cohort 2, arousal responses to personal space intrusions (as reflected by subjective discomfort ratings) were measured at different distances within (as well as outside of) personal space boundaries, to both real and virtual humans (see details below).

The conventional SDP

Passive SDP trials: Subjects were first asked to stand still while facing a human confederate (a laboratory staff member) who was standing 3 meters away from the subject. Subjects were instructed to maintain eye contact with the confederate, who maintained a neutral facial expression, and told that the confederate would start walking slowly toward them, and that they should say "okay" when the confederate reached the distance that the subject would typically maintain from a person they had just met. For these passive trials, the confederates were trained to walk at approximately 0.1 m/s. Passive SDP trials were collected in both Cohorts 1 and 2.

Active SDP trials: In Cohort 2, the active version of the SDP was also conducted, in addition to the passive version. Active trials began similarly to the passive trials, with the subject standing 3 meters away from the confederate. However, in the active version of the procedure, the subjects were instructed to approach the confederate, and to stop at the distance described above and say "okay." Again, subjects were asked to maintain eye contact with the confederate, who maintained a neutral facial expression.

Both the active and passive SDP trials were conducted with a male and a female confederate, in a counterbalanced order, with two trials per gender.

The VR-based SDP

A HTC VIVE Virtual Reality System was used to collect the VR-based SDP and the measurements of responses to personal space intrusions by avatars. A head-mounted display (HMD) presented stereoscopic images at a resolution of 1,080 × 1,200 pixels per eye, with a 110° field of view at a refresh rate of 90 Hz. A software program for measuring personal space (designed by the research team and developed by Productive Edge,[2] Chicago, Illinois, United States) was run *via* a SteamVR platform on an Alienware 15 R3 Laptop. In the HMD, each avatar was presented in the identical simple environment (a room with white walls, see Supplementary Figure S1). The avatars (i.e., non-player characters) could be placed at different distances from the subjects and could appear to walk toward subjects while maintaining eye contact with them. Both active and passive SDP trials were conducted using four different avatars (two males and two females, 50% non-white in appearance). The SDP type (active or passive), SDP modality (real or virtual), and confederate order were counterbalanced across subjects. There were two trials per avatar, with a total of eight active trials and eight passive trials (16 trials per time point).

In the VR environment, the height of each avatar was set to equal the height of the subject, and the approach speed was set at 0.1 m/s. As with the conventional SDP, in the passive trials, subjects were asked to stand still and maintain eye contact with an avatar that began walking toward them. The subjects were instructed to say "okay" when the avatar reached the distance that they would typically maintain from such a person they had just met. During the active trials, the subjects were instructed to approach the avatar, and to stop at this distance and at the same time say "okay."

Summary of design and number of trials of the SDP

Thus, for Cohort 1, the SDP included only passive trials with human confederates (the standard procedure), with a total of 4 trials collected per subject (two trials per each confederate gender).

In Cohort 2, the SDP included both passive and active trials (with two trials per each confederate gender), with both human (1 male and 1 female: 4 trials × 2 (passive and active) = 8 trials) and avatar (2 male and 2 female: 8 trials × 2 (passive and active) = 16 trials) confederates (a total of 24 SDP trials), at two time points (before and during the pandemic). Thus for Cohort 2, a total of 48 SDP trials were collected per subject.

Responses to personal space intrusions

In Cohort 2, discomfort in response to personal space intrusions was also measured, in addition to personal space size. First, personal space size was calculated independently in each individual subject for each of the two SDP modalities (real and virtual), using the average personal space size measured in the active trials of that visit, which are slightly more stable than the passive trials (Tootell et al., 2021). Then multiples of each individual subject's personal space size (25, 50, 100, 200, and 400%) were calculated. To measure discomfort in response to personal space intrusions, real or virtual humans were presented in separate runs at these 5 distances from the subject in a counterbalanced, pseudorandomized order. For each trial, the subject began the trial with their eyes closed, and then was asked to open their eyes during the presentation of each stimulus. The subject was instructed to stand still during the stimulus presentation and maintain eye contact with the real or virtual human. During each presentation, subjects were asked to rate their agreement to the statement "I want to move away" (indicating subjective discomfort) on a Likert scale from 1–5 (1: not at all, 3: somewhat, 5: very much). The order of modality (i.e., of the two procedures conducted with real vs. virtual humans) was the same as the order used for the initial SDP measurement within each subject and visit (Tootell et al., 2021).

2 https://www.productiveedge.com/

Fitting power law functions

A prior study demonstrated that relative magnitudes of discomfort in response to varying personal space intrusions (as above) were best approximated by a power law function (Tootell et al., 2021). To test whether such a pattern of discomfort responses was altered during the pandemic in Cohort 2, power law functions as $D = a\,x^b$ were fitted to the pooled discomfort ratings for each time point, where D is the reported discomfort level, x is the distance between the subject and the real or virtual human (as a percentage of pre-pandemic personal space size), and a, b (the prefactor and the exponent, respectively) are parameters obtained by minimizing the sum squared error between the power law function and the data. Separate power law functions were fitted to the data collected before and during the pandemic, and for the procedures using real and virtual humans. To test whether the power law functions were significantly different before versus during the pandemic, the fitting procedure was repeated 1,000 times in each case, by bootstrapping the data with substitution. The resultant a and b parameters of the two time points (before and during the pandemic) were compared using the nonparametric two-sample Kolmogorov–Smirnov (KS) test, separately for real and virtual humans.

COVID-19 safety procedures

For assessments occurring during the pandemic, subjects were screened for COVID-19 symptoms and travel within 48 h of arrival in accordance with MGH guidelines. In addition, mask-wearing and social distancing policies were in effect for all subjects and staff members throughout the majority of the research visits. The only exception to this (approved by the MGH COVID safety team) was during the SDP measurement of personal space to real humans; in this case, the subject wore a mask and protective eye goggles, while the confederate (i.e., staff member) did not wear a mask. This was done in order to maintain the same SDP conditions from the perspective of the subject (facing someone who is not wearing a mask) before and during the pandemic. Immediately following the SDP procedure, the staff member resumed wearing a mask.

Statistical analyses

Cohort 1

A one-way ANOVA was used to test for differences among the three groups in the size of personal space, and significant effects were followed up by Independent Sample *t*-tests, to test the hypothesis that personal space was larger during, compared to before, the pandemic.

Cohort 2

Repeated-measure ANOVAs (modality × time) and paired samples *t*-tests were used to test for differences in personal space size and discomfort ratings across modality (real and virtual) and the two time points (before and during the pandemic), to test the hypothesis that personal space size and discomfort in response to personal space intrusions increased during vs. before the pandemic in this cohort. Significance values (for paired *t*-tests comparing discomfort ratings across distances) were corrected for multiple comparisons (alpha = 0.05, Bonferroni corrected), within each time point and modality. Change scores were calculated as the difference between values collected at the second and first time point (i.e., "During" minus "Before" the COVID-19 pandemic). Thus, a positive change score indicated an increase in the respective measure over time.

Correlations

Because some of the Cohort 2 personal space measurements and the self-report questionnaire data were not normally distributed, Spearman's correlations were used in the correlation analyses, including those measuring relationships between (1) personal space size during the pandemic and (2) changes in personal space size over time and:

1. local rates of COVID-19 cases, measured as the positive COVID-19 case rate during the previous 2 weeks in the town in which the subject lived (obtained from Massachusetts Department of Public Health COVID-19 data archive).[3]
2. self-reported beliefs and experiences related to the pandemic (Gerhold, 2020), including the perceived risk of COVID infection and the practice of social distancing.

Correlations with symptoms of psychopathology and distress were also explored, including anxiety and distress related to the pandemic, as well as levels of depression (Beck et al., 1961), anxiety (Spielberger et al., 1983), and subclinical psychotic symptoms (Peters et al., 1999; Supplementary Table S1).

Results

Cohort 1

A one-way ANOVA [$F(246,248) = 5.698$, $p = 0.004$] revealed that in Cohort 1, the size of personal space (measured with respect to real humans) was significantly larger in the group assessed during the pandemic compared to both: (1) those assessed in early 2020 [$t(69) = -3.076$, $p = 0.003$] and (2) those assessed more than 6 months before the pandemic [$t(209) = -3.238$, $p < 0.001$; Figure 1].

3 https://www.mass.gov/info-details/archive-of-covid-19-cases-in-massachusetts

Cohort 2

As expected (Tootell et al., 2021), in Cohort 2, the size of personal space with respect to real humans was highly correlated with the size of personal space to virtual humans (avatars) across individuals, for both the passive and active trials, both before [passive trials: $r(17) = 0.625$, $p = 0.004$; active trials: $r(17) = 0.644$, $p = 0.003$] and during [passive trials: $r(10) = 0.958$, $p < 0.001$; active trials: $r(10) = 0.790$, $p = 0.002$] the COVID-19 pandemic.

In addition, within these Cohort 2 subjects, the size of personal space was significantly larger during, compared to before, the COVID-19 pandemic for all four measurements of personal space size [real humans: passive trials: $t(11) = 5.732$, $d = 1.655$, $p < 0.001$; active trials: $t(11) = 3.863$, $d = 1.115$, $p = 0.003$; virtual humans: passive trials: $t(11) = 2.918$, $d = 0.842$, $p = 0.014$; active trials: $t(11) = 3.082$, $d = 0.890$, $p = 0.01$; see Table 1; Figure 2; Supplementary Table S3]. Also, these changes in personal space size during the pandemic to real and virtual humans were significantly correlated with each other (passive trials: $r = 0.608$, $p = 0.036$; active trials: $r = 0.762$, $p = 0.004$; See Supplementary Figure S2).

Prior work has shown that intrusions into personal space by unfamiliar others lead to an increase in discomfort at progressively closer distances (Felipe and Sommer, 1966; Hayduk, 1981; Llobera et al., 2010; Schoretsanitis et al., 2016), perhaps following a power law function (Tootell et al., 2021). To test whether such personal space intrusion-driven discomfort levels changed during the pandemic, subjects were asked to rate their discomfort in response to real and virtual humans, which were presented at a range of distances (25, 50, 100, 200, 400% of each subject's personal space size, see "Materials and methods"), both before and during the pandemic.

The discomfort levels as a function of distance followed a power law fall-off, as previously (Tootell et al., 2021) in all four cases (to real humans, before and during the pandemic, respectively: $R^2 = 0.71$ and 0.67; to virtual humans, before and during the pandemic respectively, $R^2 = 0.73$ and 0.74). During the pandemic, discomfort to personal space intrusions increased significantly compared to the pre-pandemic discomfort ratings in response to both real and virtual humans, following a power law (real humans: $p < 0.0001$, KS statistic 0.53; virtual humans: $p < 0.0001$; KS statistic 0.21; Figure 2C). Specifically, the prefactor a was significantly different between the two timepoints ($p < 0.0001$ for both real and virtual humans, KS statistics 0.36 and 0.20, respectively) and the exponent b was significantly different between the two timepoints ($p < 0.0001$ for both real and virtual humans, KS statistics 0.53 and 0.21, respectively).

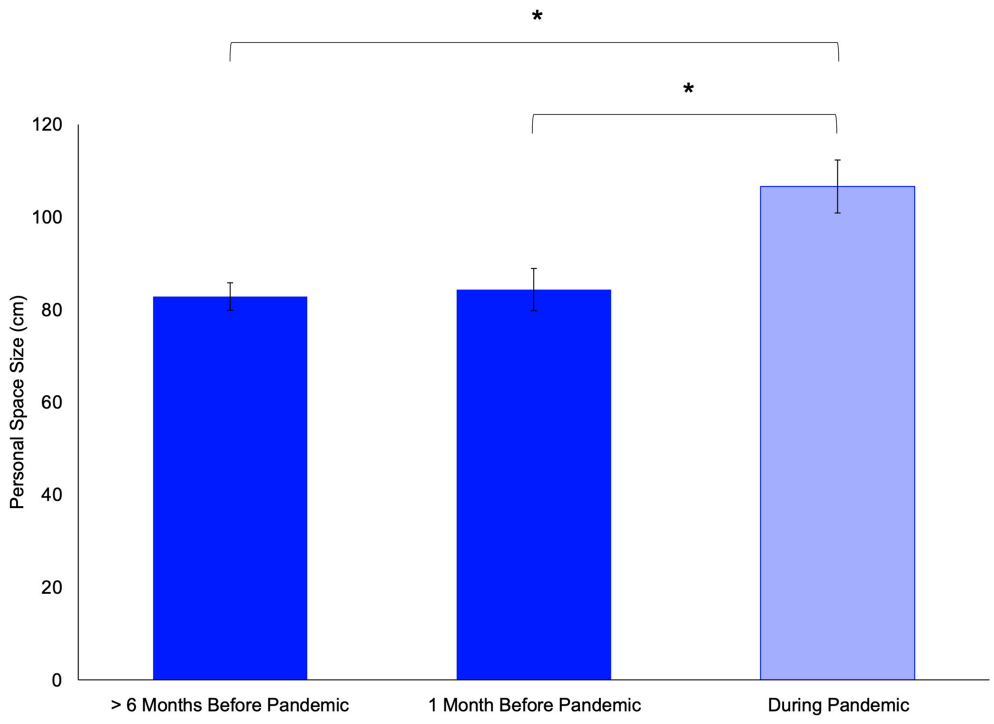

FIGURE 1
The size of personal space was larger during (compared to before) the pandemic (Cohort 1). Bar plots of mean personal space size, as measured by the standard Stop Distance Procedure (using human confederates), of the three groups of subjects in Cohort 1 are shown. Personal space size was significantly larger in the group assessed during the pandemic (light blue bar) compared to (1) those who had been assessed in early 2020 [1 month before the pandemic; $t(69) = -3.076$, $p = 0.003$; right dark blue bar] and (2) those who had been assessed well before the pandemic [> 6 months before the pandemic; $t(209) = -3.238$, $p = 0.001$; left dark blue bar]. There was no significant difference between the mean personal space size of the two groups assessed before the pandemic [$t(214) = -0.222$, $p = 0.824$]. Error bars indicate standard errors of the mean. * $p < 0.005$.

TABLE 1 Personal space size measurements, Cohort 2.

	Personal space size to real humans				Personal space size to virtual humans			
	Baseline	Before the pandemic	During the pandemic	Percent change	Baseline	Before the pandemic	During the pandemic	Percent change
Passive trials	82.6 (26.9)	78.8 (23.3)	124.5 (36.0)	58.0%	91.67 (26.3)	93.1 (24.1)	125.1 (47.1)	34.4%
Active trials	67.3 (25.2)	62.0 (21.7)	99.0 (37.8)	59.7%	73.7 (25.1)	72.6 (23.9)	96.9 (36.5)	33.5%

Mean personal space size in centimeters [mean (standard deviation)] and percentage change in personal space size, measured with respect to real and virtual humans, in Cohort 2 at baseline ($n = 19$) and in those who were assessed at the two time points (before and during the pandemic, $n = 12$). There were no significant differences between the Baseline ($n = 19$) and Before the Pandemic ($n = 12$) means (all $p > 0.59$).

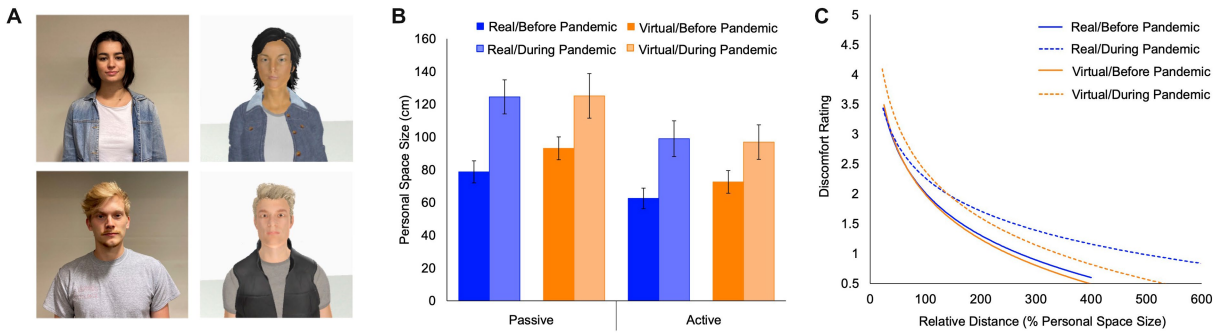

FIGURE 2
Personal space size and discomfort during personal space intrusions increased longitudinally within individuals during the COVID-19 pandemic (Cohort 2). **(A)** Examples of real and virtual human confederates that were used in the Stop Distance Procedure (SDP) and **(B)** the measurements of mean personal space size in Cohort 2 are shown. Personal space size, measured using the SDP with real and virtual humans, increased significantly during the COVID-19 pandemic within individuals. Also, the increases in personal space during the pandemic to the real and virtual humans correlated with each other (all $r > .608$; all $p < .036$). **(C)** Power law fits to the before- and during-pandemic discomfort ratings, as a function of distance from real or virtual humans, expressed as percentages of before-pandemic personal space size, are shown.

Correlations with beliefs and experiences during the pandemic

For those assessed during the pandemic (of Cohorts 1 and 2 combined, $n = 43$), personal space size (in response to real humans, passive trials) was significantly positively correlated with social distancing behavior (ratings of "I stay at least 6 feet away from people when I am outside"; $r(41) = 0.358$, $p = 0.019$; Figure 3A). There were no significant correlations between personal space size during the pandemic and perceived or actual risk of infection, COVID-related anxiety or distress or any psychopathology measure (all $p > 0.126$).

In Cohort 2, the within-subject increase in personal space size during the pandemic in response to both real and virtual humans was significantly correlated with the *perceived* risk of being infected with the COVID-19 virus (ratings of "How likely do you think it is that you might become infected with COVID-19 in the near future?") across all four personal space measurements (all $r > 0.603$; all $p < 0.038$; Figure 3B). In contrast, there were no correlations between the increase in personal space size during the pandemic and rates of *actual* infection, as reflected by case rates in the towns where the subjects lived. Perceived and actual risks of COVID infection were not correlated with each other ($r = -0.030$, $p = 0.927$).

Also, ratings of pandemic-related anxiety and distress and social distancing behaviors during the pandemic did not correlate with the increase in personal space size during the pandemic (all $p > 0.073$).

Discussion

Summary of findings

Here we report evidence derived from two independent cohorts of subjects that personal space boundaries expanded during the COVID-19 pandemic. In the first cohort, an increase in personal space size was observed in individuals assessed during the pandemic in comparison to two similar groups assessed either immediately before, or greater than 6 months before, the beginning of the pandemic. In a second smaller cohort, comprehensive measurements of personal space characteristics, collected both before and during the pandemic in the same subjects, revealed a large (~40–50%) increase in personal space size following the onset of the pandemic, accompanied by an

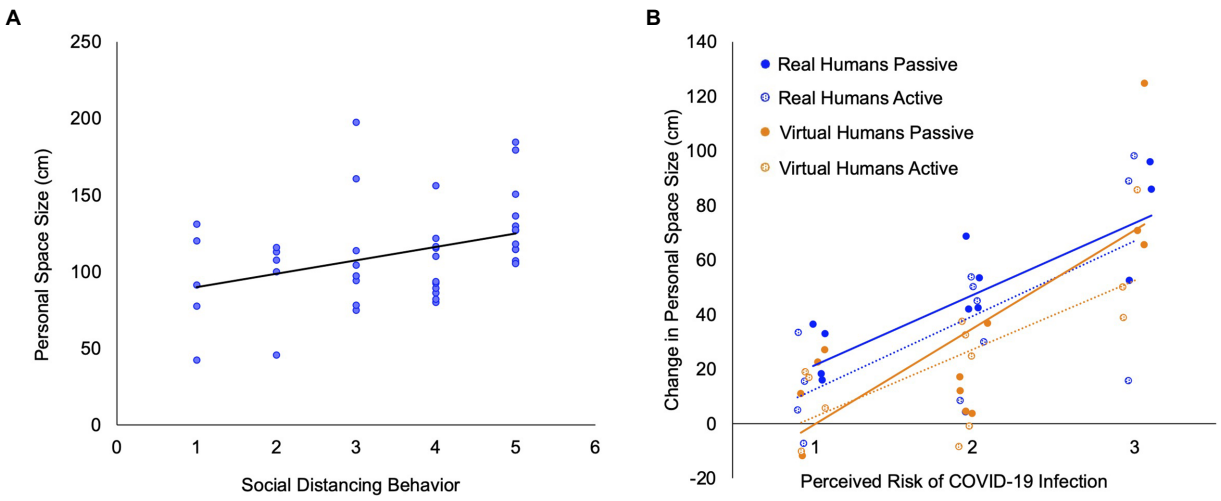

FIGURE 3
Associations with social distancing behavior and perceived risk of being infected with COVID-19 during the pandemic. **(A)** There was a significant correlation between personal space size during the pandemic and social distancing behavior (as assessed using ratings of the statement "I stay at least 6 feet away from people when I am outside"; $r(41)=0.358$, $p=0.019$) in the subjects assessed during the pandemic (31 subjects of Cohort 1 and 12 subjects of Cohort 2; total $n=43$). Two subjects of Cohort 1 did not complete the scale measuring beliefs and experiences related to the pandemic. **(B)** Across all four personal space measurements (i.e., real and virtual, passive and active SDP trials), the change in personal space size observed in Cohort 2 that occurred following the onset of the pandemic (During – Before) was significantly positively correlated with perceived risk of COVID-19 infection (Real: passive: $r(10)=0.745$, $p=0.005$, active: $r(10)=0.656$, $p=0.021$; Virtual: passive: $r(10)=0.603$, $p=0.038$, active: $r(10)=0.738$, $p=0.006$).

increase in discomfort with the physical proximity of others. These longitudinal changes in personal space size occurred in response to both real humans and to avatars encountered in a virtual setting in the absence of COVID infection risk. The fact that the identical effect was observed in response to both real humans and avatars suggests that changes in personal space regulation during the pandemic became somewhat habitual and automatic over time.

Consistent with this interpretation, we also found that the size of personal space during the pandemic was significantly correlated with social distancing. Prior evidence for plasticity in the intrinsic mechanisms involved in monitoring external space near the body (Canzoneri et al., 2013; Martel et al., 2016; Serino, 2019) suggests that such plasticity occurring in response to social distancing or isolation may underlie changes in personal space-related behaviors during the pandemic. Thus, the current data raise the possibility that experience-dependent modifications in personal space regulation can be maintained and reinforced over time by a habitual behavior such as social distancing. However, further testing of this hypothesis is necessary to fully understand the mechanisms underlying these behavioral changes.

In addition, the perceived, but not the actual, risk of being infected with COVID-19 was correlated with the pandemic-associated change in personal space size in the second cohort. Thus, beliefs about the infectiousness of the virus may have contributed to a preference for greater distance from others during the pandemic, which was manifested even in response to avatars encountered in an immersive virtual reality environment in this study. This link between personal space size and perceived risk of infection replicates and extends a prior finding of an association between self-reported personal space preferences (assessed using a projective, online scale) and perceived, but not actual, COVID-19 infection risk during the early pandemic (Iachini et al., 2021). It is also consistent with a finding of an association between greater segregation of near and far space during the pandemic and greater germ aversion (Serino et al., 2021).

Intriguingly, interpersonal distances measured during the pandemic have been found to be smaller if the confederate in projective measurements of such distances appears to be wearing a mask when compared to non-mask-wearing confederates (Cartaud et al., 2018; Lisi et al., 2021; Biggio et al., 2022). These findings suggest that the presence of a mask elicits a sense of safety that influences personal space regulation. Based on these findings, we can speculate that the inclusion of mask-wearing confederates in the current study might have reduced or eliminated the pandemic-linked increases in personal space size. However, given that we found that perceived risk of COVID infection was not correlated with actual risk, and perceived infection risk was associated with increases in personal space size during the pandemic, it is possible that the presence of masks (and knowledge about their protective effects) would not have strongly impacted these results.

Subjective discomfort ratings increased in concert with the observed increases in personal space size in the current study. These findings are broadly consistent with other evidence for discomfort with the physical proximity of others during the pandemic, such as higher arousal ratings and more negative appraisals of images depicting large social gatherings during the early pandemic (Massaccesi et al., 2021). The time course of this discomfort response (i.e., the length of time it may take to abate after the most

threatening aspects of the pandemic, related to the risks for serious illness, death, or loss, have substantially lessened) remains unclear.

The functions of personal space

Although one goal of maintaining a safety zone around the body is the avoidance of harm (Graziano and Cooke, 2006), in humans there are clearly other functions of personal space-related behaviors beyond the physical protection of the body. Adjustments in personal space during social interactions are used by humans to communicate non-verbal, social signals (Hayduk, 1983) similar to the way that other forms of "body language" convey this type of information to others. For example, smaller interpersonal distances can signal trust, support, or comfort, whereas larger distances can convey fear or respect. During the pandemic, this normally automatic channel of social information exchange has not been fully available in many circumstances, i.e., it has been blunted or modified in many contexts due to social distancing practices, concerns about infection risk, and related avoidance behaviors. The specific impediment to social communication associated with the blunting of "natural" personal space regulation during the pandemic is analogous to that associated with wearing masks (i.e., mask-related interference with facial affect recognition; Pavlova and Sokolov, 2022). Given the length of time that such practices were in effect (and are still intermittently reinstated or voluntarily adopted) in some parts of the world, it is not surprising that this specific form of nonverbal communication may have been impacted. Some individuals may require time to regain full use of some of these tools of social interaction, such as personal space regulation.

In addition, individuals who had experienced some impairments in these domains or who had not yet fully developed these skills (e.g., children) before the pandemic may find this period of recovery (or transition to an endemic phase of the pandemic) particularly challenging. Personal space abnormalities have been observed in autism (Kennedy and Adolphs, 2014; Asada et al., 2016), schizophrenia (Park et al., 2009; Holt et al., 2015; Schoretsanitis et al., 2016; Lee et al., 2021; Zapetis et al., 2022), and Post Traumatic Stress Disorder (Bogović et al., 2016) and have been linked to loneliness (Layden et al., 2018), anxiety (Iachini et al., 2015) and social functioning impairments (Nechamkin et al., 2003; Holt et al., 2015; Zapetis et al., 2022). Thus, persistently impaired regulation of personal space in certain individuals could indicate a need for further evaluation, close monitoring or therapeutic intervention.

The neural basis of changes in personal space during the pandemic

Although personal space-related behaviors have been linked to the function of the network of parietal and frontal cortical brain regions involved in monitoring the space near the body (Graziano and Cooke, 2006; Huang et al., 2012; Cléry et al., 2015; di Pellegrino and Làdavas, 2015), it is not known whether the function or structure of this network has been altered in parallel with changes in personal space-related behaviors during the pandemic. Given that the functional connectivity of this network (Holt et al., 2014; Zapetis et al., 2022) and variability in its responses (Ferri et al., 2015) have been linked to individual differences in personal space preferences, it is possible that changes in this circuit may have accompanied habitual enlargements in personal space during the pandemic. If such changes are persistent, longitudinal neuroimaging studies may be able to detect them and potentially shed light on some of the mechanisms underlying the plasticity of personal space regulation.

Limitations and future directions

The findings of this study must be interpreted with caution due to several limitations of this work. The sample size of the second cohort was small, and inclusion in the second assessment of this cohort was based on the subjects' willingness and ability to participate in research during the pandemic. However, the effect sizes of the longitudinal changes observed in this cohort were consistently large across all four measurements of the size of personal space (0.84 to 1.66), suggesting that these findings are relatively robust. Follow-up studies will be necessary to determine the time course of these changes as society emerges from the pandemic and resumes social activity levels that are closer to pre-pandemic norms. For those with persistent fears about the risks associated with physical proximity to others, the development of behavioral interventions that address these concerns may be helpful.

Data availability statement

The datasets presented in this study can be found in online repositories. The names of the repository/repositories and accession number(s) can be found at: https://osf.io/hp2n4/?view_only=a017443177bf425087daccd1ca86fd74.

Ethics statement

The studies involving human participants were reviewed and approved by Massachusetts General Brigham Institutional Review Board. The participants provided their written informed consent to participate in this study. Written informed consent was obtained from the individual(s) for the publication of any potentially identifiable images or data included in this article.

Author contributions

DH developed the study concept, obtained the funding for the project, and oversaw the study. DH, SZ, and RT were involved in

the study design. SZ and JZ collected the data. SZ, JZ, and BB analyzed the data. DH and SZ drafted the manuscript. RT, BB, and JZ revised the manuscript. All authors contributed to the article and approved the submitted version.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Publisher's note

Supplementary material

The Supplementary material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fpsyg.2022.952998/full#supplementary-material

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Psychological distance and user engagement in online exhibitions: Visualization of moiré patterns based on electroencephalography signals

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The COVID-19 pandemic has significantly affected the exhibition of artworks in museums and galleries. Many have displayed their collection online. In this context, experiencing an online exhibition is essential for visitors to appreciate and understand the artwork. Compared with offline exhibitions, visitors to online exhibitions are often unable to communicate their experiences with other visitors. Therefore, in this study, by facilitating communication *via* Zoom call, we established a system that allows two people to visit the museum together through the Google Arts and Culture (GA&C) website. To reduce the psychological distance between online visitors and help increase user engagement, we designed and developed a media device based on moiré pattern visualization of electroencephalography (EEG) signals. The participants were divided into two groups to visit the online museum, communicating remotely through Zoom. The objective of this study was to test whether a real-time EEG signal visualization device could help close the psychological distance between participants and whether it could increase user engagement with the online exhibition. Participants were randomly assigned to either the normal online exhibition experience (NOEE) group or EEG signal visualization device (ESVD) group. Participants in the NOEE group experienced four online exhibitions (Task1, Task2, Task3, and Task4) together (two participants per test unit). The conditions for participants in the ESVD group remained the same, apart from adding a media device to enable them to visualize EEG signals. A total of 40 university students participated in this study. Independent samples *t*-tests revealed that participants in the ESVD group perceived a significantly closer psychological distance between themselves and the participants on the opposite side than those in the NOEE group ($t=-2.699$; $p=0.008<0.05$). A one-way ANOVA revealed that participants experienced Task3 with significantly closer psychological distance assessments than Task1 ($p=0.002<0.05$), Task2 ($p=0.000<0.05$), and Task4 ($p=0.001<0.05$). Repeated ANOVAs revealed that participants in the ESVD group had higher overall user engagement than those in the NOEE group, with marginal significance ($p=0.056<0.1$). Thus, this study shows that EEG visualization media devices can reduce the psychological

distance between two participants when experiencing an online exhibition. Moreover, it can increase user engagement to some extent.

KEYWORDS

COVID-19, online exhibition, psychological distance, electroencephalography (EEG), user engagement (UE), user experience (UX), moiré patterns

Introduction

COVID-19 has impacted many areas of our daily lives, including the exhibition of artworks. Most museums and galleries have restricted the number of visitors to prevent the spread of COVID-19 by ensuring social distancing. In public health, social distancing is also called physical distancing (Hensley, 2020; Venske, 2020). Physical distancing involves staying at least 6 ft away from others to avoid contracting an airborne disease such as COVID-19. It is a set of non-pharmaceutical interventions or measures designed to prevent the spread of infectious diseases by maintaining physical distance among people and reducing the number of times people come into close contact (Perra, 2021). Physical distance maps the psychological distance between individuals, reflecting the degree of intimacy in interpersonal relationships (Shenghua, 1997, pp. 118–119). Physical distance is even more important for museum and art gallery visitors, especially in terms of processing, experiencing, and appreciating art. Therefore, in pandemic situations, visitors are limited in viewing the exhibition, since it is difficult to convey ideas to others and listen to their thoughts and feelings.

In 1912, Bullough developed the concept of psychological distance in the aesthetics field to illustrate those esthetic feelings stem from the psychological distance that an observer perceives between themselves and the artwork (Dhar and Wertenbroch, 2000; Chen and Li, 2018). In light of this, in the pandemic and post-pandemic era, the categories of distances in Personal Space Theory proposed by Hall (1959) were diminished, losing the "intimate distance" (0–0.45 m, 0–1.5 ft), "personal distance" (0.45–1.2 m, 1.5–4 ft), and part of the "common distance" (1.2–3.6 m, 4–12 ft) and "public distance" (3.6–7.6 m, 12–25 ft). Hence, the distances of Personal Space Theory have changed. On the other hand, and more importantly, online communication is becoming more common; for example, online classes (Pokhrel and Chhetri, 2021), online work (Blanchard, 2021), and online psychotherapy (Weinberg, 2020); this phenomenon has accelerated online communication and interactions and even become a necessity for many.

As a result of COVID-19, the trend of online communication has become more prominent; consequently, many museums and art galleries have provided online viewing experiences to visitors. International Council of Museums (ICOM) reported that online activities would continue to increase, particularly by creating new digital communication channels in the wake of lockdowns. Additionally, an increasing number of museums and galleries are planning to add online exhibitions to their activities after the end of lockdowns (an increase of 5.6%), and more are planning to start online exhibitions (an increase of 6.5%; International Council of Museums, 2021, pp. 15–16). Digital communication activities increased by at least 15% in museums in Europe and Asia, while the Network of European Museum Organisations (2020) reported that 58% of museums held digital activities (an increase of 37%) and 23% started new activities (King et al., 2021). Thus, the trend of online exhibitions is in line with the trend of online activities. Additionally, online exhibitions are more inclusive, allowing access to people who normally do not have access to physical museums and galleries.

The Internet network makes it possible to chat across time and space and seems to make the distance between people disappear. However, something inherently embedded in the virtual world distorts communication when using AI-facilitated chatting tools (Radziwill and Benton, 2017). Overall, we face uncertain and confused distances both in the physical and virtual worlds (Dewey, 2018), bringing us into a new era of a "distance crisis." Psychologically distant objects and events are not present in a direct experience of reality. In this case, distance is not limited to the physical surroundings, and it could also be abstract (Trope and Liberman, 2010).

With the development of online exhibition technologies, digital devices, such as virtual reality (VR), 3D panoramic VR, and 3D web engines have been used to display artwork (Styliani et al., 2009). Cell phones, computers, tablets, and interactive multimedia devices [e.g., VR/augmented reality (AR) devices], as information dissemination media and bearers of digital technology (Chang et al., 2014; Wu and Li, 2022), gradually change people's exhibition viewing modes, making their experiences more human and emotional. The Google Arts and Culture (GA&C) website is one of the most representative online exhibition sites, featuring selected content from more than 2000 top museums, galleries, and archives (Google Arts and Culture, 2018). Therefore, we selected four different interactive exhibitions from the GA&C website as experiential tasks in our experiment. As visiting and appreciating artworks is also a process of mutual communication and exchange of feelings among visitors, online exhibitions are also increasingly enabling online multiplayer experiences to increase interaction and communication between users. For example, the GA&C website features an interactive multiplayer game called "Puzzle Party" in which participants work together to put together

scattered pieces of the puzzle based on reference images of the artwork (Google Arts and Culture, 2020). However, only a few studies have focused on exploring the psychological distance between users in remote interactions.

Our study focuses on exploring a new way of interaction to decrease the psychological distance between participants in online exhibitions. Because people's physiological signal data are closely related to their emotional and physical states and reactions, we aim to express the "distances" between people by visualizing physiological signals. Among physiological signals, brainwave signals originate from voltage fluctuations caused by ionic currents within brain neurons and have been shown to represent macroscopic activities on the surface layers of the brain (Niedermeyer and da Silva, 2005). Considering this, our study aimed to apply electroencephalography (EEG) signals to explore new physical distance expressions. Currently, an increasing number of studies are incorporating user EEG signals. Relevant studies and applications exist in many fields, such as user experience analysis during human–computer interaction (Lee, 2004; Frey et al., 2013; Li et al., 2022b), driver fatigue detection (Jap et al., 2009; Borghini et al., 2014; Gao et al., 2019), emotion recognition (Alarcao and Fonseca, 2017; Shu et al., 2018), etc. Additionally, more studies have used headset-based noninvasive brain–computer interfaces (Cincotti et al., 2008; Cecotti, 2011). These studies demonstrated that EEG headset devices have increased accuracy (Maskeliunas et al., 2016; LaRocco et al., 2020; Fu et al., 2022).

This novel form of distance expression needs to be visualized to help people's awareness of "distance." The data visualization of various types of information has always been an effective way to transform abstract data and concepts into clearly understandable images. Many fields have applied EEG signal visualization, including affective visualization (Liu et al., 2010; Fu and Li, 2022), interactive art exhibitions (Christopher et al., 2013, 2014), gaming experiences (Kerous et al., 2018), etc., to enhance participants' understanding and visual perception of their EEG signal changes. Therefore, distance visualization can enhance the perception of human interaction.

We simulated two participants together experiencing four online exhibitions from the GA&C website by designing a system. This system was as follows: the two participants were in the same room, and a computer and a screen displaying the EEG signal visualization was assigned to each participant. As the participants were separated by two screens, they could not see each other, thus simulating the scenario of real remote interaction. The experiment used in this study was a comparison experiment. The only independent variable was a media device that transformed the difference in EEG signals between the two participants into real-time moiré patterns. From the 17th to the 20th century, moiré patterns were gradually discovered and explored in mathematics, physics, and art (Isaac, 2000). These were defined as interference images produced by more than two similar fence-like overlapping stripes. Participants were divided into two groups, one of which communicated through Zoom with the camera turned on during the exhibition. The other group was exposed to EEG signal visualization screens. Each screen was placed in front of the participant. During the intervention, participants were able to view the changes in the moiré images displayed on the screens.

Our research questions are as follows:

- R.Q.1: Does visualization of EEG signal differences in the online exhibition experience help users reduce psychological distance?
- R.Q.2: Can EEG enhances user engagement in online environments?

Materials and equipment

Participants

We considered a sample of university students. They were deemed suitable for testing whether the addition of an EEG visualization device would help improve psychological distance and user engagement, given the operational complexity of online exhibitions and evaluation of engagement in online experiences. Before we recruited the participants, we designed our experiments in accordance with the Declaration of Helsinki by the World Medical Association. The ethics review office of the Faculty of Library, Information and Media Science of the University of Tsukuba in Japan approved the study (permission number 22–4).

In the notice for recruiting participants, we marked the general content and flow of the experiment, explicitly stating that two people were required to participate in the experiment as a unit. To reduce the effect of the difference in familiarity between the two participants in each experiment on psychological distance, we selected participants who had known each other for a long time (65% of participants were mutually acquainted for more than 1 year) and were mainly from the same research laboratory. Before starting the experiment, we informed the participants that there was no compensation for participation in the experiment. After the participants received a complete explanation of the study, they agreed to participate and subsequently signed a written informed consent form. Permission of publication of any potentially identifiable images or data included in this study was obtained from pertinent individuals.

Materials

Experimental scenarios and equipment

The experiment location was a classroom with an area of 39 m^2 equipped with Wi-Fi. The equipment used during the experiment included the following: six single light wood-colored desks, made of particleboard covered with a laminate; two Mac laptops displaying the online exhibition; two Apple earphones; two EPOC X headsets for capturing EEG signals; two laptops for recording

EEG signal data; two 70-in screens displaying moiré patterns based on EEG signals; two iPads for answering questionnaires; and one DJI Pocket 2 video camera for recording the whole experiment.

Google arts and culture

In this study, we classified online exhibition websites into four types based on the differences in the interaction methods between exhibits and users on the GA&C website. The GA&C Project was launched in 2011 in collaboration with 17 collaborating museums. The original 1,061 high-resolution images (created by 486 artists from different backgrounds) were displayed in 385 virtual exhibition rooms with 6,000 street-view-style panoramic images (AtoZ Wiki, 2011; Kennicott, 2011). With the aim of making culture more accessible, the project digitized millions of artifacts and made them available online, accessible to everyone (Kennicott, 2011).

Google Arts and Culture has a wealth of content and features, including Virtual Museum Tour, Explore and Discover, Zoom Views, Create Your Own Collections, and educational content. The homepage of the GA&C website is divided into different modules based on these contents and functions, including 2D images and information, 3D virtual space, game interaction, and video explanation. Based on the functions and modules mentioned above, we selected four corresponding exhibitions based on four different interaction types on the GA&C website as tasks in this experiment. The four interaction types are as follows:

- Task1: 2D information kiosk; this describes to the visitor what the exhibit expresses, specifically narrative logic, through pictures/text/diagrams, etc.
- Task2: 3D virtual exhibition; this is a virtual recreation of physical three-dimensional (3D) exhibitions or museums that allow a visitor to navigate in a way that is closer to reality.
- Task3: Interactive game; the user can complete the game (puzzles/coloring games/photography games) tasks with artworks in single or multiplayer mode.
- Task4: Video instruction; this explains information related to the artwork through dynamic video (including motion graphics and sound effects).

The EEG signal visualization device

The human brain contains neurons that communicate *via* electrical impulses. EEG signal measurement is a practical method for detecting sequential changes in brain activity without significant time delays. When we attempted to communicate the relationships between the two brainwave images, we automatically associated them with moiré patterns. Brainwaves and moiré patterns have many common characteristics, not only in principles but also in visual properties.

Illusory patterns always appear as water ripples when shooting a screen with digital devices. This type of pattern is called moiré, which is accidental, transient, and fluid; while it is easy to ignore, it contains variable visual forms (Spillmann, 1993).

We conducted two experiments (Li et al., 2022a). The operating principle of the EEG signal visualization device is to detect the participants' EEG signals; therefore, we built a platform to calculate the differences in real time (see Figure 1). We applied moiré patterns to visualize EEG signal discrepancies to create the following analogy: when the brainwaves from two participants (A and B) were in phase and got more similar, the generated moiré patterns consequently had smaller sizes with shorter diameters, echoing constructive interferences and shorter "distances" between the two participants, and vice versa (see Figure 2). The six scenario images in Figure 2 represent images on the monitor at six different time points. The distance between the two endpoints of the graph on the screen indicated the numerical difference between participant A and participant B's EEG signals and real-time changes. Therefore, when the difference between the EEG signals of the two participants decreased, the shape of the moiré pattern became smaller.

Questionnaire 1: Psychological distance mapping diagram

We designed a picture of a male or female (non-binary gender people could independently choose a closer image) to help participants enhance their identification with the questionnaire (see Figures 3A,B). The concepts of distance and location were evoked by a paper questionnaire printed with an image that suggested the participants' positional orientation and 3D space (Kundrát and Rojková, 2021). The image was printed on A4 paper, and the participants achieved placement by pasting pre-prepared cards (corresponding to the four tasks). The participants used different prompts to identify which part of the image was closer or farther away. One of the cues was a linear perspective convergence grid supported by the texture gradient coverage.

The participants positioned the given cards on the pictures (the cards represented images of participants interacting together) according to the evoked notions of proximity and distance. After each completed online exhibition experience, they received neutral oral instructions to "place this card on the picture depending on whether you feel close or far from the object of interaction" (see Figures 3C,D).

According to the distance theory, we divided the picture into four zones (Hall, 1959): intimate distance (0–0.45 m, 0–1.5 ft), personal distance (0.45–1.2 m, 1.5–4 ft), social distance (1.2–3.6 m, 4–12 ft), and public distance (3.6–7.6 m, 12–25 ft; see Figure 3E). Additionally, we arranged the corresponding score for each grid separately, from 1 to 25 points (see Figure 3F). The closer the participant, the higher the score value, and vice versa (see Figures 3G,H).

Questionnaire 2: User engagement scale-short form

The User Engagement Scale-SF (UES-SF) is a measure developed to evaluate user engagement and has been used in

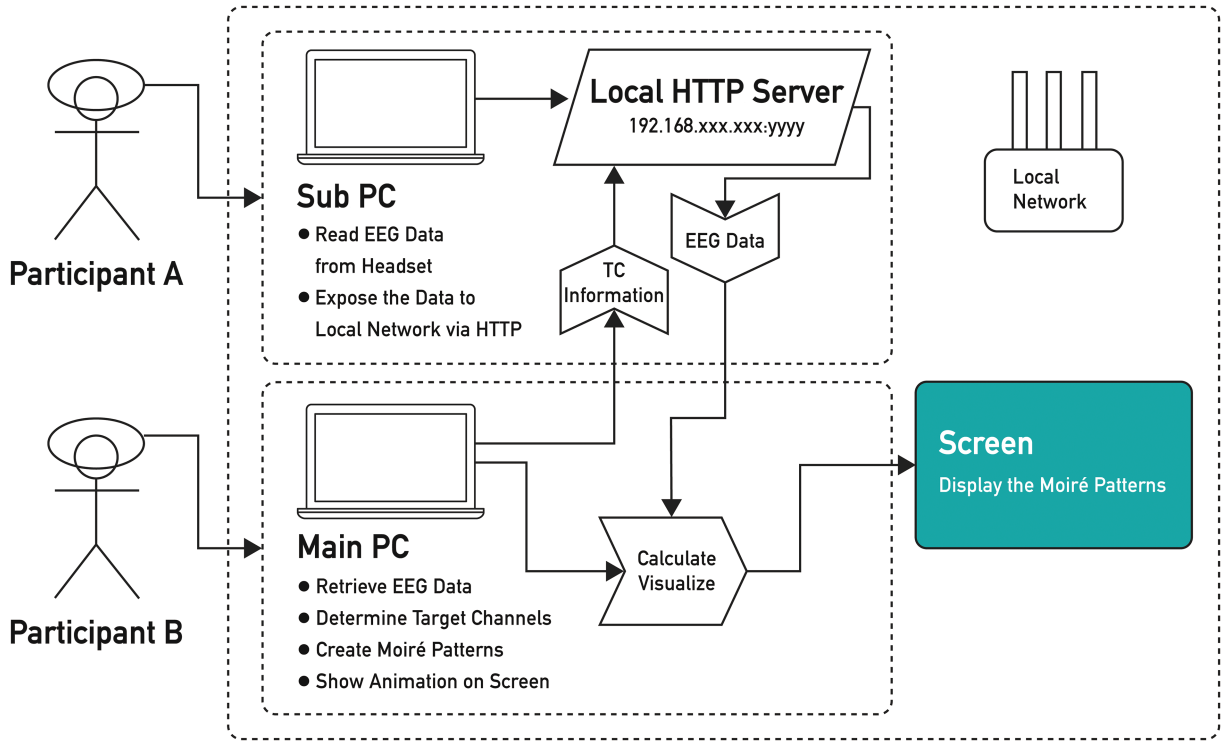

FIGURE 1
Flowchart of the operation of the experimental platform.

a variety of digital applications (O'brien and Toms, 2013). It is designed to measure six attributes of user engagement: aesthetic appeal, focused attention, novelty, perceived usability, sensory engagement, and persistence. The UES-SF is a short form (SF) of the User Engagement Scale (UES), shortened from 31 to 12 items, reducing the response time burden on users (O'Brien et al., 2018). It consists of the following components.

- FA: Focused attention, including three items.
- PU: Perceived usability, including three items.
- AE: Aesthetic appeal, including three items.
- RW: Reward factor, a set of elements (three elements) consisting of EN (persistence), NO (novelty), and FI (sensory involvement) components of the User Engagement Scale.

Design

In the between-subjects design, we designed two conditions, and each participant was tested in only one of the conditions (see Figure 4). The participants were randomly assigned to two groups. These two groups were based on two conditions: the normal online exhibition experience group (NOEE group) and the group with an additional EEG signal visualization device (ESVD group). The difference between the two groups is that we added an independent variable, a media device that translates the difference in EEG signals between two participants into real-time moiré patterns, in the ESVD group. The total duration of the experiment was 5 days (10:00–18:00/day), with the NOEE group performing on Day 1–2.5 and the ESVD group on Day 2.5–5.

Procedures

At the beginning of the experiment, the implementer explained the procedure to the participants and asked them to fill in their personal information. To capture the EEG signals in real time, the participants wore the EPOC X headset-based EEG equipment. Simultaneously, the experiment implementer used two other computers to record the captured data using EMOTIVPRO 3.0.

Subsequently, the participants moved on to the next task until all four tasks and questionnaires were completed within 1 h (see Figure 5). The participants learned how to operate Tasks 1–4 in online exhibitions to familiarize themselves with the specific interaction processes and used the PC's touch area to control the interface. The PC's built-*in camera* and Zoom were used to display images of the faces of the participants in real time during the experiment. Each PC was connected to an earphone that was used

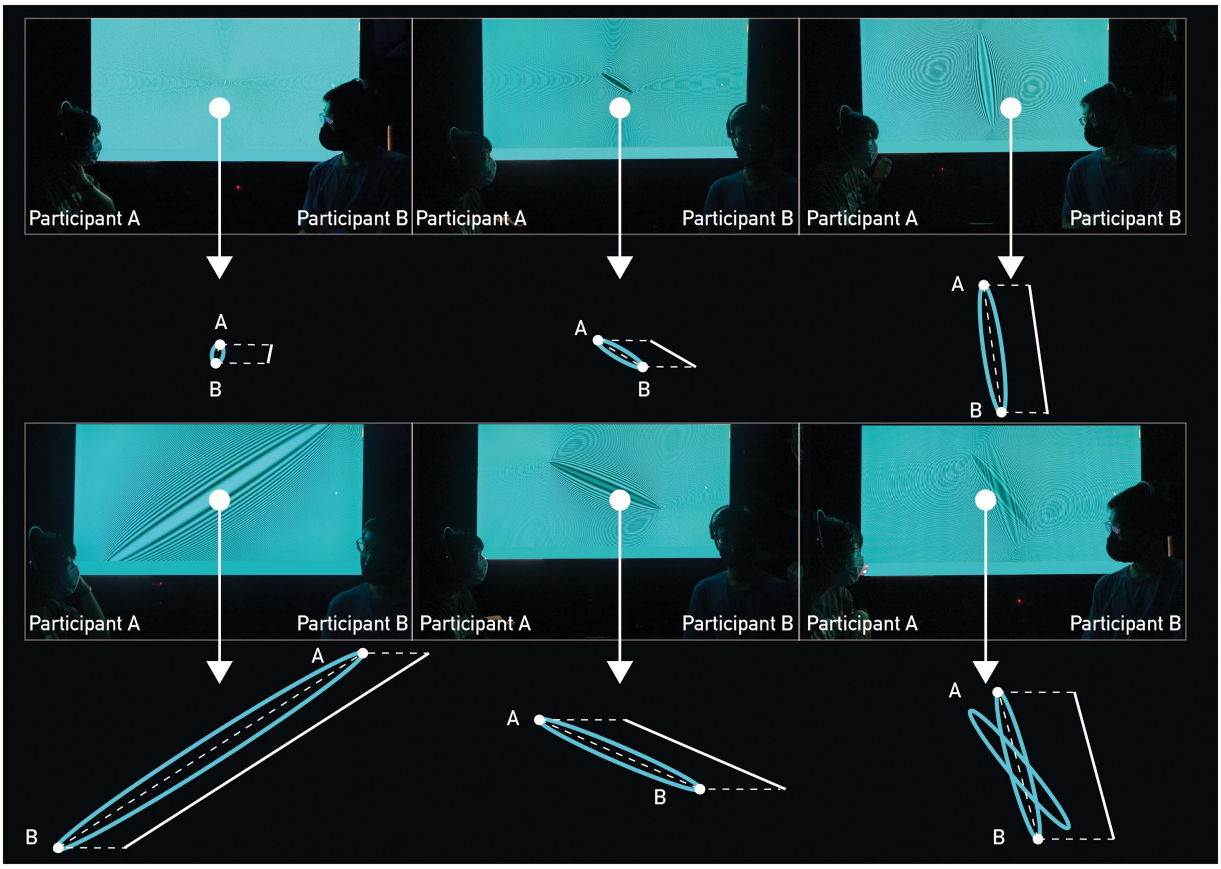

FIGURE 2
We transformed the difference between the electroencephalography (EEG) signals of participant A and participant B into the moiré pattern, and the pattern displayed six different states on the monitor (the images of the six states are six randomly selected time moments).

by the participants for communication. After visiting each exhibition, participants were required to answer a paper questionnaire (PDMD) and an electronic questionnaire (UES-SF) on an iPad.

In contrast to the NOEE group, in the ESVD group, the experimental implementer explained the EEG visualization media device to the participants before the start of the experiment. Additionally, this media device was used as a background screen (the background in front of both participants showed the same view) during the online museum experience, which participants could freely view at any time.

At the end of the experiment, we asked participants to write their feedback based on their overall experience of the experiment by describing the response requirements in the relevant field in the questionnaire. The headings in the questionnaire were described in three languages: English, Japanese, and Chinese, and the participants responded in their native language. The experiment implementer assisted the participants in this process by explaining the questionnaire titles by using neutral vocabulary and did not guide the content of the participants' responses.

Statistical analysis

We used SASS version 25.0 for statistical analysis of the data collected during the experiment. We used descriptive statistics for the sample and divided the experimental data into three main parts:

- Questionnaire data on the characteristics of the experimental participants, including gender, duration of mutual acquaintance, and most frequently used software for online meetings.
- Questionnaire data on the perceived psychological distance of the participants during their experience with Tasks 1–4.
- Questionnaire data on the user engagement of the participants during their experience with Tasks 1–4.

We utilized the following analysis methods:

- Experimental participants: We analyzed the differences in age between groups using independent samples *t*-tests. Differences in gender, region, duration of mutual acquaintance with the other participants, and the most

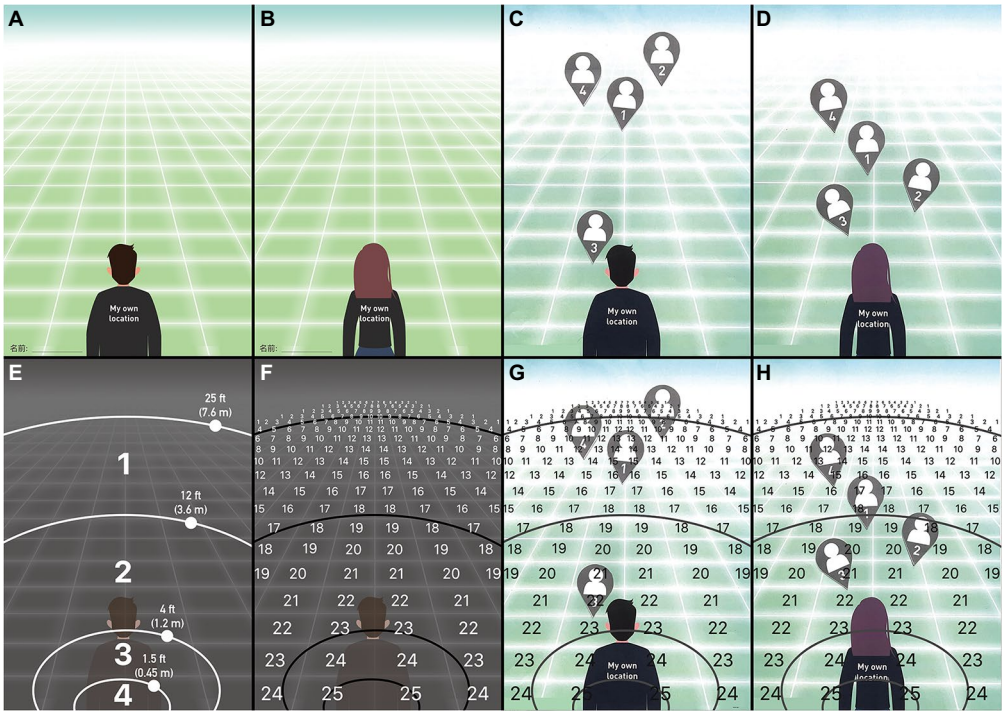

FIGURE 3
(A) Visual stimulus material for those who identified as males; **(B)** Visual stimulus material for those who identified as females; **(C)** Example of a worksheet completed with four tasks of the humanoid card, pasted by a participant who identified as male; **(D)** Example of a worksheet completed with four tasks of the humanoid card, pasted by a participant who identified as female; **(E)** Classification of personal space represented in visually stimulating materials; **(F)** Specific scores (from 1 to 25 scores) for each square represented in the visual stimulus material; **(G)** Example of a worksheet (completed by a participant who identified as male) that displayed scores when counting scores; and **(H)** Example of a worksheet (completed by a participant who identified as female) that displayed scores when counting scores.

frequently used online meeting software were also analyzed using χ^2 tests with SASS version 25.0.

- To solve R.Q.1: Regarding psychological distance during the interactions, we used one-way ANOVA and an independent samples *t*-test to investigate the differences among the four tasks within groups and the users between the groups.
- To solve R.Q.2: Finally, UES-SF questionnaires were analyzed with repeated ANOVA to determine the differences in user participation between groups.

Results

Feasibility and participation

A total sample of 40 students from the University of Tsukuba participated in this study, including 20 males, 19 females, and one non-binary gender person. All participants were East Asian (specifically, Japanese and Chinese). The NOEE group included 20 participants (12 males and eight females) with a mean age of 24.9 ± 1.5 years. In the NOEE group, 14 participants were mutually acquainted for more than 1 year for two people involved in the same experiment (additionally, two participants were mutually acquainted for more than 6 months less than 1 year, two participants for more than 1 month less than 6 months, and two for less than 1 month). The NOEE group included 12 participants who used Zoom most frequently for online meetings, and eight participants used Microsoft Teams. The ESVD group consisted of 20 participants (eight males, 11 female, and one non-binary gender individual) with a mean age of 24.3 ± 2.3 years. In the ESVD group, 12 participants (comprising the groups of two people involved in the same experiment) were mutually acquainted for more than 1 year (in addition, four participants were mutually acquainted for more than 6 months and less than 1 year, two participants for more than 1 month and less than 6 months, and two participants for less than 1 month). The ESVD group had 15 participants; they used Zoom most frequently for online meetings, and five participants used Microsoft Teams. There were no significant differences between the groups in terms of mean age ($p = 0.375$), sex ratio ($p = 0.343$), duration of acquaintance ratio ($p = 0.946$), and commonly used online meeting software proportion ($p = 0.501$). Further details are provided in Table 1.

All participants in the NOEE and ESVD groups completed the appropriate experimental processes without encountering any technical difficulties or significant participant disturbances, which might have terminated the experience. We observed the

FIGURE 4
(A) The normal online exhibition experience (NOEE) group's overall experimental scene; **(B)** The experimental scene of a participant in the NOEE group; **(C)** The experimental scene of another participant in the NOEE group; **(D)** The EEG signal visualization device (ESVD) group's overall experimental scene; **(E)** The experimental scene of a participant in the ESVD group; and **(F)** The experimental scene of another participant in the ESVD group.

participants' behavior and determined that all participants were focused on and motivated from the beginning to the completion of the trial.

Evaluation of psychological distance

We divided the results of the participants' psychological distance assessment into three parts:

- Whether there was a difference between the four tasks within the NOEE group
- Whether there was a difference between the four tasks within the ESVD group
- Whether there was a difference between the NOEE and ESVD groups

In the NOEE group, there were statistical differences among the four tasks within the group according to the results of the one-way ANOVA ($F = 7.473$; $p = 0.000$; see Table 2). According to the results of multiple comparisons, the scores of Task3 were higher than those of the other three tasks, and there were significant differences between the scores of Task3 and Task1 ($p = 0.002$), Task2 ($p = 0.000$), and Task4 ($p = 0.001$; Table 3).

In the ESVD group, there were significant differences between the four tasks within the group according to the results of the one-way ANOVA ($F = 4.510$, $p = 0.006$; see Table 4). According to the results of multiple comparisons, the scores of Task3 were higher than those of the other three tasks, and there were significant differences between Task3 and Task1 ($p = 0.048$), Task2 ($p = 0.001$), and Task4 ($p = 0.021$; Table 5).

According to the results of statistical tests (independent samples t-test) between the four tasks in the NOEE and ESVD groups, there were no significant differences between Task1 in the NOEE group and Task1 in the ESVD group ($p = 0.098$), between Task2 in the NOEE group and Task2 in the ESVD group ($p = 0.061$), between Task3 in the NOEE group and Task3 in the ESVD group ($p = 0.516$), and between Task4 in the NOEE group and Task4 in the ESVD group ($p = 0.162$). After analyzing the two groups' overall engagement (OE), the mean ± SD was 17.88 ± 4.379 for the NOEE group and 19.56 ± 3.478 for the ESVD group. Furthermore, a statistical test (independent samples t-test) for these two groups yielded $T = -2.699$, $p = 0.008$, and $p < 0.05$. This result indicated a statistical difference between the NOEE and ESVD groups (Table 6), where the ESVD group had higher scores than the NOEE group.

Evaluation of user engagement

We evaluated user engagement in the NOEE and ESVD groups, first by detecting within-subject effects for different indicators in the two groups, followed by comparing the two groups in pairs.

Table 7 illustrates the repeated-measures ANOVA for all participants' scores to compare the differences between the four tasks. The four tasks differed significantly in the PU indicator ($F = 4.559$, $p = 0.034$), but not in the FA ($F = 0.504$, $p = 0.479$), AE

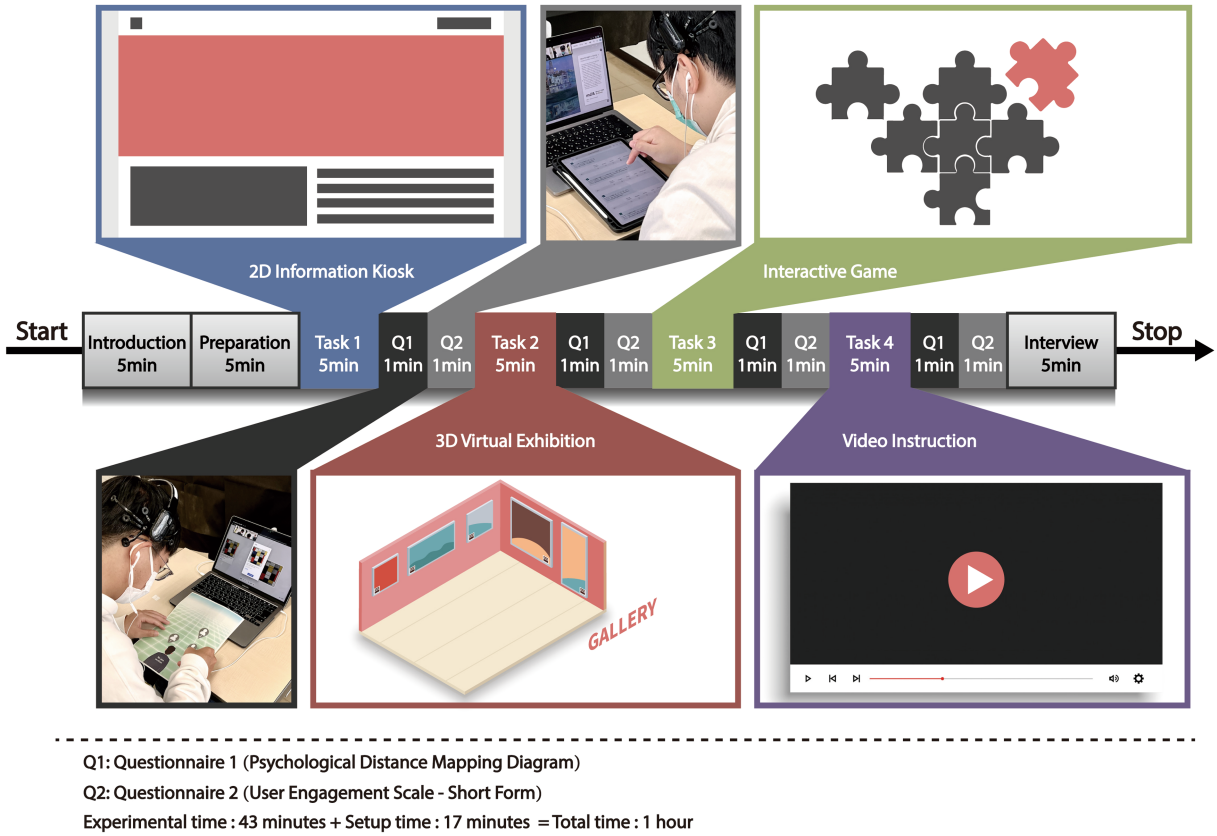

FIGURE 5
Flow diagram of the experimental procedures.

TABLE 1 Participant characteristics.

Characteristics	NOEE Group ($N=20$)	ESVD Group ($N=20$)	Statistics	
			T or χ^2	p
Age mean (SD)	24.9 (1.5)	24.3 (2.3)	$T=0.897$	0.375
	N (%)	*N* (%)		
Gender				
Male	12 (60)	8 (40)	$\chi^2=2.191$	0.343
Female	8 (40)	11 (55)		
Non-binary gender	0 (0)	1 (5)		
Duration of acquaintance				
>1 year	14 (70)	12 (60)	$\chi^2=1.061$	0.946
0.5 years to 1 year	2 (10)	4 (20)		
1 month to 0.5 years	2 (10)	2 (10)		
1 month>	2 (10)	2 (10)		
Online meeting software				
Zoom	12 (60)	15 (75)	$\chi^2=1.026$	0.501
Teams	8 (40)	5 (25)		

NOEE group, online exhibition experience group; ESVD group, additional EEG signal visualization device group.

($F=1.968$, $p=0.163$), and RW ($F=2.587$, $p=0.11$). Table 8 presents the paired comparisons of the overall engagement values for the two groups (NOEE and ESVD). Paired comparisons showed that participants' overall engagement was marginally significantly higher in the ESVD group than in the NOEE group ($p=0.056$; $0.05<p<0.01$).

Discussion

The experimental results showed that increasing the visualization of participants' EEG signals during the GA&C website experience could reduce perceived psychological distance to some extent. In comparing the analysis of user engagement on the GA&C website, we found that the ESVD group, that is, the group with added the EEG signal visualization media, had a slightly higher user engagement. Although the psychological distance is a widely used theoretical construct in literature, there is little clarity on what makes things appear to have greater or less psychological distance. Our study found that EEG signal visualization reduces the perceived psychological distance to some extent and enhances user engagement.

TABLE 2 One-way ANOVA within the NOEE group.

Task	*N*	Mean ± SD	*F*	*p*
Task1	20	17 ± 4.46	7.473	0.000*
Task2	20	16.35 ± 4.146		
Task3	20	21.45 ± 1.877		
Task4	20	16.7 ± 4.578		

*Significance at the 0.05 level.

TABLE 3 Multiple comparisons between Task1/2/3/4 within the NOEE group.

(I) Task	(J) Task	MD (I-J)	*SD*	*p*
Task1	Task2	0.65	1.362	0.997
Task1	Task3	−4.45	1.082	0.002*
Task1	Task4	0.3	1.429	1
Task2	Task3	−5.1	1.018	0*
Task2	Task4	−0.35	1.381	1
Task3	Task4	4.75	1.106	0.001*

*Significance at the 0.05 level.

TABLE 4 One-way ANOVA within the ESVD group.

Task	*N*	Mean ± *SD*	*F*	*p*
Task1	20	19.2 ± 3.694	4.510	0.006*
Task2	20	18.55 ± 2.964		
Task3	20	21.85 ± 1.981		
Task4	20	18.65 ± 4.043		

*Significance at the 0.05 level.

TABLE 5 Multiple comparisons between Task1/2/3/4 within the ESVD group.

(I) Task	(J) Task	MD (I-J)	*SD*	*p*
Task1	Task2	0.65	1.059	0.989
Task1	Task3	−2.65	0.937	0.048*
Task1	Task4	0.55	1.224	0.998
Task2	Task3	−3.3	0.797	0.001*
Task2	Task4	−0.1	1.121	1
Task3	Task4	3.2	1.007	0.021*

*Significance at the 0.05 level.

Social distance and technology

There are various ways of experiencing online exhibitions, including cell phones, tablets, VR devices, and computer screen displays (Broeck et al., 2017). Different experience methods have different degrees of impact on users' psychological distance. During the COVID-19 pandemic, emerging technologies such as tracking apps, AI, big data, 5G, drones, and robotics are being used in China and Japan (Shaw et al., 2020). The high penetration rate of the Internet and smartphones, combined with the acceptance of new technologies, particularly among urban youth in these countries, may have contributed to the positive perception of the moiré patterns generated in this study.

By comparing the four exhibitions within the group, we found that different interaction methods had other effects on the psychological distance between the users. In Task3, two participants were required to work together to complete a pair of puzzles. In this task, compared with the other tasks, they could see the trajectory of each other's operations in real time, and the displayed operation interface was synchronized. The synchronized interface provided an additional way for participants to understand each other's emotions. The statistical results showed that in the NOEE and ESVD groups, the users' psychological distance was the closest in the experience of Task3 (interactive puzzle game) than the others (see the section "Evaluation of Psychological Distance," for a description of the within-group comparison results). Additionally, the participants had the highest number of conversations during the interaction of Task3, and more than half of them expressed a desire to continue experiencing Task3.

Synchronization is considered a joint change in psychophysiological signals when people interact intensively with each other (based on Ekman et al., 2012). Such phenomena while playing games have proven to be psychologically and physically beneficial (e.g., Motataianu, 2015; Robinson et al., 2020). Synchronization can increase socialization capabilities through shared interactions and online experiences (e.g., Sadhukhan et al., 2021). Given that art as a shared experience can also foster emotional contagion in viewers (Gernot et al., 2018), combining online galleries with visualizations of psychophysiological signals (in this case, EEG) may have reinforced empathy among our participants. This could also have influenced the reduction in psychological distance.

The intensity of user engagement may influence users' perceived psychological distance to some extent. Higher user engagement in the ESVD group likely reduced the perceived psychological distance. Van Boven et al. (2010) showed that a reduction in objective distance and emotional intensity reduces perceived psychological distance. Emotional intensity also affects user engagement, as a good emotional design induces a sense of pleasure and security in the user, thus promoting user engagement during the experience (Lee et al., 2002).

Social distance pre- and during COVID-19

Some studies describe psychological distance as the degree of divergence from the direct experience of the self, here and now, along with temporal, spatial, and social viewpoints or theoretical perspectives (Trope and Liberman, 2010). It is divided into dimensions such as temporal, spatial, and social viewpoints, or theoretical (Liberman and Trope, 2014). Scerrati et al. (2022) demonstrated that the pandemic likely drives the results of individual differences in the assessment of social proximity. Our

TABLE 6 Independent sample *t*-test for Task1/2/3/4 and overall Task between NOEE and ESVD groups.

Task and OT	NOEE Group Mean ± SD	ESVD Group Mean ± SD	T	p
Task1	17 ± 4.46	19.2 ± 3.694	−1.699	0.098
Task2	16.35 ± 4.146	18.55 ± 2.964	−1.931	0.061
Task3	21.45 ± 1.877	21.85 ± 1.981	−0.656	0.516
Task4	16.7 ± 4.578	18.65 ± 4.043	−1.428	0.162
OT	17.88 ± 4.379	19.56 ± 3.478	−2.699	0.008*

NOEE group, online exhibition experience group; ESVD group, additional EEG signal visualization device group; OT, overall task.
*Significance at the 0.05 level.

TABLE 7 Within-subjects effect test for different indicators under the NOEE and ESVD groups.

UES-SF	SS	df	MS	*F*	*p*
Focused attention (FA)	1.008	1	1.008	0.504	0.479
Perceived usability (PU)	9.633	1	9.633	4.559	0.034*
Aesthetic appeal (AE)	3.169	1	3.169	1.968	0.163
Reward factor (RW)	3.502	1	3.502	2.587	0.11
Overall engagement (OE)	3.763	1	3.763	3.715	0.056

*Significance at the 0.05 level.

study focuses on the "social distance" dimension, such as the distance between oneself and others.

Given that our participants were East Asians, we must discuss perceptions of social distance in these regions. In China, one regional aspect influencing social distance is *guanxi*, which is usually applied to business relationships, where the more the trust, the shorter is the social distance (Song et al., 2012). There is also an indication that social distance is slightly greater in urban settings (Ma et al., 2015). As for minorities, while the Chinese perceive some regional and international minorities as close, others are perceived far (Fong and Spickard, 1994).

Among minorities in Japan, indigenous people were considered as closer than people from mixed nationality backgrounds (Ball, 2009). In both countries, the social distance was greater when interacting with people with mental disabilities (Haraguchi et al., 2009; Ando et al., 2013), although physical contact was more frequent among Chinese nationals.

There was an indication of social isolation and depression among Japanese youth before the COVID-19 pandemic (Takagi et al., 2013), and such phenomena increased during the pandemic, including the suicide rate, particularly among women (Sugaya et al., 2020; Osaki et al., 2021). In China, poor mental health is associated with social distancing (Goodwin et al., 2021). The existing evidence suggests that such effects can be mitigated by family support (Li and Xu, 2022).

Social distancing is usually discussed in medical terms in the literature. In contrast, our study addresses social distancing as an opportunity for university students to experience art. Many of these students move out of their homes to pursue their education, and in the case of international students, they currently face the challenge of adapting to a different country amid a global pandemic. These factors can exacerbate isolation. Thus, we propose an alternative to decreasing the perception of social distance, with the potential mitigation of isolation among East Asian students, which could aid in addressing other mental and physical health issues.

We discovered in the feedback that the participants in the ESVD group were more concerned about their partners with whom they experienced the online exhibition together than those in the NOEE group. We also collected textual feedback from participants in the study. Figure 6 compares the keywords that appeared in the final feedback messages and the number of occurrences between the participants in the NOEE and ESVD groups. The percentage in the bottom-right corner of each keyword in the figure represents the percentage of participants who mentioned that keyword. The larger the value, the larger is the area shown in the figure. Overall, 36 of the 40 participants (18 in each of the two groups) submitted feedback. We found that the high-frequency word that was mentioned by five out of 18 participants and was the highest of all words in the NOEE group was "online" (28%); in the ESVD group, that was mentioned by seven out of 18 participants and was the highest of all words it was "feeling" (39%). The comparison between the two groups revealed that the words mentioned by the participants in the ESVD group were more often related to the partners who participated in the experiment, such as "Close to" (17%), "Conversation" (17%), "Group work" (11%), "Partner" (11%), "Distance" (11%), etc. (see Figure 6A). The words mentioned by the participants in the NOEE group were more related to online experiences, such as "Museum" (22%), "Mouse" (22%), "Experience" (17%), and "Impression" (17%), "Explain" (17%), etc. (see Figure 6B).

Study limitations

Our study has several limitations. First, the sample size was relatively small. A more extensive sample size is necessary to provide more meaningful data to evaluate the efficacy of using an EEG signal visualization system for the user experience of an online exhibition. The results of this study might have differed if the sample included older adults or people from nonurban settings.

The second is the relatively single mode of experience. In this study, we used the GA&C website as a case study. The GA&C website is mainly experienced by users through computers, which are used more frequently than VR and AR devices in daily life for most users (Udell, 2019). With the evolution of virtual exhibitions, experience modalities have become more diverse. Using technologies such as Web/X3D, VR, and AR, visitors are offered the possibility of exploring

virtual museums, interacting with virtual exhibits in real time, and visualizing these exhibits in contexts such as 3D gallery spaces (Petridis et al., 2005; Styliani et al., 2009). Additionally, the web-based form of online museums is one of the earlier developed and most popular ways to experience virtual museums; therefore, we chose this form as a way for participants to experience them in this study. Participants visited virtual museums in different modes of experience, which produced different effects. In the future, we will add to this study and continue to explore the impact of different experiential modes on participants' psychological distance and engagement.

Additionally, we observed that participants did not significantly observe the state of EEG visualization images during the experience of focusing on the online exhibition, possibly because the online experience and EEG visualization were displayed on separate screens. In this case, the participants needed to raise their heads to move their eyes from the computer screen to the monitor. While the participants were fully engaged in viewing the artwork and reading information about it, their eyes were mainly focused on the computer screen. They spent less time observing the screen displaying the EEG signals. Therefore, if the EEG signal is displayed on the same screen as the artwork, participants are likely to spend more time focusing on the changes in the EEG signal, which may have a different effect on the results of the experiment.

TABLE 8 Paired comparisons for the NOEE and ESVD groups.

(I) Group	(J) Group	MD (I-J)	*SD*	*p*
NOEE Group	ESVD Group	0.177	0.092	0.056

Conclusion

The COVID-19 pandemic has resulted in the need to maintain social distancing in public places; thus, the distance between people has been affected. Work (Hodder, 2020), study (Azorín, 2020; Bozkurt et al., 2020), exhibition viewing (Hoffman, 2020), etc., have been compulsorily shifted online to reduce the exposure of face-to-face contact. The distance between people and others has changed, becoming less perceptible and more complex. The development of remote services may change the way we perceive psychological distance. Our study reflects the "social distance" between people in post-pandemic situations. We also explore how the visualization of EEG signal differences in a virtual space can help reduce the psychological distance between users.

FIGURE 6
(A) High-frequency words that appeared in participants' descriptions of the overall experience in the NOEE group (including percentages); **(B)** High-frequency words that appeared in participants' descriptions of the overall experience in the ESVD group (including percentages).

In this study, we developed and provided an EEG signal visualization system that provides a new way for users to experience online exhibitions and understand each other's emotions. Users employing the system in different spaces can learn the differences in each other's EEG signals through visualized images. We used printed pictures during the experiment to evoke the feeling of "psychological distance" between participants and others (Kundrát and Rojková, 2021). Within-group and between-group analyses were conducted for both groups by using independent sample *t*-tests and one-way ANOVA. User engagement was also investigated by using the UES-SF questionnaire, and repeated ANOVA was used to compare the differences between the two data groups. We summarize the following findings for both research questions:

- R.Q.1: Based on independent samples *t*-tests and one-way ANOVA analysis and on observations during the experimental procedure, we concluded that participants in the ESVD group perceived a significantly closer psychological distance between themselves and the participants on the opposite side than those in the NOEE group ($t = -2.699$; $p = 0.008 < 0.05$); additionally, participants experienced Task3 with significantly closer psychological distance assessments than that of Task1 ($p = 0.002 < 0.05$), Task2 ($p = 0.000 < 0.05$), and Task4 ($p = 0.001 < 0.05$).
- R.Q.2: Based on the repeated ANOVA analysis, we concluded that participants in the ESVD group had higher overall user engagement than the NOEE group, with marginal significance ($p = 0.056 < 0.1$).

In future research, we will continue to improve the presentation of EEG signal visualization. For example, we will combine the visualization with an online exhibition interface to make it easier for users to view and analyze whether the design of the visualization graphics affects the psychological distance between the users to some extent. Additionally, we intend to explore whether there are any similarities in the brain function network maps of two participants who are simultaneously experiencing the online museum; we also aim to determine whether the visualization of brainwaves affect the state of a user's brain functional network map to a certain extent. We will continue to analyze the raw EEG data of the participants during the experience, whether there is a link between it and EEG visualization, and whether there is a link between it and the user-perceived mental distance. Regarding users' physiological signals, we will continue to explore what other physiological signals (e.g., heartbeat, body temperature, and eye movements) can be visualized to help users better perceive psychological distance in addition to EEG signals. Additionally, in future experiments, we will increase the diversity of the sample (participants of different ages, nationalities, occupations, etc.), and the participants will not be limited to college students.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Ethics statement

The studies involving human participants were reviewed and approved by the ethics review office of the Faculty of Library, Information and Media Science of the University of Tsukuba in Japan, the permission number is 22-4. The patients/participants provided their written informed consent to participate in this study. Written informed consent was obtained from the individual(s) for the publication of any potentially identifiable images or data included in this article.

Author contributions

JL designed the study, conducted the experiments, performed the statistical analysis, analyzed and interpreted the data, created the images and tables, drafted the manuscript, and reviewed and revised the manuscript. YY participated in the design of the Moiré Pattern and the discussion of the EEG visualization scheme in the study. ZZ participated in the construction and implementation of the EEG visualization system. NY participated in the implementation of the experiments, assisted in the collection of data, took videos of the process, and reviewed and revised the manuscript. VX provided research guidance, wrote part of the discussion section, and critically reviewed and revised the manuscript. YO provided research guidance, research funding, experimental sites, laboratories, instrumentation, and other material resources related to the experiments. All authors contributed to the article and approved the submitted version.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Publisher's note

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The mediating role of personal values between COVID-19-related posttraumatic growth and life satisfaction among Chinese college students: A two-wave longitudinal study

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Despite considerable disruption of social order caused by the COVID-19 pandemic, it has also been said to contribute to positive psychological changes and influence on the perception of public life satisfaction. The present study aimed to explore the association between the COVID-19 related posttraumatic growth and life satisfaction and the mediating role of personal values. A two-wave longitudinal design was used. 226 self-quarantined Chinese college students (58.8% male) completed post traumatic growth inventory (Time 1), satisfaction with life scale (Time 2), personal values questionnaire (Time 2) between February 2020 and May 2021. Results showed that more than half of self-quarantined Chinese college students reported moderate to high levels of the COVID-19 related posttraumatic growth. A structural equation model revealed that COVID-19 related posttraumatic growth was positively associated to life satisfaction, and self-transcendence and self-enhancement values partially mediated this association. These findings shed light on whether and how pandemic-related posttraumatic growth influenced personal life satisfaction, supporting the outcome and process perspectives of posttraumatic growth as well as Schwartz's value theory. Based on the findings, some positive psychology interventions, such as online rumination activities and mindfulness practice, were proposed to enhance self-quarantined college students' posttraumatic growth and life satisfaction.

KEYWORDS

COVID-19, posttraumatic growth, life satisfaction, personal value, mediating role

Introduction

The outbreak of the novel coronavirus disease in 2019 (COVID-19) caused a major public health crisis worldwide and has inflicted over 400 million infections and 6 million fatalities (WHO, 2022). Havoc on social stability and economic prosperity made this epidemic an ongoing, chronic and collective traumatic event (Cheng and Liu, 2022) with a

significant decrease in life satisfaction among the public (Brooks et al., 2020). As a consequence, finding effective ways to maintain or develop public LS is a crucial issue, especially in the post-epidemic era. As famously said by Nietzsche (1998), "That which does not kill me makes me stronger," posttraumatic growth (PTG) refers to the positive psychological changes catalyzed by struggling with trauma or extremely challenging circumstances (Tedeschi and Calhoun, 1996; Tedeschi et al., 2018). Empirically, the positive effects of PTG in enhancing LS and mental health have been extensively documented in the literature (e.g., Triplett et al., 2012; Rzeszutek et al., 2019; Mostarac and Brajković, 2022).

Despite a growing interest in the COVID-19 related PTG, current literature lacks a theoretical framework and empirical evidence that explains whether and how the COVID-19 related PTG is beneficial to the public LS. Methodologically, previous studies mostly used cross-sectional designs to assess the beneficial effects of PTG on LS. Longitudinal designs are also needed to strengthen conclusions about the temporal ordering of effects. Additionally, most empirical studies on COVID-19 related PTG mainly focus on populations directly exposed to the pandemic, such as health care workers. Some gaps, nevertheless, remain among self-quarantined college students in this line of research. In fact, stressful experiences such as the threat of death and infection, academic pressure, and poor interpersonal relationships can all contribute to low LS (Gundogan, 2021) while simultaneously creating possibilities for PTG among self-quarantined college students.

To narrow these research gaps, this study aims to investigate whether and how the COVID-19 related PTG affects LS among self-quarantined college students from a positive psychology perspective, theoretically drawing on the comprehensive model of PTG and Schwartz's value theory, and methodologically using a two-wave longitudinal design. As a broad, ideal, cross-situational goal (Rokeach, 1973; Schwartz, 1992), personal values were introduced to explore the influence mechanism of PTG on LS, considering the shifting of personal values in the PTG process (Weiss, 2014) and the prominent role of personal values in life goal setting and cognitive evaluation (Bardi et al., 2014; Sortheix et al., 2019).

Posttraumatic growth

Tedeschi first proposed the term "PTG" to describe positive psychological changes resulting from struggles with a highly challenging living environment or traumatic occurrences (Tedeschi and Calhoun, 1996). These positive changes involved relating to others, recognition of new possibilities, a feeling of personal strength, spiritual change, a greater appreciation of life, realignment of life priorities, and identification of new values (Tedeschi and Calhoun, 1996, 2004). The COVID-19 pandemic, as a biological disaster, is undeniably a traumatic stressor for individuals who are directly experiencing symptoms, witnessing the suffering of the patients, experiencing realistic or unrealistic fear of infection, social isolation, financial hardships, or the community at large (Chen et al., 2021). People exposed to COVID-19 may also experience PTG. Empirically, researchers have examined the prevalence of COVID-19 related PTG and found moderate to high levels detected among healthcare workers (Chen et al., 2021; Finstad et al., 2021; Lyu et al., 2021; Moreno-Jiménez et al., 2021; Yıldız, 2021; Feingold et al., 2022) and American veterans (Pietrzak et al., 2021) as well as low levels among adolescents (Jian et al., 2022; Ulset and Soest Von, 2022) and young adults (Hyun et al., 2021).

For self-quarantined college students, the challenges of moving learning sessions from face-to-face arrangement to online sessions, and the disruption of graduation and further education plans have greatly increased the academic and employment pressure (Lederer et al., 2021). Meanwhile, young college students maintain a higher frequency of inter-individual contacts, and social restriction measures would aggravate poor interpersonal relationships due to travel bans and self-isolation, among others (Birmingham et al., 2021). Furthermore, college students today are more susceptible to media sensationalism as frequent users of the internet. They are in many cases paying too much attention to negative emotions such as fear and anger, and witnessing death and suffering of ordinary people in unfortunate circumstances (Bian et al., 2020; Yuan et al., 2021). All these are risk factors for low LS (Gundogan, 2021) and severe psychological problems (Duan et al., 2020) among college students in self-quarantine beyond the threat of death and infection. However, given that challenges and suffering also provide opportunities for PTG realization, they are by far a perfect fit for COVID-19 related PTG (Chi et al., 2020) study with direct experience of the pandemic.

Posttraumatic growth and life satisfaction

As a cognitive component of subjective well-being, LS refers to a cognitive assessment of individual's life according to subjectively shaped standards about appropriate circumstances (Diener et al., 1985). The individual's assessment of satisfaction is high if the subjectively perceived life circumstances match a unique set of criteria (Pavot and Diener, 1993; Mostarac and Brajković, 2022). While negative situations such as trauma, stress, and fear that the individual has experienced decrease LS, many situations such as the individual's positive life experiences, social support, and being psychologically strong are factors that would increase LS (Gundogan, 2021).

Previous studies on other traumatic events have demonstrated that PTG can directly or indirectly improve individual LS. In meta-analysis reviews, PTG was found to be positively related to LS, an indicator of well-being (Helgeson et al., 2006), and this positive link may become stronger the more time has elapsed after the traumatic event (Park, 2004). Recently, cross-sectional studies found a positive association between PTG and LS in patients with cancer (Mostarac and Brajković, 2022) and HIV (Rzeszutek et al.,

2019) and nurses exposed to work violence (Itzhaki et al., 2015). Furthermore, albeit less often, researchers have found mediators of the association between PTG and LS, such as meaning in life (Triplett et al., 2012; Mostarac and Brajković, 2022).

Theoretically, the explanations of the relations between PTG and LS have largely grouped two perspectives. From an outcome perspective, the development of PTG is theorized as positive changes in multiple dimensions of life, such as a greater appreciation of life, more intimate social relationships, heightened feelings of personal strength (Tedeschi and Calhoun, 2004), as well as the development of life narratives and wisdom (Pals and McAdams, 2004). These positive shifts in life can easily be linked to higher LS (Jayawickreme and Blackie, 2014). Some scholars even believed that the two constructs of PTG and subjective well-being are essentially similar (Joseph and Linley, 2005). From a process perspective, the comprehensive model of PTG proposed that a traumatic event shakes or destroys core beliefs and then triggers rumination progresses to rebuild or repair it (Tedeschi and Calhoun, 2004). Rumination progresses from initially automatic (e.g., intrusive memories and images) to more deliberate (e.g., analyzing the new situation and re-appraisal; Zoellner and Maercker, 2006). Such constructive cognitive activities directly reduce emotional distress, promote individuals' ability to adapt to the traumatic environment and maintain or improve LS (Calhoun et al., 2010; Calhoun and Tedeschi, 2014). In addition, PTG may indirectly influence LS through reconstructed core beliefs such as clarity of life priorities (Joseph and Linley, 2005). We explore this in detail below. In sum, PTG is seen as both a process and an outcome—it is a positive outcome in and of itself, but the process of coming to terms with trauma and identifying positive changes is a long-term process that may also result in greater LS in the long run (Jayawickreme and Blackie, 2014).

Mediating roles of personal values

To further explore the underlying psychological mechanism that explains the positive effect of the COVID-19 related PTG on LS, we resort to personal values. According to the comprehensive model of PTG, the process of PTG involves core belief reconstruction such as value clarification and changing priorities (Tedeschi and Calhoun, 2004; Weiss, 2014). These individuals' value priorities shifting may promote cognitive changes in perception of traumatic events (Vecchione et al., 2012), retrieval of traumatic memories (Xiu et al., 2017), and choice of coping strategies (Tweed and Conway, 2006), affecting people's evaluation of life. Therefore, PTG may have a positive indirect effect on LS by influencing personal values.

The dominant model in the personal value literature is the one proposed by Schwartz (1992). Regarding personal value content, this theory has evolved from the original 10 basic personal values (Schwartz, 1992) to the refined 19 (Schwartz et al., 2012). These values form a circle structure (see Schwartz et al., 2012, p. 669) based on the degree of compatibility or conflict between the goals expressed. The array of values represents a motivational continuum, i.e., values placed next to each other have more compatible motivations (e.g., benevolence and universalism), whereas those placed further apart are more conflicting (e.g., power and universalism). Schwartz (1992) grouped these values into two pairs of higher-order value dimensions: openness to change versus conservation, and self-enhancement (SE) versus self-transcendence (ST). Additionally, the circle of values is a continuum, in which values blend into one another rather than forming discrete entities (Schwartz, 1992; Schwartz et al., 2012). This implies that one can partition the value circle arbitrarily into as many or as few value categories as is convenient (Sagiv and Schwartz, 2022).

In this study, SE (expressed by power, achievement, and face values) and ST (expressed by humility, benevolence, and universalism values) values were mainly considered to analyze the influence mechanism of the COVID-19 related PTG on LS. The reason is that compared with other traumatic events, exposure to collective traumatic events (e.g., earthquakes and the COVID-19 epidemic) shifts people's values toward prosocial directions (Oishi et al., 2017), and the PTG of collective traumatic events involves not only positive changes in individual life but also group-communal strength and social benefits, especially in collectivist cultures such as China (Wlodarczyk et al., 2017). A national representative study has also found that the COVID-19 related PTG is associated with high identification with all humanity and priority given to human rights over self-interest (Vazquez et al., 2021). Therefore, the SE and ST values capture the conflict between concern for the welfare and interests of others, and concern for one's material possessions, relative success (Sagiv and Schwartz, 2022), are more appropriate than other value categories to be considered in COVID-19 related PTG research.

The indirect effect of PTG on LS may be achieved by raising the ST value priority and lowering the SE value priority. Reprioritizing personal values was a crucial theme of PTG. For individuals experiencing PTG, new priorities included a greater appreciation of one's own internal self-worth rather than material possessions and a new understanding of other people, which led to greater compassion and the drive towards altruism (Martin et al., 2017). For example, burn-related PTG studies found that burn survivors had a greater appreciation for their health and well-being, as well as for family and friends (McLean et al., 2015; Martin et al., 2016). Evidence from collective traumatic events studies also reported a positive association between PTG and prosocial behaviour and altruism among refugees exposed to violence (Canevello et al., 2021) and adolescents who experienced earthquake (Liu et al., 2021). It was clear that the reminder of one's mortality drove appreciation of the present moment, with regard to both one's own personal and spiritual growth as well as the wellbeing of others.

Personal values, as a cognitive representation of goals to be pursued (Sagiv and Schwartz, 2022), affect the subjectively shaped standards of appropriate circumstances based on which individuals evaluate life quality. Thus, individuals with different

value orientations have different subjective LS. One theoretical perspective that proposes an effect of personal values on LS is the "healthy values" perspective (Sagiv and Schwartz, 2000; Sortheix and Schwartz, 2017). This perspective argues that pursuing growth values (e.g., benevolence and universalism) enhances well-being because these values are self-actualizing. In contrast, pursuing deficiency values (e.g., face and power) is believed to lead to perceptions, attitudes, or behaviors that reduce well-being. Schwartz et al. (2012) suggested that the pursuit of ST is relatively anxiety-free and fosters self-expansion and growth. It is considered a healthy growth value that can promote individual LS (Sortheix and Lönnqvist, 2014; Sagiv and Schwartz, 2022). In contrast, SE value is seen as an unhealthy deficiency or self-protective value that reflects the pursuit of avoiding anxiety and self-preservation, leading to lower satisfaction (Dittmar et al., 2014; Sagiv and Schwartz, 2022). Thus, ST will be associated with more, and SE with less, LS.

In sum, the COVID-19 pandemic was a traumatic event for self-quarantined college students while also providing them with an opportunity for PTG realization. In the long run, COVID-19 related PTG may have a direct effect on their LS, as well as an indirect effect mediated by personal values. Drawing on the comprehensive model of PTG and Schwartz's personal value theory, we proposed a research model shown in Figure 1 to examine the long-term positive effect of COVID-19 related PTG on LS and the mediating role of ST and SE values among self-quarantined college students. To this end, a two-wave longitudinal design was conducted to look into the following hypotheses:

> *Hypothesis 1*: The COVID-19 related PTG positively predicts LS.
>
> *Hypothesis 2*: The COVID-19 related PTG negatively predicts SE value (H2-a) and positively predicts ST value (H2-b).
>
> *Hypothesis 3*: SE value negatively predicts LS (H3-a) and ST value positively predicts LS (H3-b).
>
> *Hypothesis 4*: The correlation between PTG and LS is mediated by SE (H4-a) and ST values (H4-b).

Materials and methods

Participants and procedures

Data were collected from February 27, 2020 (the peak phase of the COVID-19 in China, all universities in China have suspended offline classes and students have been asked to stay confined at home, Time 1) with a 1-week duration until May 5, 2021 (the post-pandemic phase in China, Time 2), with a 2-week duration. At Time 1, 300 self-quarantined undergraduate students from two universities in southwest China were recruited. Participants come from different provinces all over the country. 33 participants who had self-quarantined at home for less than 1 month were excluded, and 267 valid questionnaires were retained. One year later (Time 2), 41 withdrew from the study, and 226 adults from Time 1 were retained. Therefore, the final sample consisted of 226 participants between 18 and 23 (M_{age} = 19.64, SD_{age} = 0.87, Male 58.8%) who completed the two-wave survey. G*Power was employed to calculate the sample size required for this study (Erdfelder et al., 2009). *A priori* analysis showed that a sample size of 187 was required to detect a small effect size of 0.1 with a power of 0.95 (3 predictors). Thus, 226 subjects were an adequate sample size.

Both surveys were performed online using *SOJUMP*,[1] a popular online survey platform in China, after being announced on students' social media groups. Participants voluntarily clicked the link in the announcement to access the survey platform after learning about the objectives and design of the study. They then completed the questionnaire after providing an informed consent. Participants in the initial survey were encouraged to take part in a follow-up survey 1 year later. If they consented, participants were requested to supply valid contact information (e.g., email addresses). To control the common method bias, procedurally, we ensured the anonymity of all participants and reminded them to answer according to the actual situation. Additionally, acquiescence was reduced by reverse scoring some of the items. The Chongqing Ninth People's Hospital Review Board, China, approved this study (approval number: 2019016).

Measures

Posttraumatic growth

The Post Traumatic Growth Inventory (PTGI) developed by Tedeschi and Calhoun (1996) was adapted to measure the COVID-19 related PTG at Time 1. This inventory is composed of 21 items grouped into five subscales: relating to others (seven items), new possibilities (five items), personal strength (four items), spiritual change (two items), and appreciation of life (three items). Instructions of the PTGI were modified to index experiences associated with the COVID-19 pandemic: e.g., "Please indicate the degree to which you experienced these changes in your life as a result of the COVID-19 pandemic: knowing I can handle difficulties." The responses were based on a six-point Likert scale, where a score of zero indicates 'not at all' and a score of five indicates 'very great'. Higher scores indicate more growth after the experience of the COVID-19 pandemic. The overall Cronbach's α for PTGI was 0.95. The coefficients for each of its domains were: relating to others (0.87), new possibilities (0.82), personal strength (0.79), spiritual change (0.71), and appreciation of life (0.73).

Life satisfaction

Satisfaction with Life Scale (SWLS) developed by Diener et al. (1985) was used to evaluate individual's overall LS at Time 2. The questionnaire includes five statements on a five-point Likert scale, where a score of one indicates 'strongly disagree' and a score of

1 http://www.sojump.com

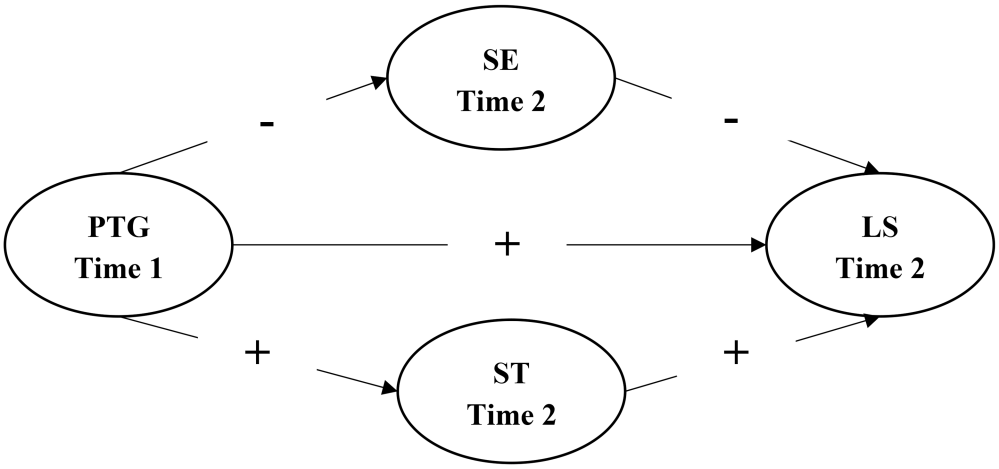

FIGURE 1
Hypothesized structural equation model of the relationships between the COVID-19 related posttraumatic growth (PTG), life satisfaction (LS), self-enhancement value (SE), and self-transcendence value (ST). Time 1=the peak phase of the COVID-19 pandemic in China, Time 2=the post-pandemic phase of the COVID-19 in China.

seven indicates 'strongly agree'. Higher scores indicate more LS. A representative item was "In most ways, my life is close to my ideal." The scale showed high internal consistency (Cronbach's $\alpha = 0.86$) in the current study.

Personal values

Personal values at Time 2 were assessed by the Personal Values Questionnaire (PVQ) developed by Schwartz et al. (2012). The current study focuses on SE and ST value dimensions in Schwartz's value theory, which are measured by 25 items. ST value dimension consists of benevolence (5 items), universalism (8 items), and humility values (2 items). SE value dimension consists of achievement (3 items), power (5 items), and face (2 items) values. Each item offers verbal portraits of different people, and respondents were asked to evaluate how similar they are to the portrait. A sample item was "he/she wants people to do what he/she says." Items were scored on a six-point scale, where a score of one indicates 'not like me at all' and a score of six indicates 'very much like me'. In this sample, the Cronbach's α of SE and ST value dimensions were 0.85 and 0.97 respectively, indicating high internal consistency.

Analytical strategy

First, a series of preliminary analyses were conducted: (1) common method bias analysis using the Harman one factor test, (2) calculating the mean (M) and standard deviations (SD) of the study variables, and (3) testing the gender and age differences in the study variables, and (4) calculating the correlation between the study variables. The SPSS 22.0 statistical programme (SPSS, Chicago IL, United States) was used in preliminary analyses. All p values were two-sided, and those less than 0.05 were considered statistically significant.

Next, we tested the measurement model by calculating the convergent validity and discriminant validity to ensure a satisfactory model to proceed to the path analysis. The following criteria were adopted: (1) factor loadings higher than the minimum threshold of 0.4 (Tabachnick and Fidell, 2007), (2) composite reliability (CR) higher than the recommended threshold of 0.70 (Gefen et al., 2000), (3) average variance extracted (AVE) higher than 0.5 (Sarstedt et al., 2022), and (4) the square root of AVE for each construct greater than its correlations with other constructs (Sarstedt et al., 2022).

Then, structural equation modeling (SEM) was employed to estimate the mediation effects with Amos 22.0 (Arbuckle, 2013). The default estimation of the maximum likelihood method was used. To study the adequacy of the estimated model, we determined good model fit if the $\chi^2/df < 3$ and the Comparative Fit Index (CFI) and Tucker-Lewis Index (TLI) were greater than 0.9 as recommended by Salisbury et al. (2002). The Root Mean Square Error of Approximation (RMSEA) and Standardized Root Mean Square Residual (SRMR) values less than or equal to 0.08 represent an acceptable fit (Bryne, 2013).

Finally, the Bootstrap method (5,000 samples) was used to evaluate the significance of the mediating effect. Bootstrapping generated a large sample from the data set and estimated the bias-corrected 95% confidence intervals (CI) for the indirect effect, indicating a significant indirect effect when the CI did not include 0 (Cheung and Lau, 2008).

Results

Preliminary analyses

The Harman single factor test has been conducted to ensure that the dataset is free of common technique bias. The statistical

results found that the highest covariance explained by one factor is 27.15%, lower than the cut-off value of 50% (Harman, 1967), indicating that none of the factors significantly dominated the explanation of the variance. Thus, the common method bias was not a serious concern in this study.

Table 1 presents the means and standard deviations of all study variables. The results indicated a moderate level of PTG and LS, as well as high level of ST and SE values among self-quarantined Chinese college students. Regarding the specific dimensions of PTG, spiritual change scored the highest, followed by appreciation of life, personal strength, relating to others, and new possibilities. Given that the total and subscale scores were non-normally distributed (all Shapiro–Wilk test p values <0.0001), scores were dichotomized so that responses of "moderate," "great," or "very great" growth indicated a positive endorsement of PTG (Pietrzak et al., 2021; Feingold et al., 2022). In the current sample, 65.4% endorsed at least moderate levels of PTG. Regarding the specific dimensions of PTG, the most prevalent domains are spiritual change (69.5%), followed by appreciation of life (64.2%), personal strength (60.2%), relating to others (56.6%), and new possibilities (45.1%).

Independent sample t-test results show that there were no gender and age differences in all study variables. Correlation analysis shows that PTG was positively correlated with ST value and LS, PTG was negatively correlated with SE value; ST value was positively correlated with LS, and SE value was negatively correlated with LS (see Table 2).

TABLE 1 Descriptive statistics, convergent validity, and construct reliability results.

Constructs	Indicators	M	SD	Loading	CR	AVE
PTG		3.32	0.98		0.93	0.73
	Relating to others	3.25	1.09	0.88		
	New possibilities	2.97	1.10	0.90		
	Personal strength	3.37	1.14	0.89		
	Spiritual change	3.56	1.27	0.81		
	Appreciation of life	3.45	0.99	0.78		
LS		3.32	0.75		0.86	0.57
	LS1	3.54	0.87	0.84		
	LS2	3.50	0.87	0.75		
	LS3	3.72	0.89	0.89		
	LS4	3.23	0.95	0.68		
	LS5	3.00	1.04	0.55		
SE		4.00	0.79		0.75	0.51
	Power	4.23	0.91	0.68		
	Achievement	3.71	1.01	0.69		
	Face	4.26	0.93	0.75		
ST		4.99	0.86		0.90	0.76
	Humility	4.70	1.06	0.73		
	Benevolence	5.05	0.90	0.94		
	Universalism	5.05	0.89	0.93		

All loadings significant at the $p < 0.001$ level; LS1-LS5 = 5 items of life satisfaction.

TABLE 2 Inter-construct correlation matrix.

	PTG	SE	ST	LS
PTG	(0.85)			
SE	−0.24**	(0.75)		
ST	0.16*	−0.40**	(0.71)	
LS	0.53**	−0.23**	0.30**	(0.87)

Square roots of average variances extracted are shown in parentheses on the diagonal. *$p < 0.05$ and **$p < 0.01$.

Testing the measurement model

The factor loadings, CR, and AVE values were evaluated to confirm convergent validity. The results revealed factor loadings, CR, and AVE values (see Table 1) to be greater than the threshold value mentioned above, demonstrating acceptable convergent validity. The discriminant validity of the constructs was also assessed by contrasting the square root of the AVE values for each construct with the inter-construct correlations. The square roots of the AVE values (presented in parentheses in Table 2) were larger than the respective inter-construct correlations, indicating acceptable discriminant validity.

Testing the structural model

With PTG (Time 1) as the independent variable, SE and ST values (Time 2) as the mediating variables, and LS (Time 2) as the dependent variable, the mediating effect model was constructed (see Figure 2). Previous studies have shown that there is a relatively robust correlation between SE and ST values (Schwartz et al., 2012), and a moderate correlation is also detected in the above correlation analysis. Therefore, a correlation path is established between SE and ST values. This model showed a good fit to the data [$\chi^2/df = 1.81$, $p > 0.05$, CFI = 0.96, TLI = 0.96, RMSEA = 0.06 (90% CI for RMSEA = 0.05, 0.07), SRMR = 0.05].

The results revealed that PTG was found to be a positive and significant predictor of LS ($\beta = 0.50$, $p < 0.001$) and ST value ($\beta = 0.18$, $p < 0.05$), but a negative and significant predictor of SE value (= −0.28, p 0.001). Thus, Hypotheses 1 and 2 are supported. It was also found that SE value is a negative and significant predictor of LS ($\beta = -0.19$, $p < 0.05$), while ST value is a positive and significant predictor of LS ($\beta = 0.33$, $p < 0.001$), supporting Hypothesis 3.

Testing the meditation effects

We conducted a bootstrapping analysis (5,000 samples) to test the mediating effects of personal values. The results showed that the mediating effects of SE and ST values on the association between PTG and LS were 0.05 and 0.06, respectively, and the

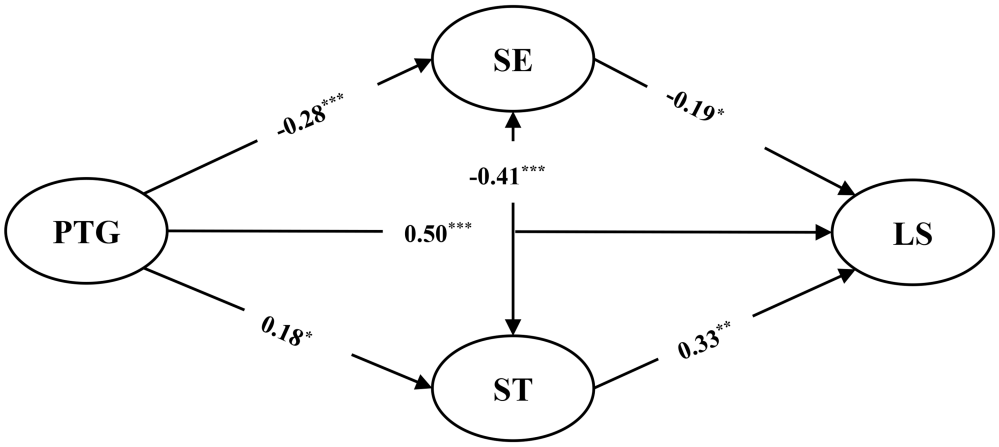

FIGURE 2
The mediation model of SE and ST values between COVID-19 related PTG and LS. Path coefficients are standardized. *p<0.05, **p<0.01, ***p<0.001.

95% confidence intervals for both mediating effects do not include 0. Furthermore, the total effect of PTG on LS was 0.61, among which, the total indirect effect of PTG on LS through SE and ST values was 0.11, accounting for 18.33% of the total effect. The coefficients and confidence intervals of direct and indirect effects are presented in Table 3. These results indicate that the partial mediation of SE and ST values between PTG and LS were observed, as in Hypothesis 4.

TABLE 3 Testing the mediation effects of SE and ST values between PTG and LS.

Paths	β	SE	95% CI
Direct effect			
PTG → LS	0.50	0.08	[0.34, 0.66]
Indirect effect			
Total indirect effect	0.11	0.04	[0.08, 0.14]
PTG → SE → LS	0.05	0.02	[0.04, 0.07]
PTG → ST → LS	0.06	0.02	[0.04, 0.07]
Total effect			
PTG → LS	0.61	0.05	[0.50, 0.70]

The effect coefficients are standardized.

Discussion

This study assessed the positive impact of the COVID-19 pandemic on individuals' perception of life from the perspective of positive psychology. Using a longitudinal design with data collected from two waves, our results demonstrated that the COVID-19 related PTG was a positive factor of self-quarantined college students' LS 1 year after the outbreak, and personal values played a mediating role in this relationship. These findings enrich research on public well-being under the COVID-19 pandemic and help illuminate how coronavirus-related PTG contributes to personal LS.

COVID-19 related posttraumatic growth and life satisfaction

The results showed that 65.4% of participants experienced at least medium levels of positive changes as a result of the COVID-19 pandemic, most commonly greater spiritual change and appreciation of life. These results were supported by a previous study, which found that 66.9% of Chinese college students had experienced PTG during the COVID-19 pandemic (Chi et al., 2020). Additionally, while the prevalence of the COVID-19 related PTG in the present sample is lower than the 77% rate reported among healthcare workers (Feingold et al., 2022), it is markedly higher than the previous prevalence observed among home-confined Chinese adolescents (20.6%; Jian et al., 2022), Norwegian adolescents (9.6%; Ulset and Soest Von, 2022), and American veterans (43.3%; Pietrzak et al., 2021). Different cut-off values, the time after the disaster, cultural context, or age disparities might all have contributed to these discrepancies. Our findings shed light on a reassuring fact that if self-quarantined college students without direct exposure to COVID-19 can see this crisis as a positive turning point, engage in deeper rumination and insight into their own life, they can also experience similar PTG to those who have been directly exposed to COVID-19, such as healthcare workers.

The current study found that PTG at the peak phase of the COVID-19 pandemic was positively associated subsequent LS 1 year later. Although the long-term effect of COVID-19 related PTG on LS has seldom been examined, our results are comparable to previous cross-sectional studies, which reported a positive relationship between PTG and LS observed among cancer survivors

(Mostarac and Brajković, 2022), people with physical disabilities (Kim et al., 2016), as well as myocardial infarction survivors (Ogińska-Bulik, 2014). This finding suggested that COVID-19 related PTG is also equally beneficial to individuals' LS in the long run, extending the positive effect of PTG on LS to pandemic diseases. This direct effect of PTG on LS reinforced the outcome perspective of PTG, which held that PTG as a positive change in individuals' life after struggling with trauma involved awareness of their previously undiscovered strengths and appreciation of life, among other things (Janoff-Bulman, 2004).

The moderating role of personal values

The effect mechanism of PTG on LS is explained for the first time in this work using personal values. Given the collective traumatic nature of COVID-19, we proposed that the indirect effect of PTG on LS may be achieved by raising the ST value priority and lowering the SE value priority based on Schwartz's personal value theory. As expected, the association between COVID-19 related PTG at Time 1 and LS at Time 2 was partially mediated by ST and SE values at Time 2. This indirect effect of PTG on LS through personal values reinforced the process perspective of PTG, which held that changing values priority is an essential process for achieving PTG and will affect the life goals setting and life quality assessment in the post-traumatic surroundings and even in the future (Nolen-Hoeksema and Davis, 2004; Martin et al., 2017). Additionally, the opposite correlation direction of ST and SE values with PTG and LS also extended the conflict of goals expressed by these two values, as postulated in Schwartz's (1992) personal value theory, to the conflict of relationship between the two values and other psychological constructs.

Each of the individual links in our mediation model is worth noting. We found that PTG at Time 1 was positively related to ST value, while negatively related to SE value at Time 2. The results are consistent with the collective trauma study found that Chileans who experienced earthquakes-related PTG, reported greater group strengths and an emphasis on social benefits (Wlodarczyk et al., 2017). This finding suggested that the COVID-19 related PTG may prompt self-quarantined college students to value others' interests more than their own, indicating an enhanced collectivist tendency. Indeed, In deliberative rumination about the COVID-19 pandemic trauma, a core process of PTG, social supports from the country (e.g., free testing and treatment), groups, and even strangers (e.g., donations from social groups) catalyzed self-quarantined college students to value more collective interests (Sibley et al., 2020; Cheng and Liu, 2022). In the meantime, we also found that ST value was linked to higher LS, while SE value pointed to the opposite. This result is consistent with research findings that individuals with ST value rather than SE value report higher LS, especial in collectivist cultures such as China (Fischer and Boer, 2011; Du et al., 2014). This result supported the healthy values perspective, which held that pursuing values that satisfy psychological needs for growth and self-actualization promotes LS directly, whereas pursuing values that promote self-aggrandizement and self-interest undermines LS (Sagiv and Schwartz, 2000; Sortheix and Schwartz, 2017).

Limitations

The following limitations of the current study should be addressed. First, a self-reported measure was used in this investigation. Although we adopted anonymous online survey according to Tourangeau (2014), this assessment method still cannot completely avoid the influence of response bias, such as social desirability on the results. Conceivably, individuals may overstate or understate in their responses based on social expectations, especially in personal value surveys. Future studies are suggested to use multiple approaches (e.g., observational or experimental methods) and multi-informant methods. Second, despite the longitudinal nature of the study, causal inferences should be avoided because PTG and LS were not evaluated repeatedly. Longer-term follow-up studies with repeated assessments (e.g., autoregressive cross-lagged panel designs) will be helpful in examining the causal relationship between PTG and LS. Third, in this study, based on the Schwartz's personal values theory, only the mediating effects of ST and SE values were considered. Studies focusing on other values categories (such as work values, life values) should be encouraged. Finally, this study has a small sample size, with all participants being Chinese college students. As a result, the generalization of the findings obtained from this study is limited, even if the results are consistent with previous studies. Future studies with a larger sample size are recommended to replicate the present findings.

Implications

There are some key theoretical and practical implications of this study. Theoretically, this study contributes to the necessary knowledge about the positive impact of COVID-19 trauma by providing a theoretical framework to explain whether and how COVID-19 related PTG could benefit LS. The direct long-term positive association between COVID-19 related PTG and LS, as well as the indirect association through raising ST value and lowering SE value revealed by this study supported the outcome and process perspectives of PTG, respectively. Simultaneously, the opposite correlation direction of ST and SE values with PTG and LS that we examined also supported the conflict of goals expressed by these two values and extended it to the relationship between two values and psychological constructs, reinforcing Schwartz's value theory.

Practically, this research found ways to promote self-quarantined college students' LS from the perspective of positive psychology. Based on the findings of the long-term positive association between PTG and LS, and the mediating

role of personal values, psychologists should implement more positive psychology interventions to assist students in struggling with distress and amplifying positive emotions and experiences in their current life. For instance, the SEARCH framework proposed by Waters and Loton (2019) could be employed to promote PTG and LS through six pathways: strengths, emotional management, attention and awareness, relationships, coping, and habits and goals. Given the outbreak of COVID-19, some online rumination activities and mindfulness practice should be encouraged. For example, teachers can encourage students to engage in positive writing to explicitly identify positive experiences and unrecognized personal strengths that have occurred during COVID-19, to clarify their value priorities, and to identify positive possibilities in the aftermath of the pandemic (Waters et al., 2021).

Conclusion

The current study has found that (1) more than half of self-quarantined Chinese college students reported moderate to high levels of the COVID-19 related PTG; (2) PTG during the peak phase of the COVID-19 pandemic positively predicted a year-later subsequent LS and ST value and a negative SE value; (3) ST value was positively associated with LS, while SE value presented a negative association; and (4) ST and SE values partially mediated the effect of PTG on LS.

Data availability statement

The original contributions presented in the study are included in the article/supplementary material; further inquiries can be directed to the corresponding author.

Ethics statement

The studies involving human participants were reviewed and approved by the Chongqing Ninth People's Hospital Review Board, China. The patients/participants provided their informed consent to participate in this study.

Author contributions

J-QX: conceptualization, methodology, formal analysis, investigation, writing - original draft, and editing. HZ: conceptualization, investigation, and writing – review. XZ: methodology, investigation, and writing - review. M-ZY: formal analysis and investigation. JY: formal analysis and investigation. KC: conceptualization, resources, funding acquisition, supervision, writing - review, and editing. J-RX: conceptualization, methodology, investigation, and resources. Y-QC: conceptualization, methodology, and writing - review and editing. All authors contributed to the article and approved the submitted version.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Publisher's note

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The application of network agenda setting model during the COVID-19 pandemic based on latent dirichlet allocation topic modeling

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Based on Network Agenda Setting Model, this study collected 42,516 media reports from Party Media, commercial media, and We Media of China during the COVID-19 pandemic. We trained LDA models for topic clustering through unsupervised machine learning. Questionnaires (N =470) and social network analysis methods were then applied to examine the correlation between media network agendas and public network agendas in terms of explicit and implicit topics. The study found that the media reports could be classified into 14 topics by the LDA topic modeling, and the three types of media presented homogeneity in the topics of their reports, yet had their own characteristics; there was a significant correlation between the media network agenda and the public network agenda, and the We Media reports had the most prominent effect on the public network agenda; the correlation between the media agenda and the implicit public agenda was higher than that of the explicit public agenda. Overall, findings showed a significant correlation between network agendas among different media.

KEYWORDS

agenda setting, LDA topic modeling, agenda network, implicit public agenda, explicit public agenda

Introduction

The COVID-19 pandemic has had a significant impact on all aspects of society from the start, and almost every member of the public has been affected. Many participated in discussions on the Internet on topics related to the pandemic in numerous ways, expressing their emotions and opinions. Whether the media and the public share the same focus on a topic—in this case, the pandemic—and whether there has been a cross influence between them is a core focus of agenda-setting theory. Studies have shown that there is a high correlation between the key topics that media and the public choose to focus on.

Attribute differences of issues were later introduced into network-agenda setting theory, such as the commonly used issue classifications of "substantive attribute agenda" and "affective attribute agenda." McCombs et al. (1997) analyzed data from a study of the 1995 Spanish regional municipal elections and found that the attribute agenda setting and the affective attribute agenda of candidates presented in the mass media influenced the attribute agenda of candidates' image among voters. Subsequently, Golan and Wanta (2001) also found in their survey data from the 2000 U.S. presidential election in New Hampshire that the attribute agenda mentioned in newspaper reports influenced voters' judgments about the attributes of the two Republican candidates.

The above two types of theoretical perspectives begin with two types of variables—media types and agenda attributes—to examine the interaction between public and media perceptions of an issue. However, not all media have the same influence, and the Internet environment is more complex. Traditional media leadership has been particularly challenged by the rise of social media. Communication scholars are beginning to pay more attention to the public's ability to upend the media agenda. Wang et al. (2021) found that agenda-setting for wildlife-related issues on Weibo did not follow a one-way path from media to audience, but instead exhibited a reciprocal, dynamic interaction during the COVID-19 pandemic.

Network agenda-setting during the COVID-19 pandemic has also been challenging. First, the pandemic has involved and affected almost every member of the public, and the influence and scope of public agenda setting are more extensive. Second, types of media are also more complex in the Internet environment, for example, We Media, influencers, and Internet celebrities have played important roles in agenda-setting regarding the pandemic. Finally, the pandemic prompted the media to push out information quicker and break the "cocoon" between communities, enabling individuals to pay attention to other groups. In a sense, it has facilitated community-to-community connections. Based on the above three realities, this paper asks the research question: what kind of network structure characteristics do the agendas among media, between media and public, and among different types of issues present in the coverage of the COVID-19 pandemic?

This study focuses on and explores several aspects. First, theoretically, the cross-interaction relationship between media and public agendas is examined from Network Agenda Setting Model (NAS) in the case of the COVID-19 pandemic. Second, in terms of methodology, machine learning methods were used to process the massive amount of public and media agenda-setting data. Recent literature has recognized that computer-assisted textual analysis can allow for a more holistic picture to be obtained when working with a large volume of text data (Gong and Firdaus, 2022). Compared to traditional content analysis, this approach increases the efficiency of text classification tasks. Furthermore, in terms of media type, existing research has focused on the role played by mainstream media yet neglected the power of We Media. Some studies have shown that official media failed to lead the discussion, whereas commercial media tended to be more influential than in the past in crisis cases (Wang and Shi, 2022). Whether this conclusion is also able to be proven in the pandemic is still a question. Therefore, in the current study, we further broke down media into three specific types: Party Media, commercial media, and We Media.

Theoretical background

Network agenda setting model

Network agenda setting (NAS) theory was first proposed by Guo and McCombs (2011) to explore the interaction relationship between media and public agenda networks. Over time the theory has developed to become widely applied in the analysis of the issue network relationship between traditional media and social media. Vargo et al. (2014) analyzed a large Twitter dataset using a series of methods, verifying that different audiences "melded" the agendas of various media in distinctly different ways. Kweon et al. (2019) found that media agenda-setting functions have an increasing influence on public perceptions of social network sites in the context of economic issues in Korea.

More recently, further variables have been taken into account in the exploration of NAS. For instance, Wang (2016) integrated crisis and non-crisis news into the network. Meanwhile, country differences have also been introduced as important variables in related studies. Guo et al. (2019) examined news coverage of the South China Sea dispute on Twitter in three countries, China, the U.S., and the Philippines. Su and Hu (2020) examined the issue of the Diaoyu Islands dispute as reported in Chinese, Japanese, and American newspapers as well as on Twitter and studied the mediating effects between newspapers and Twitter. Scholars have also examined the reliability, validity, and effectiveness of NAS in non-Western contexts.

The theory of NAS has been gradually introduced into other fields beyond political science, and the theoretical horizon is expanding accordingly. Guo and Vargo (2015) integrated NAS with issue ownership theory and proposed the concept of an issue ownership network. In the field of science communication, Chen and Zhang (2021) adopted the NAS model to delineate the salient attributes of gene-editing and their networks in the online agendas of gene-editing and to investigate the interactions between different actors' agendas.

In addition to applying NAS theory in different research fields, scholars have also used it to explore network characteristics. However, few NAS studies have combined substantive and affective attributes to explore their interactions with the public agenda.

Media network agenda interaction in different stages of the event

Inter-media agenda-setting is concerned with the interaction of agendas between different types of media, focusing on their mutual influencing roles (Vargo and Guo, 2017). For a long time, research has focused on the differences between traditional media, which is dominated by elite journalists, and social media, which is dominated by the public. McCombs (2005) argued that elite journalists have special power in the process of inter-media agenda setting. Vu et al. (2014) tested 5 years (2007–2011) of aggregate data from national news media and polls in the U.S., and found a high degree of similarity in issue networks across media, including newspapers, radio, television, and online news media. Vargo and Guo (2017) studied online media sources in the U.S. in 2015, and their modeling suggests that media agendas are highly homogeneous and complementary, with elite newspapers no longer in control of the news agenda, the public preferring to follow online partisan media, and online partisan media replacing elite newspapers in holding a dominant role in the overall media agenda.

In addition to examining traditional and social media differences, Weaver et al. (2010) identified another two ways to consider media, vertical and horizontal, which have been gradually incorporated into current research. Vertical media refers to media that radiates to all segments of society, while horizontal media focus on people with specific interests and expertise. Guo and Vargo (2015) examined the 2012 U.S. presidential election using an online agenda-setting model, and confirmed that Obama supporters tended to follow the network agenda of vertical mainstream media, whereas Romney supporters were more in line with the conservative niche media—horizontal media.

These two media segmentation methods, however, do not consider the impact of the different stages of an event. Sung and Hwang (2014) found that in the field of crisis communication, although social media may play an important role as a major news source during the initial stage, once traditional news reports appear, these take the lead in setting the agenda. Significant differences were also observed in the influence of agenda-setting by various media at different stages of the COVID-19 pandemic in China. In the early stage of the outbreak, mainstream media, with their resource advantages, were able to take the lead in first-line reporting, providing the public with timely and accurate information. This shows that vertical media had a greater influence on the agenda over horizontal media at the start. Meanwhile, in the subsequent stages of the pandemic, the focus of We Media seemed to profoundly influence the issues of traditional media. Generally, We Media is better able to report on social issues affecting niche or vulnerable groups. These issues have also been of great concern to the public as the pandemic has reached it later stages. Based on this preliminary observation, the current study takes the event progression process as an important variable reference to examine whether there is a correlation between the agenda networks among media at different stages. Therefore, this paper proposed the following hypothesis.

> *Hypothesis 1 (H1)*: Regarding the media coverage of the COVID-19 pandemic, there was a significant correlation between the network agendas of different types of media in the different stages of the pandemic development.

Interactive relationship between media network agenda and public agenda: From linear influence to the network influence

Media influence on public issues occupies a large proportion of existing studies on the relationship between the media network agenda and the public agenda. Schultz et al. (2012) found that institutions can reverse public attention and issue-focused perceptions through the media, while Guo and Vargo (2015) showed that new media can influence public perceptions not only with individual issues but also with the network relationship between issues. But this relationship is not unidirectional. Within the context of the Internet environment, the influence between public agendas and media agendas is mutual. Weiss-Blatt (2016) found a positive correlation between the salience of technology-based coverage issues in traditional media coverage and blogs written by the public. However, due to media network agendas, audiences do not always hear about all current issues as the process of agenda-setting is influenced by many individual factors, such as individual demographic differences, media exposure, user needs, and partisan stances.

Continuing on from the above theory and findings, the issue of the COVID-19 pandemic is particularly complex with numerous considerations one must consider, and its social impact has had a particularly large scope. The agenda relationship between the public and the media has more "network" characteristics than linear influences. The agendas surrounding the COVID-19 pandemic have been relevant to everyone, and the public's perception of this issue is an important variable to be examined. Therefore, in this study, issue differences are placed as important variables in the relationship between the two.

Network agenda under the differences between explicit agendas and implicit agendas

The NAS model posits the existence of two levels of public agendas: implicit and explicit (Guo, 2012). "Implicit" here means unconscious, indirect, and automatic. Individuals may not even realize when they unconsciously connect two things in their minds. In contrast, an explicit public agenda refers to a conscious, active connection. Some studies have found that media agendas are more closely associated with the public's implicit agendas. This

TABLE 1 Focus group.

Focus group	Number of participants	Gender	Age
1	6	3Males + 3females	18–23
2	6	3Males + 3females	24–29
3	6	3Males + 3 females	30–35
4	6	3Males + 3 females	36–40

view was verified in the study of Jiang and Cheng (2018), who found that newspaper agendas were found to be more closely associated with implicit public agendas. Subsequently, Jiang et al. (2021) validated the NAS model in multiple social contexts. In analyzing the THAAD event (the deployment of the Terminal High Altitude Area Defense system in South Korea), research data from China, the United States, and South Korea showed that the NAS effect on the implicit public agenda was stronger than its corresponding effect on the explicit public agenda. A possible explanation for this could be that when the media agenda transmitted messages to the public, individuals might not have explicitly realized the connection between the any two attributes they have made and were thus more quickly influenced by the messages coming *via* the implicit media agenda.

By breaking down the explicit and implicit associations in the public agenda, it is possible to more closely examine how and at what level the media agenda influences public thought (Vargo et al., 2014). Therefore, this study proposes the following hypotheses based on the above findings.

> *Hypothesis 2 (H2)*: There was a significant correlation between the media network agenda and the explicit public agenda regarding media coverage of the COVID-19 pandemic.
>
> *Hypothesis 3 (H3)*: There was a significant correlation between the media network agenda and the implicit public agenda regarding media coverage of the COVID-19 pandemic.

Research methods

Subjects and data

Media agendas

In this study, three types of media were selected as research subjects according to the characteristics of China media: Party Media,[1] commercial media (Southern Metropolis Daily), and We Media.[2] As Party media, ChinaNews.com is one of the top 10 most important news organizations in China; as mainstream media with a high degree of marketization, Southern Metropolis Daily has influence nationally; and finally, the reports collected from the official cn-healthcare.com website were from "health" channel, which is a popular health We Media platform. The platform invites a large number of content creators—most of which are medical practitioners—to share health policies, disease knowledge, and other health-related content. All three media ranked first in their number of reports about the outbreak of the pandemic in their particular media category, ensuring that they were influential media players. The data collected in relation to the COVID-19 pandemic were obtained from the WiseNews database, with data volumes of 23,452 for ChinaNews.com, 11,902 for Southern Metropolis Daily, and 7,162 for cn-healthcare.com.

Public agendas

Questionnaires were the primary way used to collect data regarding public agendas. First, focus groups were used as pre-studies to supplement the questionnaire design. Focus group interviews were conducted to obtain public perceptions of the COVID-19 pandemic. Based on the narratives in the focus group interviews, we compiled a list of topics that made up the public agenda. Comparing the topics from the focus group interviews with the media report topics, a large number of synonymous or near-synonymous expressions were found, so a final list of 14 topics were integrated into the content analysis that was used in designing the questionnaire. Considering participants' gender and age differences, the focus groups were divided into in four groups, with six participants in each group (see Table 1).

The study used the mind-mapping method to collect data for both the implicit and explicit network public agendas in the questionnaire. In the first part, respondents selected certain topics from the full list of topics to test for implicit associations. In the second part, respondents selected related topics from the selected topics and established a link between two to test the explicit associations.

The questionnaire was distributed through the wjx.cn platform from April 26, 2021 to May 11, 2021. The public was still in the midst of the pandemic during this period, so we were able to observe the impact of the media agenda on the public. To proportionally represent Chinese netizens, the current study refers to survey data from the 47th Statistical Report on Internet Development in China released by the CNNIC in February 2021 for sampling based on gender, age, and education (China Internet Network Information Center, 2021). About 470 participants completed the survey, and 240 participants (51%) were male, and 230 (49%) were female. The mean age of participants was 29.3.In terms of education level, 40.4% had high school education or below, while 59.56% held a bachelor's degree or higher.

Definition of the main variables

The basis for the stage division of the pandemic

According to the "Fighting COVID-19 China in Action" White Paper issued by the State Council Information Office of the

1 ChinaNews.com

2 cn-healthcare.com

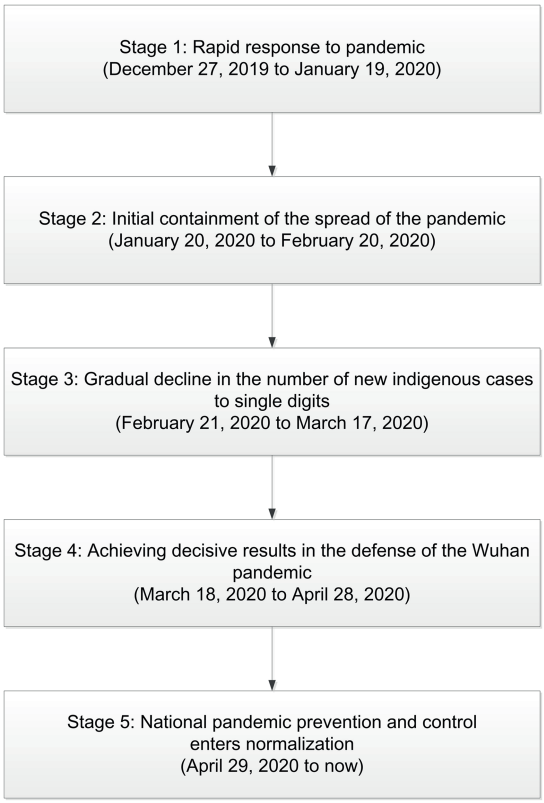

FIGURE 1
Five stages of fighting COVID-19 in China.

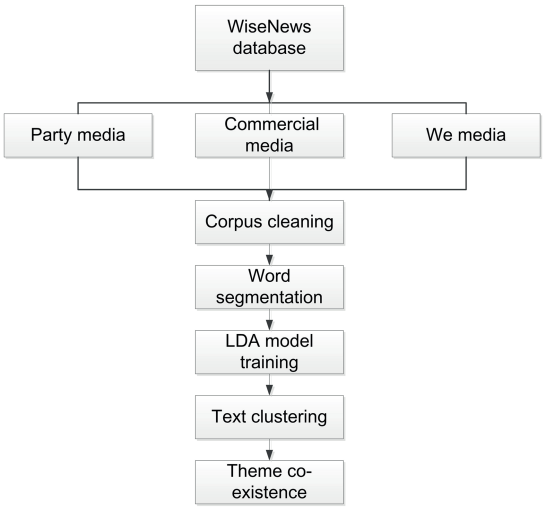

FIGURE 2
Analysis process.

People's Republic of China, China's arduous journey through the pandemic can be divided into five stages, as shown in Figure 1.The study focused on the time interval from December 27, 2019 to April 28, 2020, with consideration that the pandemic was in its normalization phase from April 29, 2020 to April 29, 2021.

Classification of explicit and implicit issues

The explicit and implicit measurements in NAS have been a topic of discussion in academic circles. Currently explicit and implicit measures can be divided into "mind mapping" and "elaboration." In this study, the "mind mapping" method was used to measure explicit and implicit associations. In practice, this means that if participants select words from a word list, they are considered to have an implicit relationship with each other, while if participants construct connections between these words by drawing lines, the words marked by the lines are considered to be explicitly related (Jiang and Cheng, 2018). In our study, as part of the questionnaire design, participants were first asked to select up to 10 words from the topic list to describe COVID-19 pandemic, and co-occurrences of the selected words were used to measure the implicit association between the attributes; for the explicit association, participants connected the attribute words they considered to be related to each other by drawing lines, and the lines clearly marked the explicit association between the attributes.

Main analysis tools

Machine learning and LDA topic modeling

In this paper, we used unsupervised machine learning—Latent Dirichlet Allocation (LDA) Topic Modeling—for big data analysis using Python. The LDA model can automatically generate text collections to identify salient topics in news stories, and existing research has proven that LDA database-based topic modeling can effectively discover and understand the underlying topic structure for topic analysis (Guo et al., 2016). The analysis process is shown in Figure 2, where the pre-processing of different news corpus was performed using the Chinese word splitting tool "jieba," setting custom dictionaries to add words specific to the pandemic context (e.g., names of people, places, drugs, etc.), set deactivation words, and filter out useless words. For the LDA Topic Modeling, all news articles in the three media types were trained using the Python three-way library "genism." With reference to fixed metrics such as perplexity, topic coherence, and multiple training sessions, the *k*-value interval was calculated approximately. The optimal result was determined by trying each of the *k*-values in this interval, resulting in 14 generated topics. LDA Topic Modeling can calculate the topic probability distribution of each article based on the trained topics, which provides the conditions for co-occurrence between topics. By calculating the *k*-value set to 14, the average value of each topic probability was 0.07. At this point the probability of two or more topics in a report was greater than or equal to 0.14, and these topics would then be considered to be one co-occurrence. The topics in each report that met this requirement were retained. The final step

was to build the topic co-occurrence matrix by the matrix function.

QAP analysis

Quadratic Assignment Procedure (QAP) calculates the measures of nominal, ordinal, and interval association between the relations in two matrices, and uses quadratic assignment procedures to develop standard errors to test for the significance of associations (Hanneman and Riddle, 2005). In this paper, QAP analysis was conducted using UCINET to test whether there was a network correlation between media network agendas and public agendas. Finally, the study used NetDraw in UCINET to visualize and analyze the agenda network. The iterative metric multidimensional scaling method was used to map the agenda network, in which the closer that attributes are to one another, the stronger the correlation between the two, and the closer an attribute is connected to other attributes, the closer that attribute is to the location of the center of the network (Jiang and Cheng, 2018).

Results

Inter-media network agenda-setting effect

As no reports were retrieved for the first stage of the pandemic (December 27, 2019 to January 19, 2020), only data for the second stage (January 20, 2020 to February 20, 2020), the third stage (February 21, 2020 to March 17, 2020), and the fourth stage (March 18, 2020 to April 28, 2020) are covered.

For H1, with regard to media coverage of the COVID-19 pandemic, there was always a significant correlation between network agendas of different media types as the pandemic developed into different stages. The results demonstrated statistically significant associations between network agendas of different media (see Table 2). Specifically, QAP correlation results showed that at all three stages, the agendas of any of the two media were significantly correlated, with the highest correlation coefficients for Southern Metropolis Daily and ChinaNews.com (Pearson's $r = 0.924$, 0.929, and 0.94, respectively, $p < 0.001$ for all three stages). Cn-healthcare.com and ChinaNews.com had the lowest correlation coefficients in the three stages (Pearson's $r = 0.655$, 0.691, and 0.668, respectively, $p < 0.001$ for all three stages). H1 was supported. This suggests that in the new media era, there is a correlational influence of agendas among different media with some homogeneity.

TABLE 2 Effectiveness of agenda setting different media.

Correlation coefficient (r)	Stage II	Stage III	Stage IV
Cn-healthcare.com & Southern Metropolis Daily	0.789***	0.823***	0.775***
Cn-healthcare.com & ChinaNews.com	0.655**	0.691**	0.668**
Southern Metropolis Daily & ChinaNews.com	0.924***	0.929***	0.94***

**$p < 0.01$ and ***$p < 0.001$.

TABLE 3 Effectiveness of network agenda-setting during the COVID-19 pandemic.

Correlation coefficient (r)	Explicit Public Agenda	Implicit Public Agenda
Media Network Agenda	0.381**	0.521*

*$p < 0.05$ and **$p < 0.01$.

Interaction between media network agendas and public network agendas

With regard to H2, there was a significant correlation between the media network agenda and the explicit public agenda. QAP correlation results showed statistically significant associations between media network agendas and explicit public network agendas (Pearson's $r = 0.381$, $p < 0.01$; see Table 3). H2 was supported.

For H3, there was a significant correlation between the media network agendas and the implicit public agendas regarding media coverage of the COVID-19 outbreak. QAP correlation results showed that statistically significant associations between media network agendas and implicit public network agendas (Pearson's $r = 0.521$, $p < 0.05$; see Table 3). H3 was supported.

Quadratic Assignment Procedure correlation results showed that the coefficient of cn-healthcare.com was the highest (Pearson's $r = 0.364$, $p < 0.01$), and the coefficient of ChinaNews.com was the lowest (Pearson's $r = 0.308$, $p < 0.01$) between media agenda and explicit public agenda (see Table 4).

Only cn-healthcare.com was significantly associated with the implicit public agenda (Pearson's $r = 0.658$, $p < 0.01$), confirming the professional role played by medical We Media in the COVID-19 pandemic.

Media agenda network during the COVID-19 pandemic

Homogeneity and individuality of media network agenda

The LDA algorithm was used to extract 14 topics from the total sample (42,516 reports) to build a co-occurrence matrix. Topic of "Supply of materials such as masks" accounted for the largest proportion at 16.31%, followed by the topic of "Healthcare workers" (12.73%) and "government policy"(11.79%). And the degree centrality was calculated using UCINET for ranking and visualization. The media reports were related to the supply of

TABLE 4 Effectiveness of agenda-setting in different media networks.

Correlation coefficient (r)	Explicit Public Agenda	Implicit Public Agenda
Cn-healthcare.com	0.364**	0.658**
Southern Metropolis Daily	0.325**	0.361
ChinaNews.com	0.308**	0.305

**$p < 0.01$.

materials, such as masks (426,273), healthcare workers (422,823), government policy (400,098), community prevention and control (396,651), virus analysis (378,335), social mobilization (367,750), overseas outbreaks (364,082), vaccine development (356,496), support Wuhan (353,602), anti-pandemic measures (346,614), global cooperation (305,707), case reports (218,521), overseas input (197,075), and Chinese medical treatment (158,693; See Table 5).

In general, all three media types presented homogeneity in reported themes, with all prioritizing "supply of masks and other materials" and "healthcare workers." As shown in Table 6, the third-ranked topic in the cn-healthcare.com was "virus analysis," which focused on professional medical issues in the public health vertical, while the Southern Metropolis Daily focused on "community prevention and control," and on residents' lives and grassroots management, reflecting the professionalism of the media. Meanwhile, ChinaNews.com mainly reported on government policies and measures, and actively relayed government programs, reflecting the media's attribute as the mouthpiece of the Party. While other media paid little attention to "overseas outbreaks," while ChinaNews.com paid more attention to the status of the pandemic in various countries around the world and the lives of Chinese people living overseas.

Network structure of tripartite confrontation

Figure 3 shows the agenda network of media coverage, and the 14 topics were further grouped into three major categories according to the relevance of the content. The first category was prevention and treatment, including "virus analysis," "vaccine development," "anti-pandemic measures," "Chinese medical treatment," and "supply of masks and other materials." The second category was the status of the pandemic domestically, including "case reports," "offshore input," "healthcare workers," "support Wuhan," "government policy," "community prevention and control," and "social mobilization." The third category was the global fight against the pandemic, and included "global cooperation" and "overseas outbreaks." These three categories of topics show a three-legged feature in terms of network characteristics. Cn-healthcare.com paid more attention to the content in the first category, while Southern Metropolis Daily and ChinaNews.com paid more attention to the content in the second category.

Features of the public network agenda during the COVID-19 pandemic

Figure 4 shows the network visualization of the explicit public agenda during the COVID-19 pandemic. According to the degree centrality as noted in Table 7, the central theme was "supply of masks and other materials" (2,357), followed by "community prevention and control" (844), and "anti-pandemic measures" (783).

Figure 5 shows the network visualization of the implicit public agenda in the COVID-19 pandemic. According to the degree centrality as shown in Table 8, the central theme was "supply of masks and other materials" (4,249), followed by "support Wuhan" (4,030), and "healthcare workers" (3,951).

Compared with the media agenda network, the public agenda paid more attention to "support Wuhan" and "case reports," which were at the center of the network, and less attention to "virus analysis" and "overseas outbreaks."

Discussion and conclusion

Using longitudinal analysis, the current study found consistently significant correlations among different inter-media agenda networks during the COVID-19 pandemic. Early on in agenda-setting research in general, the Chapel Hill study already found a high degree of homogeneity among media agendas (Vu et al., 2014), and the current study similarly demonstrated that different media also have a high degree of homogeneity at the network agenda setting level, and that in the new media era, content across different media also has a high degree of mutual influence.

Furthermore, the current study proves that there was a significant correlation between media agendas and both explicit and implicit public agendas during the COVID-19 pandemic, which indicates that the media agenda network and the public agenda are still highly correlated in the new media era. Theoretically, this study complements the empirical research on agenda-setting in the Chinese context, and practically examines the effect of media influence on the cognitive, attitudinal, and behavioral levels of the media audience. At the same time, the NAS model also inspires the media to establish connections between various elements in their reporting, and the networked information structure helps to better deliver messages to the public, influence public opinions, and guide public sentiment in the new media era.

The media agenda network is more relevant to the implicit public agenda than it is to the explicit agenda, which is also consistent with previous findings, suggesting that the media agenda is more relevant to the automatic, unconscious, implicit public agenda than it is to the directly controlled, conscious, explicit public agenda. The difference between the two is determined by the fact that the media information is weakened after going through the "barrier" of the brain's conscious

TABLE 5 The 14 topics related to the COVID-19 pandemic.

Serial number	Topics	Keywords	Proportion	Degree centrality
1	Supply of materials such as masks	Mask, production, enterprise, Supplies, epidemic, medical, need, price, supply, and purchase	16.31%	426,273
2	Healthcare workers	Wuhan, first line, medical staff, hope, anti-epidemic, war, epidemic, protective suit, hold fast, and hero	12.73%	422,823
3	Government policy	Epidemic, prevention and control, assurance, policy, measure, resumption of work and production, implement, introduced, publish, and employment	11.79%	400,098
4	Community prevention and control	Community, prevention and control, quarantine, detect, troubleshoot, manage, resident, street, staff member, and grassroots	11.35%	396,651
5	Virus analysis	Infect, virus, pneumonia, spread, wild animals, infectious disease, expert, game, symptom, and respiratory tract	8.59%	378,335
6	Social mobilization	Donate, win, blockade, xi jinping, party member, the masses, strength, love, fight, and war epidemic	7.77%	367,750
7	Overseas outbreaks	America, Japan, Confirmed, Germany, Italy, France, government, Overseas Chinese, South Korea, and International students	6.95%	364,082
8	Vaccine development	Vaccine, detect, research, R&D, clinical, technology, biology, scientific research, antibody, and laboratory	6.15%	356,496
9	Support Wuhan	Hospital, patient, Wuhan, treat, medical team, support, medical staff, mobile cabin hospitals, players, and expert group	5.22%	353,602
10	Anti-pandemic measures	Mask, disinfect, body temperature, protection, wear, touch, ventilation, register, gather, and home	5.06%	346,614
11	Global cooperation	China, economy, worldwide, nation, cooperate, develop, crisis, cope with, market, and public health	3.33%	305,707
12	Case reports	Case, confirmed, add, grand total, die, decline, data, cure, suspected case, and continuous	3.14%	218,521
13	Offshore input	Traveler, airport, flight, customs, port, entry, input, quarantine, fever, and medical observation	1.58%	197,075
14	Chinese medicine treatment	Traditional Chinese Medicine, medicinal glue, oral liquid, and shuanghuanglian	0.05%	158,693

information processing system. Because of our enhanced autonomy, humans are more likely to believe the information that our brains have chosen to hang onto after digesting it rather than to broadly accept all information immediately put out by media. The more directly the information is sent, the more likely the public is to be suspicious. This therefore offers suggestions as to how news media can communicate better, as truly effective communication is about outputting "logic," which refers to prior interventions in the formation of public attitudes and motivations, not just "opinions" directly exported by the media. In the long run, this can also influence audience's thinking, and help the audience form more rational logic through external positive guidance.

ChinaNews.com and Southern Metropolis Daily far exceeded cn-healthcare.com in terms of their posting volume, influence, and topic coverage, so the correlation between their agendas and the public agendas should have been higher than that of We Media like cn-healthcare.com. However, this study found that the latter had a significant correlation with both explicit and implicit public agendas, and the degree of correlation between the two was higher than that of the other two media and public agenda networks. This is a new finding in contrast to those of previous studies. While past studies have found that mainstream media plays an important role in guiding the public agenda, the power of We Media cannot be underestimated, particularly in the context of a pandemic. This is also closely related to the specific area of the COVID-19 pandemic, which is a public health issue, and cn-healthcare.com, as a vertical specialized We Media, has been able to meet public needs better in terms of dissemination of information regarding pandemic prevention, science, and treatments, which highlights the case of the audience reverse agenda-setting through a certain degree of selective exposure to media information. From a practical perspective, our findings can serve as useful input for public health communication during pandemic or similar situations. Apriliyanti et al. (2021) found that the media might help set the tone for policy agenda. Media can promote the interaction between science and policy. Policy makers and relevant news media should define a clear strategy as how to use social media during the pandemic. They should have a plan to know which topics are more critical to the public and work to guide them onto the public agenda (Tahamtan et al., 2022). For example,

TABLE 6 Topic ranking in different media.

Ranking	Overall	Cn-healthcare.com	Southern Metropolis Daily	ChinaNews.com
1	Supply of materials such as masks	Supply of materials such as masks	Supply of materials such as masks	Supply of materials such as masks
2	Healthcare workers	Healthcare workers	Healthcare workers	Healthcare workers
3	Government policy	Virus analysis	Community prevention and control	Government policy
4	Community prevention and control	Support Wuhan	Government policy	Community prevention and control
5	Virus analysis	Government policy	Vaccine development	Overseas outbreaks
6	Social mobilization	Vaccine development	Virus analysis	Virus analysis
7	Overseas outbreaks	Community prevention and control	Social mobilization	Social mobilization
8	Vaccine development	Anti-pandemic measures	Overseas outbreaks	Anti-pandemic measures
9	Support Wuhan	Social mobilization	Support Wuhan	Support Wuhan
10	Anti-pandemic measures	Global cooperation	Anti-pandemic measures	Vaccine development
11	Global cooperation	Overseas outbreaks	Global cooperation	Global cooperation
12	Case reports	Case reports	Chinese medicine treatment	Offshore input
13	Chinese medicine treatment	Offshore input	Offshore input	Chinese medicine treatment
14	Offshore input	Chinese medicine treatment	Case reports	Case reports

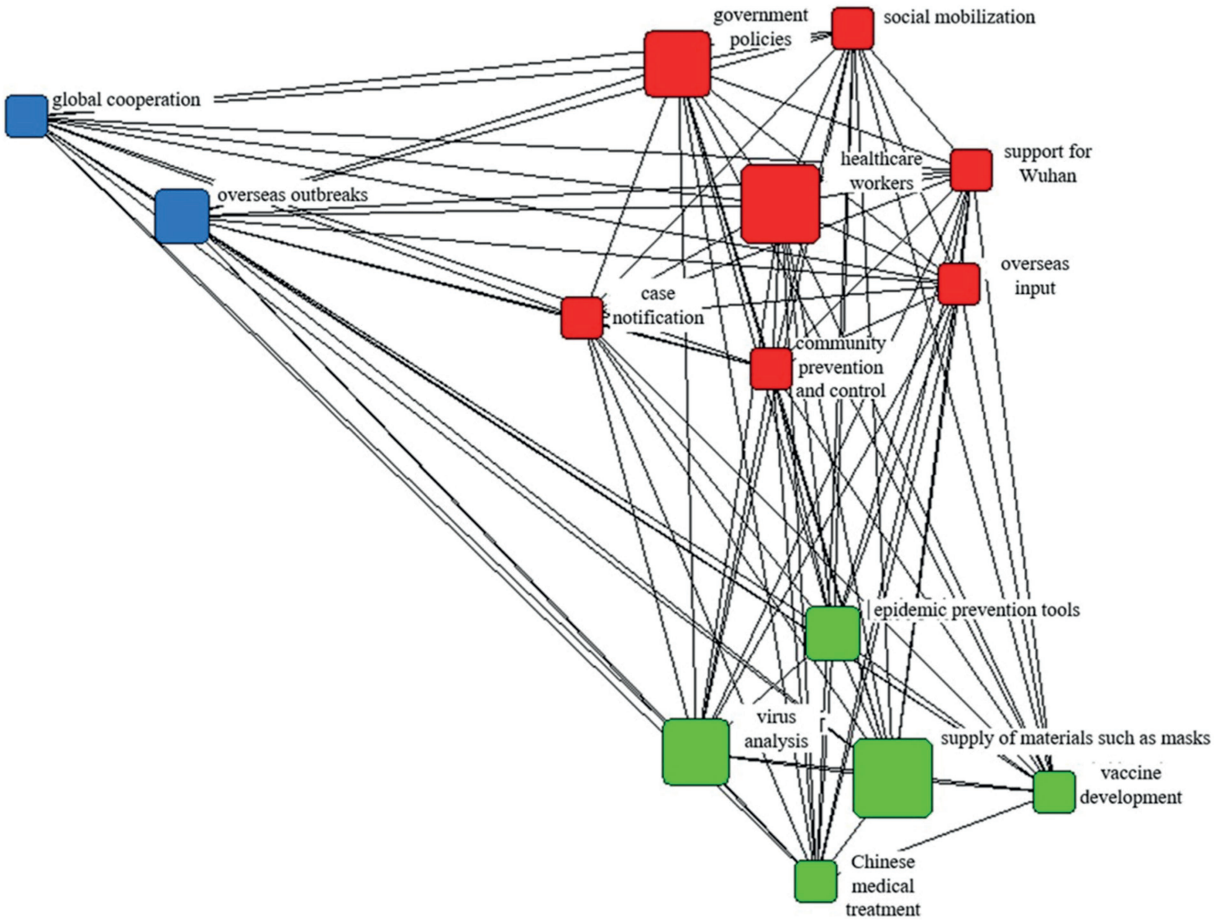

FIGURE 3
The agenda network of media coverage.

prolonged isolation can have a negative impact on physical and mental health. Based on the high level of public concern about which media to follow that can grow in response to strained physical or mental health stresses, news coverage should focus on accuracy of sources and issues such as vaccine development to ease public anxiety (Gong et al., 2022).

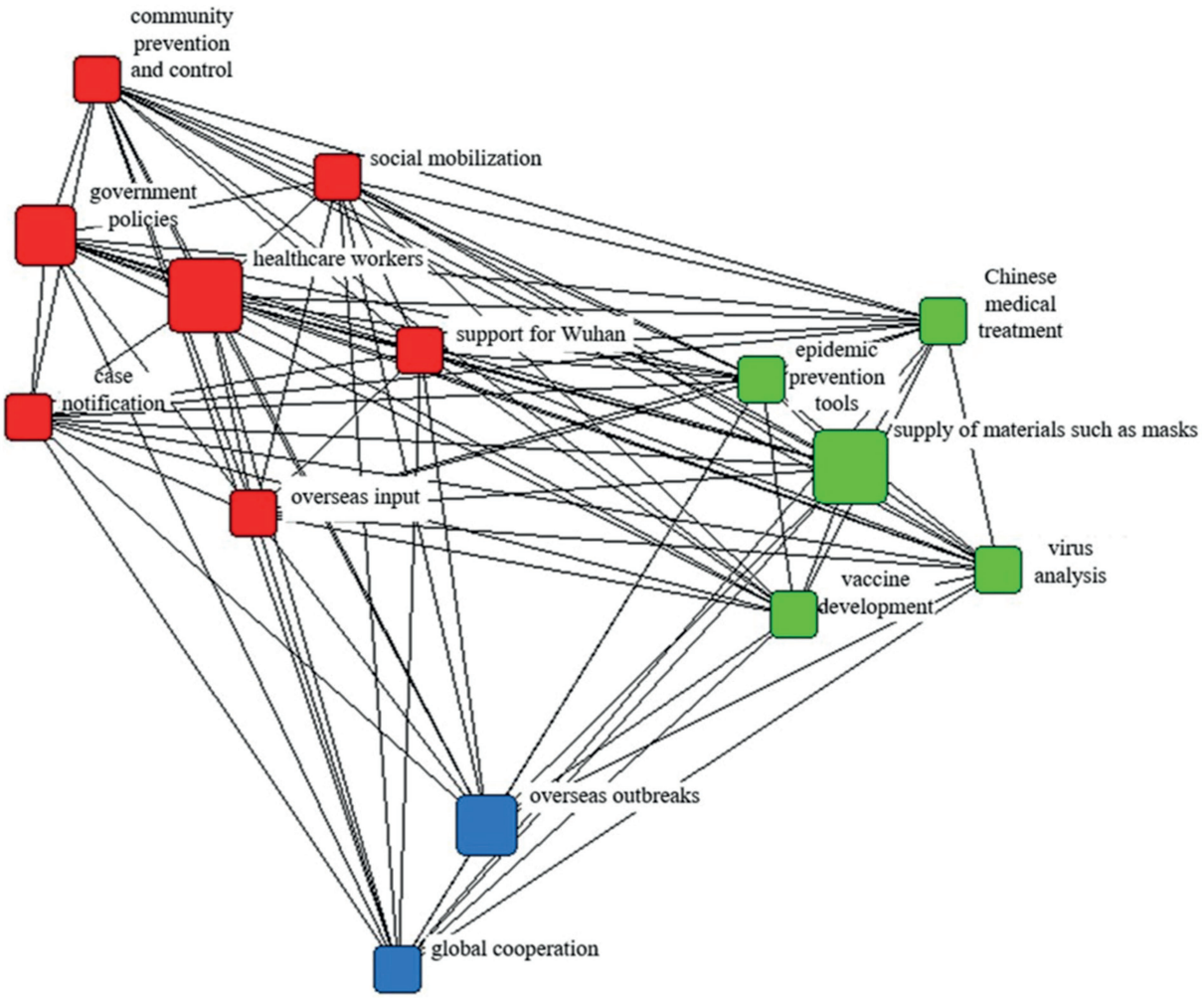

FIGURE 4
The network of the explicit public agenda.

The media market is becoming highly segmented, and media consumption is becoming more personalized. Therefore, more attention must be paid to the role of the public agenda. Compared to the media agenda network, our findings showed that the public paid more attention to "support for Wuhan" and "case reports," which were located at the center of the network. In the face of disasters, emotions are mobilized first due to many factors. Through media coverage of a series of deeds done in support of Wuhan, the public was inspired through strong emotions, and "when one side is in trouble, support from all sides" as a national spirit triggered a collective emotional resonance. This emotional narrative also offers suggestions for media communication strategies. These nationalistic emotions led to a strong and powerful portrayal of the role of health care workers fighting against the COVID-19 virus, which promoted solidarity, prosociality, and benevolence among the masses (Wang, 2022).

As individuals, however, the public is also prone to being extremely concerned about events that are closely related to their own lives. The "notification of cases" topic informed the public where outbreak was occurring and the number of confirmed cases in a clear and concise manner, saving the public time in accessing information. The public was then able to perceive and judge the seriousness of the outbreak, which in turn affected whether they would take effective measures to avoid a worse situation. Therefore, "case reports" was also a highly regarded topic by the public as an early warning device. This also demonstrates that in times of crisis, people's need for orientation is very high. Previous studies have shown that people will borrow terms from media discourse to construct an articulate, relevant discussion because these ideas and terms have been previously validated by the media (Buturoiu and Gavrilescu, 2021). Therefore, before the public has the opportunity to manufacture doubts or speculation about virus outbreaks, the role of the media should be to set the tone for the nature of the outbreak. It is better for media to filter information and guide the public to understand key messages so that they

TABLE 7 Explicit public agenda topic ranking.

Ranking	Topics	Degree centrality
1	Supply of materials such as masks	2,357
2	Community prevention and control	844
3	Anti-pandemic measures	783
4	Global cooperation	734
5	Virus analysis	688
6	Healthcare workers	650
7	Overseas outbreaks	636
8	Offshore input	492
9	Government policy	478
10	Chinese medicine treatment	443
11	Vaccine development	433
12	Case reports	410
13	Support Wuhan	314
14	Social mobilization	214

TABLE 8 Implicit public agenda topic ranking.

Ranking	Topics	Degree centrality
1	Supply of materials such as masks	4,249
2	Support Wuhan	4,030
3	Healthcare workers	3,951
4	Vaccine development	3,713
5	Case reports	3,498
6	Anti-pandemic measures	3,357
7	Community prevention and control	3,203
8	Offshore input	3,029
9	Government policy	2,997
10	Virus analysis	2,975
11	Overseas outbreaks	2,332
12	Social mobilization	2,211
13	Global cooperation	1857
14	Chinese medicine treatment	1,278

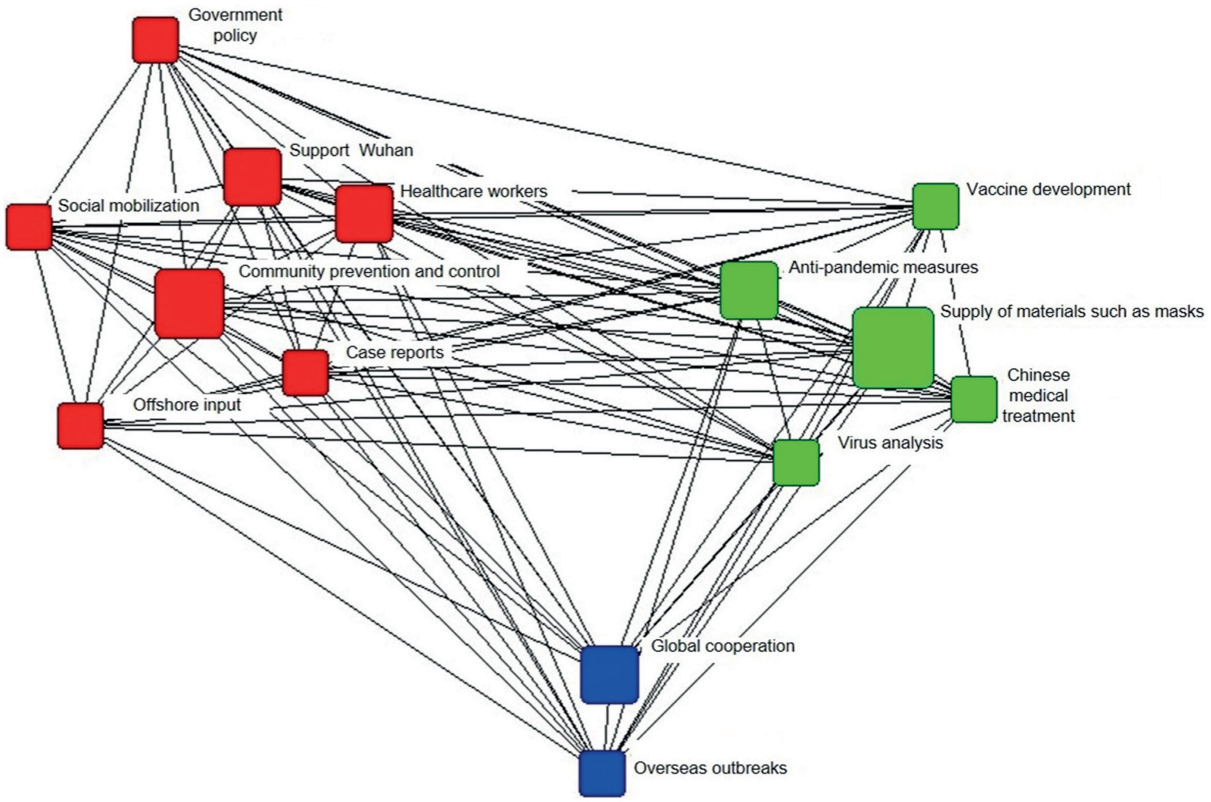

FIGURE 5
The network of the implicit public agenda.

can avoid becoming overwhelmed by the threat of pandemic information.

In this study, LDA Topic Modeling has been used for topic clustering of text content, which overcomes the flaws of traditional content analysis and uses machine learning for big data analysis and topic clustering with better results in matrix construction.

There are, nonetheless, some shortcomings to this study. In terms of the public agenda data, the sample size for the

questionnaire was small; a larger sample should be used in the future. Second, in addition to examining media coverage topics, more dimensions could be added as measures, such as sentimental dimensions or positive and negative sentiment towards key individuals or events, to examine the degree of correlation between media agenda networks and public networks. Finally, this study only proved the existence of significant correlations among different media, and did not measure the agenda-setting causality among media and further than this, which should be tested in the future by using the Granger causality test to detect causality between the different media.

Data availability statement

The original contributions presented in the study are included in the article/supplementary material; further inquiries can be directed to the corresponding author.

Ethics statement

For social sciences, most institutions in China do not have Institutional Review Board. As a protection of all participants, the studies involving human participants were reviewed and approved by Beijing Jiaotong University, China. All participants voluntarily made their decision and consent to participate in this study.

Author contributions

KL, XG, and XL: originated and designed research. XL and XG: contributed to the statistical analysis, interpretation of the results, and revision of the manuscript. All authors were involved in editing, reviewing, and providing feedback for this manuscript.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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Metaverse as a possible tool for reshaping schema modes in treating personality disorders

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Personality disorders (PD) are usually treated with face-to-face sessions and/or digital mental health services. Among many schools of therapies, schema therapy stands out because rather than simply targeting the symptoms of PD, it cordially targets the cause of PD and heals the early maladaptive schema, thus is exceptionally good at soothing emotional disturbances before enacting cognitive restructuring, resulting in long-term efficacy. However, according to Piaget's genetic epistemology, the unmet needs lie in the fact that the schemata that determine the adaptive behavior can only be formed in the interaction with the real world that the patient is living in and reconsolidated by the feedback from the object world upon the patient's newly-formed behavior. Therefore, in order to reshape the patient's schema modes to support adaptive behavior and regain emotional regulation capabilities of the healthy adult, one may have to reconstruct the object world surrounding the patient. Metaverse, the bestowed successor to the Internet with the cardinal feature of "the sense of full presence," can become a powerful tool to reconstruct a new object world for the patient with the prescription of a psychotherapist, so as to transform the treatment techniques in schema therapy into the natural autobiographical experiences of patients in the new object world, thus gradually reshape the patient's schema modes that can ultimately result in an adaptive, and more inclusive, interaction with the real world. This work describes the underlying theory, the mechanism, the process, and ethical considerations of such promising technology for the not-too-far future.

KEYWORDS

metaverse, personality disorders, schema therapy, Piaget, genetic epistemology, digital mental health services, experience setting, mental health care

Introduction: Personality disorders and schema therapy

Personality disorders (PD) refer to "an enduring pattern of inner experience and behavior that deviates from the expectations of the individual's culture" (American Psychiatric Association, 2013), including several subtypes, such as borderline personality disorder (BPD), narcissistic personality disorder (NPD), paranoid personality disorder

(PPD), avoidant personality disorder (APD), antisocial personality disorder (ASPD), schizotypal personality disorder (SPD), etc. People with PD are generally difficult to cope with, have unrelenting relationship problems with emotional dysregulation, and may cause harm to either people in his/her surroundings or him/herself and even commit crimes (Widiger and Costa Jr, 1994; Zachar et al., 2016; Dadomo et al., 2018). Indeed, even not diagnosed, we can observe in our daily life "enduring," "pervasive" and "inflexible" traits in people with "characteristic issues" (Wright and Simms, 2016), who may or may not seek help from mental health practitioners depending on the severity of their problems in their work and life, their realization of such needs weighed against perceived stigma, and the cost and accessibility to such services (Kazdin and Rabbitt, 2013; Andrade et al., 2014). As a matter of fact, even though mental health problems are widespread all over the world (Patel and Prince, 2010), studies have pointed out that even in developed countries like the United States 62% of adults with mental illness and 41% of adults with serious mental illness have not received any mental health care in the previous year (Walker et al., 2015). The COVID-19 pandemic has exacerbated this situation and urged changes in how we practice mental health care (Moreno et al., 2020; Peng et al., 2020; Vadivel et al., 2021). Therefore, it is time to consider digital mental health services (DMHS) and expand the coverage and accessibility of mental health care (Kazdin and Rabbitt, 2013; Lattie et al., 2022), especially for people with plausible PD syndromes because their symptoms are chronic or even life-time, but their motivation and approach to engage in treatment are complicated (Young et al., 2006).

Among all kinds of psychotherapeutic treatments for PD (Dixon-Gordon et al., 2011), schema therapy (ST) stands out because rather than simply targeting the symptoms of PD, it cordially targets the cause of PD and heals the early maladaptive schema (EMS), thus is exceptionally good at soothing the emotional disturbances before enacting cognitive restructuring, resulting in long-term efficacy (Young, 1999; Young et al., 2006; Dadomo et al., 2016, 2018). The term "schema" was annotated by famous psychologists from Bartlett and Piaget to Beck and Young (Pace, 1988; Adekoya, 2013). Within cognitive psychology, a schema is the developmental norm of cognitive structures (i.e., a meta-structure) formed by an individual in the process of interacting with the environment, operated by selectively organizing the on-going experience of each individual into subjectively meaningful patterns. Through the schemas, people are active constructors of their own psychological realities. Importantly, those schemas formed early in life continue to be elaborated and then superimposed on later life experiences, even when they are no longer applicable. As a result, those maladaptive schemas formed early in life (i.e., EMS) might be at the core of personality disorders, milder characterological problems, and many chronic emotional dysregulations (Young et al., 2006; Dadomo et al., 2018). The good news is that schemas not only guide behavior in response to contextual stimuli, but can also be reshaped by the interaction with the external world, thus providing a window for treatment (Dadomo et al., 2016; Taylor et al., 2017).

Indeed, schema therapists use techniques such as limited reparenting, imagery rescripting, and chair work to help clients exchange their maladaptive schema modes for an adaptive one (Dadomo et al., 2016). Accordingly, a schema mode is "an intense predominant emotional state linked to a pattern of thinking, feeling and behaving based on a set of specific needs" (Dadomo et al., 2018). These approaches have been proved to be successful in several randomized controlled trials (e.g., Taylor et al., 2013; Bamelis et al., 2014; Hoffart Lunding and Hoffart, 2016; Aloi et al., 2019; van Dijk et al., 2019). However, despite for the success of ST in treating PD, there are several lines of evidences that suggest that ST could greatly benefit from the future application of DMHS, especially the metaverse: (1) In a qualitative study done on patients' perspective on the first phases of imagery work in the context of ST (Marieke et al., 2011), PD patients reported lacking information, communication, and support during the initial phases of imagery work, and the duration of the imagery exercises was unpredictable, which created feelings of uncertainty and fear. (2) Researchers have already tried to integrate e-health tools such as *priovi* into borderline-PD-specific treatments based on ST and showed that the integration can potentially increase treatment intensity and enhance treatment effects, though therapists should monitor the usage of e-health tools, help with difficulties, and check if patients understand them and promote their usage (Fassbinder et al., 2015). (3) In a clinical trial, Hoffart Lunding and Hoffart (2016) found that schema therapy carries the risk to lead to a more negative view of parents' care during upbringing and this risk is accentuated with less benefit of therapy—this is because education about EMS enact patients' awareness of such negative experiences and may become burdensome for patients to benefit from ST. All these evidence suggest that if effortful imagination or homework in the ST could be replaced by effortless experience in the metaverse, PD patients could have their maladaptive schema modes reshaped unconsciously and regain healthy schema modes to function in the real world.

New possibility: Reshaping schema modes in the metaverse for treating PD

Theoretical basis: *Jean Piaget's theory of genetic epistemology*

Young et al. (2006) acknowledged that in psychology the term *schema* is probably most commonly associated with Piaget, who wrote in detail about schemata in different stages of childhood cognitive development. Indeed, Piaget's theory of *genetic epistemology* originates from his studies of epigenetics that emphasized the biological interactive construction process of both the innate mechanisms and the external environment (Figure 1A). Later he logically transferred the biological model

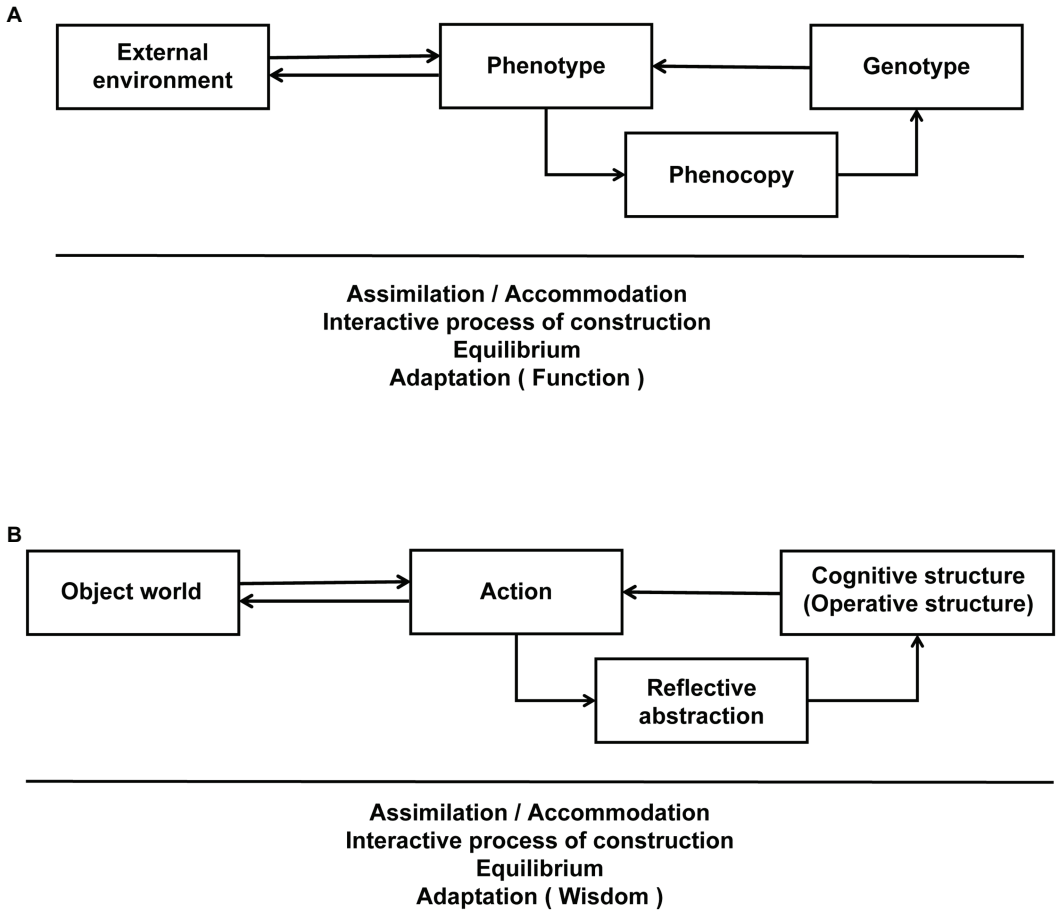

FIGURE 1
The process of interactive construction between the cognitive/operative structure and the object world (adapted and reproduced from Jiang and Li (2020) with permission). **(A)** The process of interactive construction of an organism with the external environment. The active interaction between the internal mechanisms of the organism and the external environment constructs the phenotype. There is a two-way interaction between the phenotype and the external environment as shown by the double arrows. Whereas the genotype determines the phenotype, the phenotype can feedback to the genotype through the process of phenocopy as shown by the single arrow. The effect of internal mechanisms on the external environment throughout the process is called assimilation. The active regulation of internal mechanisms is known as accommodation. Assimilation and accommodation balance the internal and external aspects of the organism to achieve an adaptive equilibrium, whose steady state is called adaptation or function. **(B)** The process of interactive construction of the cognitive/operative structure and the object world. The active interaction between the cognitive/operative structure and the object world constructs the subject's action (behavior). The interaction between the subject's action and the object world is shown by the double arrows. The cognitive/operative structure determines the subject's action but receives feedback from the outcome of the action in interaction with the object world *via* reflective abstraction, as shown by the single arrow. Similarly, the effect of internal mechanisms on the external environment is referred to as assimilation, while the active regulation of the internal mechanisms is referred to as accommodation. Assimilation and accommodation allow the subject to reach equilibrium with the environment. When the environment changes and the subject is no longer able to adapt to the environment conditions, a "de-equilibration" occurs, and the need for re-equilibrium becomes a motivation for the subject to make behavioral adjustments. The individual responds to the changes in the external world through actions, and the abstracted reflection on the outcome of the new action leads to a refreshed internal cognitive/operative structure and a higher level of rebalancing. At this point, cognitive abilities also develop to a higher level. The subject is able to adapt to the environment and gain wisdom. Note that the developmental norm of the cognitive/operative structure is called a schema.

to the field of epistemology in order to explain the constructive process of cognitive development (Figure 1B). According to this theory, the agent interacts with the object world through actions, and the reflective abstraction of the interaction, in turn, shapes the development of the cognitive/operative structure, which recursive process ultimately achieves an adaptive balance between the agent and the object world through assimilation and accommodation (Piaget, 1974/1980, 1976/1978, 1977a,b, 1979) or maladaptation in the case of PD. Therefore, one's own interaction with the object world is more likely to establish causality and enact changes directly in the schema (the developmental norm of cognitive/operative structures) than observational learning or linguistic transmission of others' experiences—this may be a key determinant for the long-term success of schema therapy. Critically, this theory has received both neurobiological (Vogel et al., 2018) and neurocomputational (Kumaran, 2013) support.

Creating a new object world in the metaverse for treating PD

Since the interaction between the agent and the object world is the source of schema formation and updating, a key problem in the therapeutic process may lie in that the therapist has very little control over the patient's object world, and therefore, the therapist cannot be sure that the patient's schema modes they strive to repair and reconstruct during the therapeutic process can still be valid or thrive in its healthy form outside the physical therapeutic workspace—in other words, the adaptive schema mode may lack the condition for reconsolidation and thus may be unable to reach the new equilibrium with the object world whereas the maladaptive ones may be reinstated by the very harmful stimuli that had triggered the original defensive response because that was an equilibrium. Therefore, the core of the problem is how to truly enable the patient to achieve automatic reshaping and renewal of schema modes *via* positive experiential feedback from their interaction with the object world so as to achieve the new equilibrium—once this new equilibrium is achieved and consolidated, then the patient can be empowered to adaptively function in the real world. Seeking changes in the object world as the source of those maladaptive schema modes is urgent, and the emergence of the metaverse technology may provide us with this opportunity.

One cardinal feature of the metaverse (and its premature version, virtual reality) is the sense of full presence, i.e., the sense of "being there" (Pl) without perceiving the technology that generates it, and "plausibility" (Psi), which includes the fidelity of the depicted situation with prior knowledge and expectations so that participants can not only carry out their intentions but also find themselves exhibiting automatic behaviors and responses as if the events in the metaverse were real (Rovira et al., 2009; Slater et al., 2022), thus is able to create a kind of "second-life" experiences for participants (Gorini et al., 2008; Parsons, 2012; Best and Butler, 2013, 2015) as well as achieving high ecological validity for neuropsychological assessment and treatment planning (Parsons, 2012, 2015a, 2017).

Indeed, the metaverse or its premature version, i.e., virtual reality, has been proposed to be used in treating attention deficits/hyperactivity disorder (Schweitzer and Rizzo, 2022), autism spectrum disorder (Lorenzo et al., 2016; Herrero and Lorenzo, 2020; Hutson, 2022), post-traumatic stress disorder (Rizzo and Shilling, 2017; Crary, 2020), anxiety and specific phobias (Parsons, 2015b; Freeman et al., 2017; Ong et al., 2022), borderline personality disorders (Good et al., 2013), various forms of psychosis (Veling et al., 2014), as well as rehabilitating offenders (Seinfeld et al., 2018; Ticknor, 2019), improving empathetic skills (Barnes et al., 2022), cultivating prosocial behavior (Rosenberg et al., 2013), and helping overcoming personal problems in life (Slater et al., 2019), etc. These pioneering work has paved the way for the future of DMHS (Ifdil et al., 2022), utilizing various forms of virtual environment in the following three ways: (1) Exposing the participants to clinically meaningful and physically safe stimuli in the virtual environment, being it fearful stimuli for exposure therapy, inclusive social support for disadvantaged groups, or neutral but helpful information and/or tools/exercises for guided learning, assessment, and practices. (2) Providing an opportunity for self-talk in different avatars or taking different perspectives by means of virtual embodiment for problem solving and/or conflict reconciliation. (3) Creating a scripted virtual story for participants to experience and providing guided feedback to their actions in the virtual environment—this approach can be regarded as the "short" form of what we aim to propose here—"short" in that it targets at reinforcing specific behaviors in specific situations (e.g., how to act appropriately in a social gathering), whereas our "long" form targets at creating a new object world with a certain *experience setting*, which can be defined as the "culture" or "norm" of the new object world in which participants experience and interact with multiple characters and a series of events that would bring out a variety of principle-guided healthy outcomes upon their actions/behavior, gradually reshaping their schema modes.

In other words, we aim at creating a new object world in the metaverse with a certain kind of *experience setting* that represents the world of healthy schema modes, which can bring a whole new set of experiences that are difficult for the PD patient to experience in the real world. In the real world, due to the solid balancing relationship of the old schema modes and the environment, it is difficult for the patient to perform the initial step of behavioral changes, and even if he/she tried, he/she would revert to the old action-outcome cycle due to the inappropriate feedback from the environment, which may even cause secondary harm to the patient. The new object world in the metaverse can provide a supportive and safe harbor for the patient to venture into different behaviors. The different behaviors will then receive appropriate feedbacks from the environment, which will gently bring positive and healing experiences to the patient. This process contributes to the automatic reshaping and reconsolidation of healthy schema modes (Figure 2A).

Importantly, the inclusive environment established in the metaverse shall be designed to be richer and more personal than the patient-therapist relationship established merely through conversations and words. By choosing different *experience settings*, patients going through the metaverse therapeutic process will then have a rich choice of schema modes for adapting to their living environment (Figure 2B). Their behavior in the real world will also be enriched by the set of healthy schema modes established in the metaverse that allow for transformative attempts without a great deal of willful effort. By breaking down solidified schema modes and establishing new ones, new behaviors will emerge more naturally and smoothly.

Detailed process of the metaverse schema therapy toolbox

Let us consider the clinical case of 36-year-old Linda[1] who had suffered from borderline personality disorders for long

1 This is the case described in Dadomo et al. (2016) as an example of applying the schema therapy to treat emotional dysregulations in borderline personality disorders.

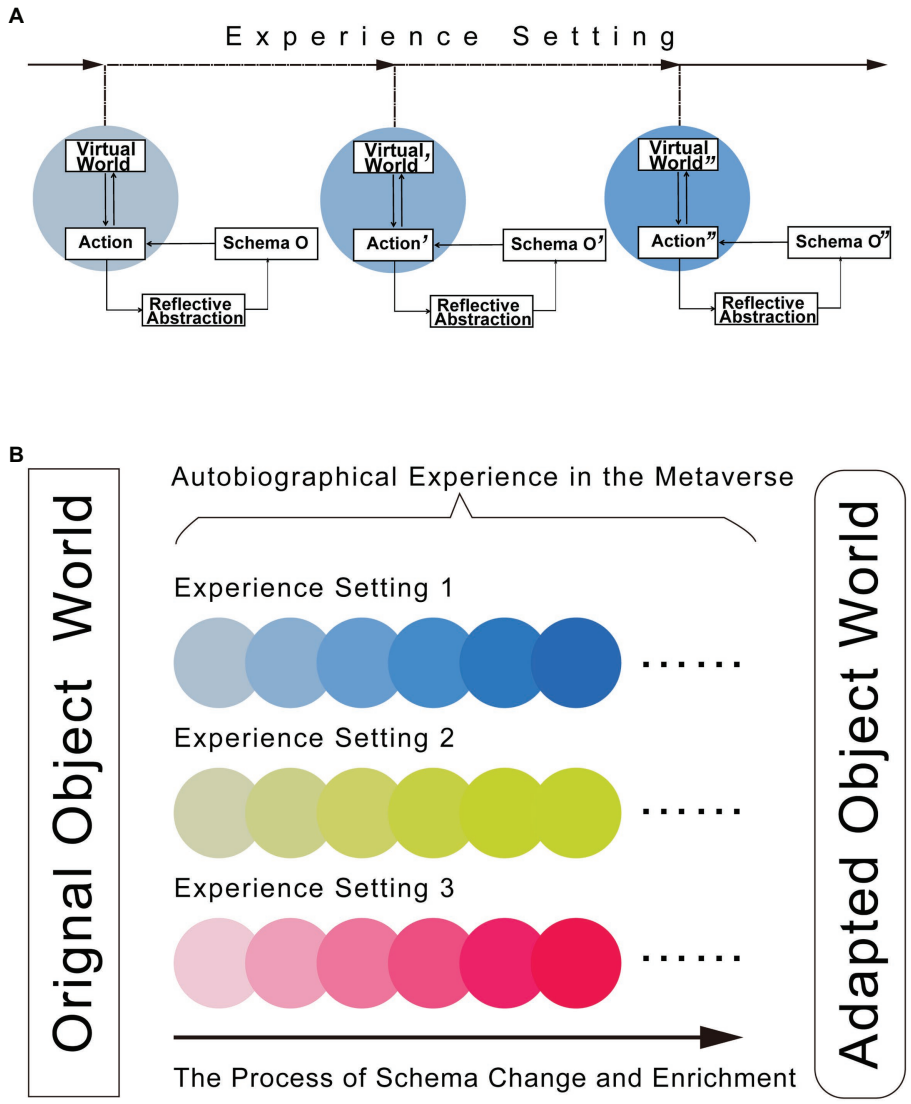

FIGURE 2
Mechanism and process of how the metaverse can be used as a tool for reshaping schema modes. **(A)** The mechanism of schema mode changes in the metaverse. After entering the metaverse, the client will encounter a virtual world with certain experience setting prescribed by the psychotherapist. The feedback of the interaction with the virtual world will be significantly different from the original world the subject is living in and where the original schema modes (O) are formed, and thus this difference in feedbacks will gradually bring about changes and enrichment in the schema modes toward a more adapted one (O') *via* reflective abstraction. The solid arrows at the top represent entering into the metaverse and returning to the real world. The dashed arrows represent entering into the multiple stages of the virtual world with certain experience setting, which is designed to foster gradual schema mode and behavioral changes through recursive interaction and reflective abstraction. The interaction between the action of the subject and the virtual world is represented by a double arrow. The background circles with different color gradients represent the convergent changes of the virtual world as defined by the experience setting and the subject's behavior. **(B)** Flow chart of the metaverse as a tool for reshaping schema modes and its impact on the client living in the real world. The box on the left side of the diagram represents the original object world, in which the client's behavior pattern may be fixed and the perception of the object world is based on predetermined schema modes. Each colored circle represents the occurrence of schema mode change brought about by the interaction between the virtual world and the client's behavior, and a series of gradual changes in the colored circles represent the gradual change and enrichment of schema modes. Through different experience settings prescribed by the psychotherapist, the subject entering the metaverse can obtain a series of autobiographical experiences that will result in a more adaptive schema mode to behave in the real object world, and the enriched schema modes can also facilitate the activation of more adapted behaviors. The various interactions between the subject and the object world will also help people shape a more inclusive and accepting environment for the client and people alike. The box on the right side of the diagram represents the adapted object world the subject is able to live in with a high degree of mental health. The arrow from left to right at the bottom represents the process of schema mode change in the subject experience the metaverse.

possibly due to her early experiences with her unattentative parents who had basically ignored her every need for care and love, and unfortunately, her attachment needs had not been satisfied throughout her life. Therefore, she was suffering from "strong mood swings, fits of anger, agitation, central insomnia characterized by waking up frequently and

anhedonia," which symptoms had turned worse after the leaving of her boyfriend who had stayed with her for 19 years. The traditional schema therapy would go through a "schema mode validation and education—limited reparenting with chair work and imagery rescripting—the Healthy Adult mode consolidation and integration" process, realized in close relationship with the therapist.

The metaverse schema therapy toolbox, in turn, would start from evaluating Linda's relationship with the object world, then, instead of building a relationship with the therapist, the focus would be on building a relationship with the object world in the metaverse. Firstly, Linda will meet with a lovable virtual assistant who will guide her through the process. Then she will be asked to construct an important figure (e.g., her significant other) as her source of mental power; if it is not possible to construct, Linda could select a non-player character that best match her needs for safety and care. This figure will act as the model for the Healthy Adult mode and will finally be incorporated into Linda's inner self. Then Linda will be invited to describe the problematic situation that is troubling her, in as much detail as possible, and construct the scenario described by Linda through natural language processing and biological feedback. Through validation of the constructed scenarios that Linda can see and experience in the metaverse, the early maladaptive schemas of Linda will be diagnosed and her schema modes will be categorized. The remote therapist at the background of the program will then prescribe several *experience settings* that aim at working with specific schema modes of Linda. For example, if the aim is to remove Linda's Punitive Parent mode and care for the Abandoned and Abused Child mode, then Linda will be guided to enter a new world in the metaverse in which Linda will be embodied into her childhood avatar and interact with her virtual parents, though no longer punitive at all and instead will be attentive to her emotional needs; if the aim is to exchange the Detached Protector mode for the Healthy Adult mode, then Linda will be guided to enter another new world in the metaverse in which the problematic scene in her assessment stage will recur but with a totally different culture of feedbacks on her actions—she will be prompted to freely express her emotions and be welcomed with constructive feedbacks and love and care. Importantly, through different sets of experiences in the metaverse, Linda's unmet emotional needs will be satisfied (as if it were all real) and her Healthy Adult mode will grow stronger and stronger, sometimes with the help from the abovementioned important figure to whom her secure attachment has been directed to if she feels her mental power is not strong enough to support her to enact behavior changes and emotional regulations. Ultimately, Linda will end her journey with successfully reshaped and enriched schema modes that will support her to better adapt to the real object world she is living in and even enact changes to her environment that becomes more inclusive to people like her.

Ethical considerations

The aforementioned schema therapy process in the metaverse seems ideal, though there are several important ethical issues to be considered before application. Firstly, the respect of dignity and autonomy of the patient shall be protected in the metaverse. Secondly, the type of data collected from the patient needs to be communicated in advance (consent from the patient shall be acquired) and all collected data shall be firmly secured from leaking. Thirdly, the principle of "maximization of benefit and minimization of harm" shall be taken into full consideration when constructing scenarios and storylines, prescribing *experience settings*, and enacting interactions with the patient. Lessons shall also be learned from pioneers in the field. For example, Slater et al. (2020), Parsons (2021), and Chekroud et al., (2021) had all provided ethical guidance for virtual environment technologies.

Reverse engineering: From the future to now

Now, where do we start from? There are two important missions from the reverse engineering perspective: the content and the technology.

For the content part, the critical mission is to accumulate an abundance of scenarios, storylines, figures, and contingencies for the accurate construction of therapeutic object world in the metaverse. Qualitative methods such as life-history interview and clinical case review could be used to find the key events and critical figures that can shape the behavioral patterns and change the schema modes in the life experiences of a representative sample of PD patients. Experimental work including animal behavioral modeling can be used to establish comparative models with key contextual factors influencing schema development. Formative materials can be developed, starting with interactive texts, moving to interactive videos and audios, then to the extended reality stage, and finally to the metaverse stage. Progressive monitoring is necessary to ensure the effectiveness of content updates and efficacy of interventions.

For the technology part, the *Minimal Viable Product* design method can be adopted: for proof of concept, one can simply start with the abovementioned interactive text toolbox, validate the design concept and treatment effects, and then upgrade the toolbox with feedbacks from the therapist, the patient, and the technological progress. Interfering issues such as cybersickness and burdened cognitive loads by the imperfect technology can be avoided by adopting this product design principle.

The overall efforts shall start from the preclinical phases to Phase I, II, and III just like other kinds of therapeutic tool development, with open minds to incorporate the discovery of new schema modes, new efficacious pathways, and theory advancement during the research and validation process.

To sum up, in addition to socio-economic considerations, PD patients usually interact with the object world in a way that both they and their counterparts feel uncomfortable, which can severely deter their minds to seek help from trusted mental health practitioners or have difficulty practicing what they have just learned from the therapist. The metaverse schema therapy toolbox could potentially help achieve adjustment and improvement at an early stage of PD symptoms, expand the beneficiaries of digital mental health services, reduce the stigma and the discomfort of some patients facing specific therapists, make it easier for people in need to move forward seeking help, and reduce the socio-economic costs of mental health services. It could also serve as a therapeutic tool for PD patients resistant to conventional therapies.

Just as Cieślik et al. (2020) quoted, "whatever limits the real world imposes on us, the virtual world is its ideal, unlimited reflection and creates a space where the impossible becomes possible, where modern technological solutions generate a new reality."

Data availability statement

The original contributions presented in the study are included in the article/supplementary material, further inquiries can be directed to the corresponding authors.

Author contributions

BY and KJ conceived of the presented idea and critically revised the manuscript. BY, Y-XW, and C-YF wrote the first draft of the manuscript. All authors contributed to the article and approved the submitted version.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Publisher's note

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Government crisis communication innovation and its psychological intervention coupling: Based on an analysis of China's provincial COVID-19 outbreak updates

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Outbreak updates are an integral part of crisis communication during epidemics. Regarding the COVID-19 crisis communication, localities in China present different strategies for managing outbreak updates, which largely determine the effect of crisis communication and the evolution of social psychology. Depending on the analysis of the update texts from 31 provincial (autonomous regions and municipalities directly under the central government) health committees in China, the study found the differences among the provincial outbreak updates and summarizes 12 innovative crisis communication ways. A coupling analysis was applied using the equilibrium-cognitive-psychosocial transition model to further expound on the psychological connotation and intervention potential of the crisis communication innovations. Coupling crisis communication with interventions has a positive effect on designing crisis communication strategies by taking into account psychological factors. It can help construct and optimize the public crisis communication systems and emphasize "care" in modernizing the emergency management capacity.

KEYWORDS

outbreak updates, crisis communication, psychological intervention, COVID-19, crisis intervention

1. Introduction

Outbreak updates are an integral part of crisis communication during epidemics and pandemics. Communicating the epidemic quickly, accurately, and effectively is key to combating the epidemic. In an interview, Yang Gonghuan, former deputy director of the Chinese Center for Disease Control and Prevention (CDC), argued that the core and most profound lesson learned from the severe acute respiratory syndromes (SARS) epidemic was to communicate the epidemic factually and mobilize the whole society toward mass prevention and treatment to overcome the difficulties (Zhao, 2020). *The Prevention and Control of Infectious Diseases Law of the People's Republic of China (Revised)*, which came into force in 2004 after SARS, clearly stipulates that the state establish a system for public information about infectious diseases. It requires the health administrative departments of the provincial governments to publish information about infectious diseases in their administrative regions regularly to the public when there is an infectious disease outbreak (The National People's Congress of the People's Republic of China, 2004).

After the COVID-19 outbreak, localities showed different levels of outbreak update management, which largely determined the effectiveness of crisis communication. The effectiveness of crisis communication also affected the public's trust in the government and the formation of social panic. What are the differences in the ways the 31 Chinese provinces (autonomous regions and municipalities directly under the central government) communicated about COVID-19? What are the psychological implications of these innovative ways? To answer these two research questions, this study takes the outbreak update texts as an entry point to compare and identify, select innovative communication ways with preservation and institutionalization values from them, and draw lessons based on the coupling of psychological interventions that have the potential to benefit all citizens.

The rest of the article is organized as follows. The second part describes the research background, which retraces the relevant studies on crisis communication as a means of crisis psychological intervention during COVID-19; the third part describes the research design, extracts a number of features in terms of both content and form, presents codes based on the practical characteristics of the outbreak updates from each province, and determines whether these innovations have the potential for intervention at the country-level scale. Five binary coupling questions are raised within the corresponding five elements of the three basic models of crisis psychological intervention. The three basic crisis intervention models are the equilibrium model, the cognitive model, and the psychological transition model, which describe how the intervention mechanism affects individuals when they are psychologically imbalanced, are recognizable, and do influential errors, respectively; in the fourth part, we analyze the coding results and summarize 12 innovative ways for communicating epidemic situations; the fifth part is the coupling analysis by matching innovative ways, according to their possible potential for large scale intervention. The Delphi method is used to carry out the study on the coupling. The experts were given a 5 × 12 table (five coupling questions and 12 innovative ways) and asked to tick the cells where the coupling was considered. Finally, the discussion and conclusion summarize the whole study and, from the perspectives of communication and psychology, propose crisis communication strategies that better balance information communication and psychosocial intervention. The present research expands the theoretical work of crisis communication for intervention, leads to further practice progress in leveraging daily-updated communication for nationwide and even worldwide intervention, provides important variables and paves the way for future empirical effect research, and promotes emphasizing "care" in the modernization of emergency management system.

2. Research background

From crisis communication to crisis intervention, the essence is to intervene in the public's mental health by using innovative ways of crisis communication so as to achieve the purpose of crisis management.

The current research frameworks of COVID-19 crisis communication are mainly based on the perspective of management. Malecki et al. (2021) used the hazard and outrage framework to analyze the risks of the current pandemic and provide crisis communication strategies for professionals. Zhang and Ran (2020) viewed crisis risk communication of COVID-19 from the perspective of "social amplification of risk." From the field theory perspective, Hou and Du (2020) took the entry, transition, and exit performance of the Guangdong Provincial Information Office in the epidemic prevention and control press conference as an example to analyze the innovative government news release mechanism for major public health events.

As for crisis intervention, Lindemann (1944) first proposed a basic crisis intervention theory that emphasizes that a person should not be overly immersed in pain such as the loss of a loved one, and he believes that grief is normal and temporary and can be treated by short-term crisis intervention; Psychologist Caplan (1964) built on his predecessors and extended the application of crisis intervention to all developmental and situational events. Current COVID-19 crisis interventions focus on specific groups. Some investigated the impact of an online intervention program on anxiety and depression levels, as well as physical symptoms, in frontline nurses fighting the COVID-19 pandemic to provide an empirical basis for crisis psychological interventions for frontline medical staff (He et al., 2022). Some found that parents, especially mothers, experienced more psychological stress during the outbreak, which may have had an impact on their children's mental health, while adolescents with higher levels of self-compassion were less psychologically affected by their mothers' anxiety (Zhou et al., 2022).

Researchers are recently paying more attention to using crisis communication for crisis intervention in the COVID-19 setting: Ribeiro et al. (2021) summarized the Portuguese's telephone-based psychological crisis intervention, which can effectively provide brief, appropriate, and timely psychological help. Lu et al. (2022) explored the changes in public sentiment in China at different stages of the COVID-19 outbreak, established an online work platform, and constructed a new model of online intervention of public emotions during the epidemic, which can effectively regulate the negative emotions of the public and provide a reference for the government's emergency management system. Qin et al. (2020) introduced the institutional settings, the management systems, treatment methods, information communication systems, and other interventions in the United States, Israel, and other developed countries to deal with psychological crises of public health emergencies. Havsteen-Franklin et al. (2020) conducted a systematic review to establish the effectiveness of art-based interventions.

However, previous research in this field has failed to (1) systematically explore the psychological connotation of COVID-19 crisis communication; (2) look at the problem at the citizen scale; they currently focus on specific subgroups, such as frontline nurses, parents, and pediatric health workers; and (3) conduct research in a Chinese context. Most of the established studies on crisis communication in China used data from Weibo and WeChat and did not use data from the official health commission website to examine authoritative crisis communication.

3. Research design

3.1. China's central–provincial relations in crisis communication

China's administrative system is characterized by complex central–provincial relations. In the health sphere, the National

Health Commission of the People's Republic of China represents the center and is in-charge of organizing the formulation of national health policies for the development of health care and overseeing their implementation. The health commission of a province (the present research studied the 31 provincial health committees in China) implements the center's guidelines, policies, and regulations with some flexible room according to the local's specific situation. Therefore, some significant local differences are reflected in COVID-19 prevention and control.

Regarding COVID-19 crisis communication, the study organizes the guidance from the central and localities' innovative methods as follows (see **Figure 1**).

3.2. Research process

The research process of the study (e.g., from initial searching to collecting, comparing and extracting, initial coding, training, reliability testing, and encoding and coupling) is demonstrated in **Figure 2**.

3.3. Identification of crisis communication innovation

The websites of health commissions at all levels in China are the primary platform for the government to communicate epidemic information. It is also the primary way for the public to obtain official information. In this study, provincial health commissions' outbreak updates were used as the research object. By combing the situation of provincial outbreak updates, we found that the provinces adopted the template of the National Health Commission's outbreak updates. The template related to the basic data information of the epidemic was described, mainly the number of new confirmed cases, cumulative confirmed cases, suspected cases, new asymptomatic infections, and the number of close contacts traced, etc. This updated template was also used as the baseline condition for this study.

> *Template: From 0 to 24 o'clock on a specific date in 2020, the present province reported a certain number of new confirmed cases of Covid-19 and a certain number of cases from abroad. Among them, how many cases in what city, how many cases in what city. . . . . As of midnight on a certain date, how many confirmed cases of Covid-19 have been reported in the province, how many cases have been cured and discharged, and how many have died of the disease. How many cases are still under hospital treatment, of which: how many cases are severe, how many cases are critical, how many cases are common types. . . . . how many existing suspected cases,. . . . . how many new cases of asymptomatic infection in the province,. . . . . how many close contacts have been traced so far and how many have been discharged.. . . . . .*

Building on the template baseline, we extracted 17 items (practice characteristics) of each province's outbreak updates. The study codes these 17 items based on two dimensions, the content and form of updates, which form the basis of the analysis for this study (see **Table 1**).

3.4. Crisis intervention models and coupling design

James and Gilliland (2016) suggested three theoretical models of crisis intervention: the equilibrium model, the cognitive model, and the psychosocial transition model. The equilibrium model assumes that individuals in crisis are usually in a state of psychoemotional imbalance, and their existing coping mechanisms cannot solve their

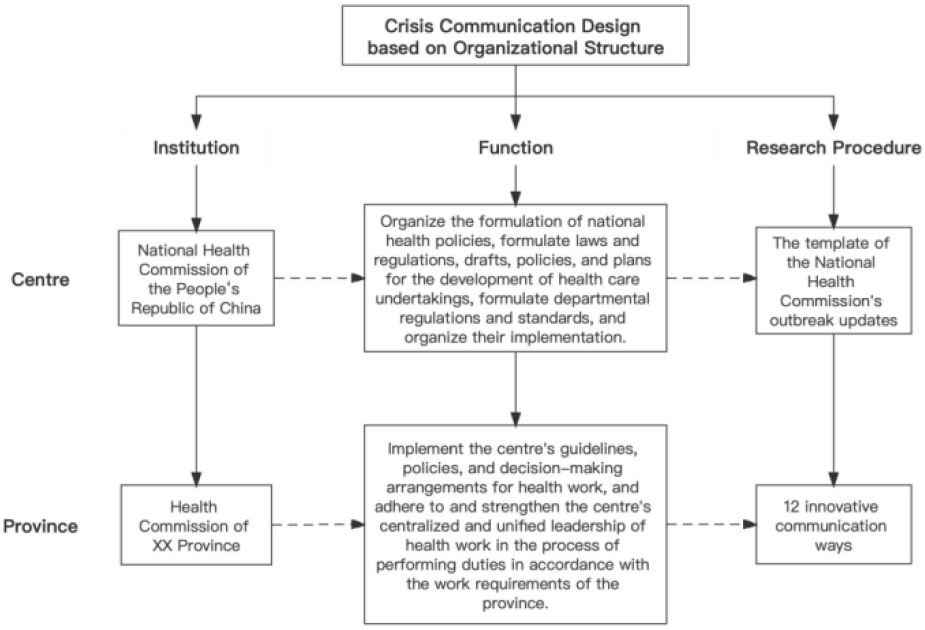

FIGURE 1
China's central–provincial relations in crisis communication.

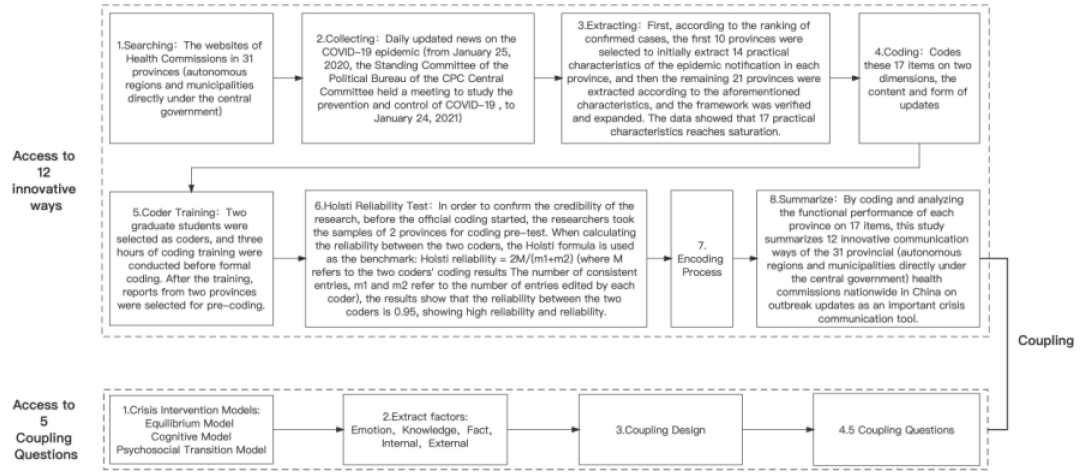

FIGURE 2
Research process.

problems. In the equilibrium model, crisis intervention works by stabilizing individuals to restore them to their precrisis state of equilibrium. The cognitive model suggests that the psychological damage caused by a crisis is mainly attributed to the individual's misjudgment of the crisis event and the situation surrounding the event, correcting the irrational and self-defeating components of the individual's cognition and providing professional knowledge and objective information so that the individual can regain control over the life crisis. The psychosocial transition model considers that the factors affecting the individual's state of crisis can be divided into internal and external components: internal qualities such as the psychological resources and coping abilities that the individual possesses and the external environment consisting of peers, family, occupation, religion, and community. The purpose of crisis intervention is to combine appropriate coping styles within individuals with social support and environmental resources so that the victim has more problem-solving options.

The present study applies the three crisis intervention models and proposes corresponding coupling questions for communication as intervention analysis (see Table 2). The Delphi method is used to carry out the study on the coupling. Each of the 15 experts in communication and psychology studies at the University of Science and Technology of China was given a 5 × 12 table (five coupling questions and 12 innovative ways) and asked to tick the cells where the coupling was considered. The coupling is established when more than eight experts check the cell on a particular item.

TABLE 1 Coding items.

	Code item (yes = 1; no = 0)
Content of the updates	Is there a description of the case's attendance at the hospital?
	Is there a description of the case's life trajectory?
	Are there demographics on the overall cases?
	Is there a description of the circumstances of the fatal cases?
	Is there a reported cure rate?
	Are there reports of re-positive cases?
	Are there any friendly tips/expert advice?
	Is there information on regional risk levels?
	Are there updates on case discharge information?
	Is the receipt/use of the donation published?
Form of the updates	Are multiple briefings conducted daily?
	Is multilingualism used for communication?
	Are charts used for the briefing?
	Is synthesized speech used for communicating?
	Are outbreak map visualization used for updates?
	Are trend charts used to inform outbreak development?
	Are press conferences held for outbreak information releases?

4. Innovative ways

Overall, the study found that all provinces used the updated template for the baseline condition in their updates. In the following, we report the coding results in content and form, respectively.

4.1 Content of the updates

First, approximately 23% of provinces (n = 7) notified the attendance of cases. For example, the Shaanxi Provincial Health Commission notified the attendance of confirmed cases on the same day of its daily outbreak updates, as shown in the following example (4 February 2020).

> *"Patient 1, male, 65 years old, currently residing in Danfeng County, Shangluo City. He arrived in Danfeng County on January 21 from Utopia County, Hubei Province. Developed symptoms on the 26th and visited Xiaohe Health Office in Taoyuan Village, Shang Town, and Danfeng County on the same day. Symptoms worsened on February 2, and Danfeng County Hospital visited the same day. Diagnosed with Covid-19 on February 4. He is currently in quarantine at Shangluo City Central Hospital and is in stable condition."*

TABLE 2 Models, factors, and coupling questions.

Models	Factors	Coupling questions
Equilibrium Model	Emotion	Can this crisis communication way directly work on alleviating negative public stress?
Cognitive model	Knowledge	Can this crisis communication way enhance public knowledge that helps the prevention and control of the pandemic?
	Fact	Can this crisis communication way help the public correctly perceive the objective *status quo*?
Psychosocial transition model	Internal	Can this crisis communication way provide psychological resources and enhance the coping ability of the public, especially for vulnerable groups?
	External	Can this crisis communication way help the public to obtain information related to social support and environmental resources?

Second, approximately 10% of the provinces (n = 3) notified the life trajectory of the cases. For example, the Shaanxi Provincial Health Commission has notified the life trajectory of the confirmed cases from the previous day since 7 February 2020, as shown in the following example (15 February 2020).

> *"Case 1: Female, 63 years old, currently residing in Gumeng East District, Beijie Street Office, Jincheng City.*
>
> *On January 20, 2020, from 8:00 to 9:00, She was shopping near the Golden Shield Market on North Street, and from 9:00 to 12:00, She was at the Temple River Jiayuan on North Zechu Road. At 17:00, She was walking in the small area where he lived, and at 17:30, She accompanied his family to the second floor of the Urban Chinese Hospital for medical treatment. At about 18:00, She was driven by her family to the emergency department of Jincheng City People's Hospital, where she accompanied her family for medical treatment.*
>
> *On January 21, 2020, her family drove her home from Jincheng City People's Hospital at about 01:00. She took bus No. 2 to accompany her family again to Jincheng City People's Hospital between 09:00 and 12:00. She was then sent home by his family.*
>
> *On January 23, 2020, at about 14:00, she walked to the second floor of Zhejiang Trade City and returned home about an hour later.*
>
> *January 24 - February 13, 2020, Occasional walks in her living area.*
>
> *On February 6, 2020, she felt unwell, felt weak, anorexic, feverish, and took medication at home on his own.*
>
> *On February 14, 2020, she attended the outpatient clinic of the Urban Chinese Hospital at around 09:00 and took a temperature of 37.2 degrees. She attended the fever clinic of the Ancient Shuyuan Mining Hospital at 14:30 and was taken by her family to the Jincheng University Hospital for consultation and hospitalization at around 17:00.*
>
> *The diagnosis was confirmed on February 15, 2020."*

Third, approximately 16% of the provinces (n = 5) reported on the demographics of overall cases. For example, the Guangdong Provincial Health Commission reported the daily statistics on the gender and age of cumulative confirmed cases, as shown in the following example (27 February 2020).

> *"662 males and 685 females between 2 months and 90 years."*

Fourth, approximately 13% of provinces (n = 4) reported fatal cases. For example, the Chongqing Municipal Health Commission informed about the fatal cases in a routine press briefing as shown in the following example (3 February 2020).

> *"Patient Lai, male, 51 years old, from Wanzhou district, was diagnosed with Covid-19 on January 24. Examination test results showed that the patient had several underlying diseases: type 2 diabetes mellitus, old tuberculosis, hepatitis B, fatty liver, poor cardiac, pulmonary, and hepatic function, high specific indexes of myocardial infarction, interstitial changes in both lungs with extensive exudation, and insufficient oxygenation capacity. After admission, though via several municipal and district-level expert consultations, clinical symptomatic active treatment, the shortness of breath, dyspnea, and other symptoms gradually aggravated. At 12:30 on February 2, 2020, the patient's heart rate suddenly dropped, and oxygen saturation dropped sharply to 38%, to the municipal and Wanzhou area expert group all-out rescue. However, the patient's heart rate never recovered. At 13:44, the case passed away."*

Fifth, a few provinces (Beijing, Anhui) informed about the cure rate. For example, Beijing had reported the cure rate since 16 March 2020 as shown in the following example (20 March 2020):

> *"As of 24:00 on March 19, a cumulative total of 415 confirmed local cases were reported, with 378 cases cured and discharged, a cure and discharge rate of 91.1%."*

Sixth, only two provinces (Tianjin and Hainan) notified the local repositive cases. For example, the updates from the Tianjin Municipal Health Commission read as follows (29 February 2020).

> *"The 29th and 43rd confirmed cases in Tianjin have been transferred to the Haihe Hospital for observation and treatment after being discharged from the hospital and retested positive for nucleic acid during their continued intensive quarantine and observation. The 29th case has been under medical observation at the centralized isolation and observation site in Heping District since its discharge on February 13; the 43rd confirmed case, after its discharge on February 11, has been under medical observation at the centralized isolation and observation site in Baodi District.*

> *On February 27, the two retested positive for nucleic acid and were again transferred to Haihe Hospital."*

Seventh, approximately 26% of the provinces (n = 8) provided warm tips or expert advice on outbreak updates. For example, the Anhui Provincial Health Commission added information such as "warm tips" or "brief analysis of the outbreak" at the end of the daily outbreak information, as shown in the following example (25/26 February 2020).

> *"Warm Tip: CDC experts reminded that the general public should still insist on wearing masks, washing hands regularly, and not gathering."*

> *"Brief analysis of the epidemic: the current momentum of the spread of the epidemic in our province has been initially contained, and the positive and positive trend continues to expand. As of 24:00 on February 24, the province's total number of confirmed cases is 989, with zero new confirmed cases reported for three consecutive days; 692 cases were cured and discharged, 35 cases are expected to be discharged today, and the cure rate will reach 73.5%; the number of critically ill patients dropped from a peak of 16 cases to 0 cases. The province continues to show the stage of "four no's": no new confirmed cases, no new suspected cases, no critically ill patients, and no new deaths."*

Eighth, approximately 16% of the provinces (n = 5) regularly published a categorized list of epidemic risk levels or a zonal grading scale on a district basis. The risk levels of counties and districts are assessed and dynamically adjusted as high, medium, or low risk according to the changes in the epidemic situation. For example, the list of epidemic risk levels published by the Jiangsu Provincial Health Commission reads the following example (29 February 2020).

> *"As of 24:00 on February 27, 2020, counties (cities and districts) (i) Low-risk areas (n = 59) Nanjing: Lihe District, Lishui District, Gaochun District; Wuxi: Xishan District, Yixing City. (ii) Medium-risk areas (n = 8) Wuxi: Huishan District, Jiangyin City; Xuzhou. Suining County. (iii) High-risk areas (n = 1) Huai'an City: Huai'an District."*

Ninth, two provinces (Shanghai and Chongqing) broadcasted cases of healing and discharges separately, informing the number and the cumulative number of discharges on the same day. For example, the Chongqing Health Commission communicates hospital discharges with "Good News!" as in the following example (15 March 2020).

> *"Good news! A confirmed case in Chongqing Changshou District was cured and discharged from the hospital. The designated hospital and medical staff meticulously treated and cared for the patient. The expert group assessed that the patient met the latest National Health Commission's discharge criteria for confirmed cases of Covid-19, and he was discharged on March 15. A total of 570 patients suffered Covid-19 have been cured and discharged from the city."*

Tenth, two provinces (Shandong and Yunnan) made public announcements on the receipt of donations, public announcements

设区的市	新增确诊病例		累计确诊病例		重症病例	危重病例	出院人数	死亡人数	疑似病例	
	数量	县区分布	数量	县区分布					新增	现有
太原市	0	——	20	万柏林区8、迎泽区6、杏花岭区4、小店区1、清徐县1	0	0	20	0	0	0
大同市	0	——	12	平城区10、云冈区2	0	0	12	0	0	0
阳泉市	0	——	4	城区2、盂县2	0	0	4	0	0	0
长治市	0	——	8	潞州区7、长子县1	0	0	8	0	0	0
晋城市	0	——	10	城区5、沁水县2、阳城县1、陵川县1、泽州县1	0	0	10	0	0	0
朔州市	0	——	8	朔城区4、应县3、怀仁市1	0	0	8	0	0	0
晋中市	0	——	37	平遥县36、寿阳县1	0	0	37	0	0	0
忻州市	0	——	7	五台县6、忻府区1	0	0	7	0	0	0
运城市	0	——	19	新绛县5、盐湖区3、平陆县4、河津市2、芮城县1、万荣县1、夏县1、绛县1、稷山县1	0	0	19	0	0	0
临汾市	0	——	2	乡宁县1、古县1	0	0	2	0	0	0
吕梁市	0	——	6	孝义市3、离石区2、文水县1	0	0	6	0	0	0
合计	0	——	133	——	0	0	133	0	0	0
境外输入	0	——	1	英国输入1例	0	0	0	0	0	2

备注：境外输入性病例单独统计。

FIGURE 3
Example of an outbreak trend map.

on the distribution of medical protection materials by the Material Security Group, and announcements on the allocation of charitable donations, and the use of donations. For example, the announcement of Shandong Province on the donation to Huanggang City, Hubei Province, reads the following example (25 March 2020).

> *"It was decided to allocate 231,658,700 yuan from the epidemic prevention and control fundraising pooling account for the purchase of key medical equipment for epidemic prevention and control, the construction and operation and maintenance of important medical facilities, and other expenditures related to epidemic prevention and control in Huanggang City, Hubei Province, and the above funds have been allocated. Another RMB 1,177,300,000 was allocated for the procurement of 66 sets of teleconferencing and diagnosis and treatment system equipment by the Shandong Provincial Health Commission to support Huanggang City in Hubei Province and the designated hospitals in the five counties and cities, all of which have been delivered on February 22, 2020."*

4.2. Form of the updates

First, approximately 26% of the provinces (n = 8) notified about the outbreak multiple times a day (two or more times). For example, Shanghai notified two times a day from 19 February to 17 March 2020. Municipalities reported two times a day. As the pressure to combat the epidemic eased, the update frequency returned to one time a day in all provinces.

Second, approximately 16% of the provinces (n = 5) communicated the epidemic in multiple languages. For example, Hunan Province communicated information about the outbreak in seven languages, Chinese, English, French, German, Japanese, Korean, Lao, and Russian. The Foreign Affairs Office of the provincial government is responsible for translating the epidemic situation into other languages and publishing it on the official website of the Provincial Health Commission.

Third, approximately 29% of the provinces (n = 9) used charts to communicate information about the epidemic. For example, the Shanxi Province communicated information about the epidemic through charts since 13 February and up to 13 May 2020, as shown in **Figure 3**.

Fourth, 39% of the provinces (n = 12) communicated by marking the cases in each district on a local map. For example, the map of the epidemic in Guangdong is shown in **Figure 4** (with 20 February 2020, as an example).

Fifth, approximately 32% of the provinces (n = 10) have presented the local epidemic development through trend charts. For example, the trend graph of the epidemic in Sichuan (as of 20 February 2020) is shown in **Figure 5**.

Sixth, approximately 10% of the provinces (n = 3) explained and supplemented the situation of the outbreak information by holding press conferences. For example, the Chongqing Health Commission held 72 press conferences as of 12 May 2020.

Seventhly, only one province (Shanghai) converted the text of the outbreak updates into speech through speech synthesis technology, and the public can listen to the outbreak broadcast by clicking on the player attached to the reader.

4.3. Selected innovative ways

From the above analysis, it is clear that, in the face of the sudden outbreak of COVID-19, the official agencies represented by the Provincial Health Commissions exhibited different levels of performance in crisis communication. In particular, compared to the communication baseline of the National Health Commissions, each Provincial Health Commission has different degrees of innovation. By coding and analyzing the functional performance of each province based on 17 items, this study summarizes 12 innovative communication ways of the 31 provincial (autonomous regions and municipalities directly under the central government) health commissions in China on outbreak updates as an important crisis communication tool (**Table 3**).

5. Coupling analysis

The COVID-19 epidemic is a great disruption to the "psychological order" of the public. Crisis communication for massive psychological intervention is important to restore psychosocial order. Based on the 12 innovative communication ways listed in **Table 3**, the psychological connotation of the innovative ways was analyzed based on three basic crisis intervention models and the coupling questions were raised to realize the coupling of the ways and psychological intervention (**Table 4**). The present study's coupling analysis was also based on the principle of "coupling first, effect second." This is due to the three factors listed in **Table 4**. First, previous research studies lack a coupling framework, and coupling mechanisms must be discovered first to lay the groundwork for empirical research of their effectiveness and ways for improvement. Second, this study emphasizes the possibility and potential of large-scale psychological interventions. The universality of the intervention object will come at the expense of effectiveness on specific targets, but this trade-off does not diminish the significance of the large-scale effect. Third, this study intended to offer a fresh perspective on the modernization of emergency management that "care" shall be a sign of progress in crisis communication.

In terms of the equilibrium model, individuals facing COVID-19 and lockdown measures are easily caught in a state of psychological imbalance. The uncertainty and unknowns make it difficult for them to meet their current needs through their original coping mechanisms and methods. The positive content of "good news from the hospital" alleviates individuals' fears and helps balance public anxiety.

In terms of the cognitive model, the quality of information on the Internet is mixed, confusing the public, and misleading individuals' judgment of events. The knowledge output of professionals, the pluralistic presentation of scientific data, and the timely update of factual information are all conducive to helping individuals recognize the irrational components of cognition, regain the rational components of thinking, and grasp knowledge and facts in a comprehensive manner.

In terms of the psychosocial transition model, internally, synthetic voice broadcasting helps the blind community to improve their ability to cope with crises. Externally, people in society cannot exist as independent individuals without the influence of the external environment. The public can recover in a caring social environment by grasping information about resource support

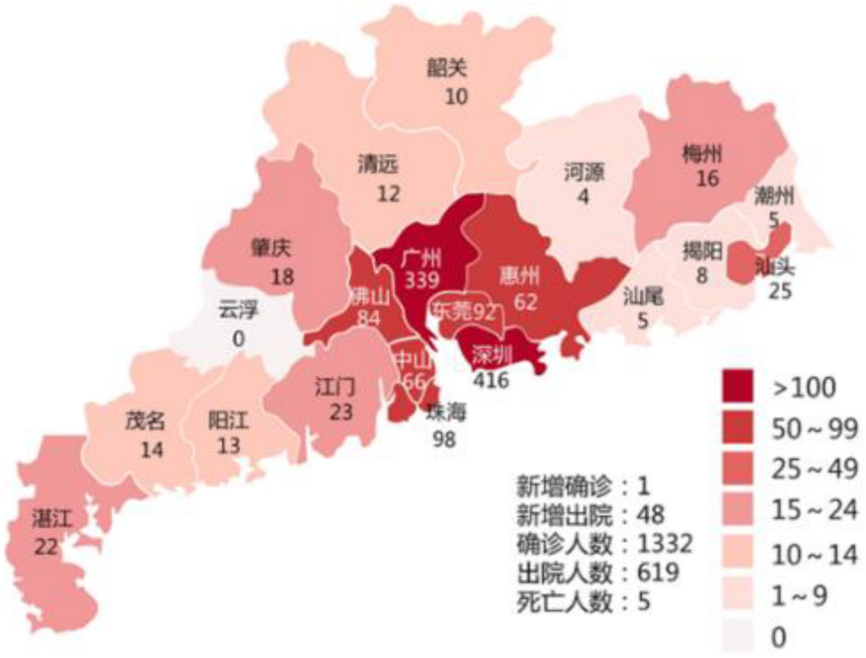

FIGURE 4
Example of an outbreak chart.

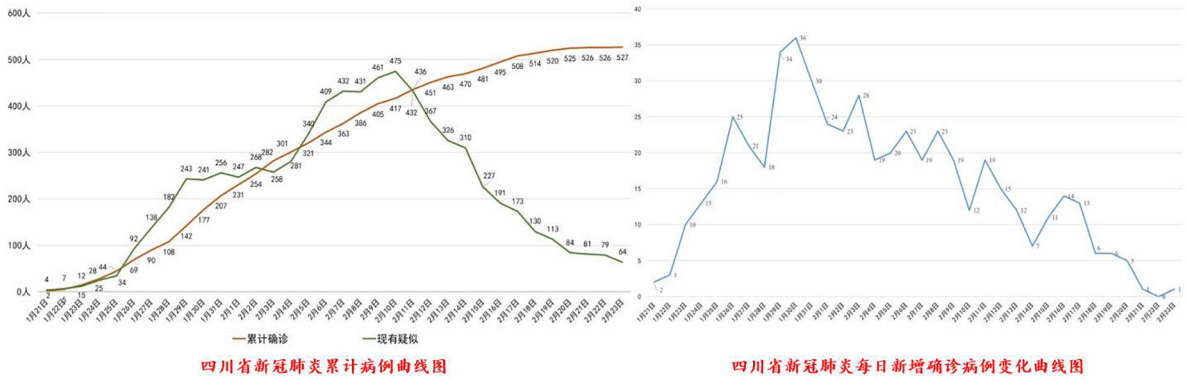

FIGURE 5
Example of an outbreak map.

such as donations or material situations. Multilingual briefing facilitates international collaboration and the integration of global social resources.

6. Discussion and conclusion

By identifying the innovative ways of outbreak updates as an important crisis communication tool from 31 provinces (autonomous regions and municipalities directly under the central government) in China and coupling them with crisis psychological intervention models, this study attempted to select innovative ways that have preservation and institutionalization value and propose a better strategy for post-COVID crisis communication and intervention.

(a) Paying attention to the multiple roles of crisis communication at the government, society, and individual levels and making reasonable institutional coupling arrangements. The success of crisis management depends largely on the smoothness of crisis communication. Furthermore, the key to the success or failure of crisis communication lies in whether a sound and complete crisis communication system is established. Crisis communication occupies a substantial proportion of the study of crisis management. However, the importance of crisis communication and its role as an intervention should be reflected in institutional mechanisms for crisis management. We suggest building or strengthening the role of the Publicity or Communication Center of the Health Commission, ensuring the smooth transition between regular communication and crisis communication in the working mechanism, continuously conducting crisis communication rehearsals and capacity accumulation during the normal period,

TABLE 3 Categories of innovative ways of updates.

Category	Innovative ways	Description
Content innovation	①Briefing on individual cases	Publication of the trajectory of confirmed cases
	②List of risk levels	Publication of dynamically adjusted risk levels on a county-by-county basis
	③Expert reminder/warm tips	Attached as an expert reminder/tip/risk warning, etc.
	④Good news bulletin for discharge	Extracting discharge information for a separate broadcast under the heading "Good News!"
	⑤Briefing on donations/materials	Disclosure of receipt and use of funds/materials for prevention and control
Form innovation	⑥Multiple updates in one day	Briefings were distributed more than once a day
	⑦Multilingual briefing	Information on the outbreak is communicated in eight languages, including Chinese, English, French, Germany, Japanese, and Korean.
	⑧Synthetic voice broadcasting	Automatic synthesis of text messages of outbreak updates into audio messages
	⑨Data list display	Presenting epidemic data by municipality/district in tabular form
	⑩Epidemic map	Presenting the epidemic situation by city/district as a heat map
	⑪Trend analysis chart	Visualization of numbers into graphs/bar charts/pie charts etc.
	⑫Press conference	Release information on the outbreak through press conferences

TABLE 4 Categories of innovative ways of updates.

Models	Factors	Coupling	
		Content	Form
Equilibrium model	Emotion	④Good news bulletin for discharge	Null
Cognitive model	Knowledge	③Expert reminder/warm tips	⑪Trend analysis chart
	Fact	①Briefing on individual cases ②List of risk levels	⑦Multiple updates in 1 day ⑨Data list display ⑩Epidemic map ⑫Press conference
Psychosocial transition model	Internal	③Expert reminder/warm tips	⑧Synthetic voice broadcasting
	External	⑤Briefing on donations/materials	⑥Multilingual briefing

setting up a communication officer position, and recruiting someone who has better departmental coordination ability and learning and innovation ability.

(b) Taking care of psychology and emotions. To be specific, combining rational and emotional narratives in the discourse system. A crisis is an aggregation of facts and feelings. Fear, anxiety, compulsion, tension, and other undesirable social mindsets may intensify the crisis, which needs to focus on the unity of authoritative release and emotional concern in crisis communication. Most of the 31 provinces in China (autonomous regions and municipalities directly under the central government) include tips and warm reminders in their outbreak updates and health tips about special groups such as children, pregnant women, and the elderly. Shanghai also helps those with dyslexia access information through speech synthesis, which can also be seen as an emotional expression of digital humanity. The Japanese poem *"The mountains and rivers are different; the wind and the moon are the same"* printed on the boxes of donated goods was well-received on the Internet in China. In addition to the good effect of macro crisis communication, the micro emotional narrative and care for special groups are essential signs of the modernization of the governance system and capacity.

(c) Developing a crisis communication toolkit to enhance its role as crisis intervention. National, provincial, municipal, and district health commissions represent different levels of crisis communication capacity. Developing a crisis communication toolkit can achieve "twice the result with half the effort" and improve the overall level of communication capacity. By absorbing international practical experience and selecting outstanding innovations presented in this study, a toolkit that serves as a crisis communication infrastructure can be developed to empower crisis management teams at all levels. Toolkit development needs to be based on the principles of uniformity and flexibility. For example, strengthening the uniformity of baseline texts in the case of outbreak updates will ensure the quality of overall crisis communication. Moreover, it will also facilitate global coordination and data mining for social research. Flexibility is about bringing into play the initiative of each crisis management team and emphasizing the inspirational role of innovative cases. From time to time, outstanding crisis communication innovations from home and abroad can be selected and added to upgrade the toolkit.

(d) Institutionalizing multilingual updates and improving global empathy to combat the epidemic. The COVID-19 outbreak has once again proved that we are in a "global risk society" and that humanity is a community of shared destiny. The response to global challenges requires concerted efforts, solidarity, and cooperation by the international community. Language is a significant barrier to international collaboration. Multilingual updates can reduce the cost of international communication, improve international cooperation to combat the epidemic, and make risk monitoring and assessment more effective. A Canadian global infectious disease risk monitoring company collects and processes texts such as official public health agency statements in more than 65 languages to identify the risk of infectious diseases globally at an earlier stage (Bowles, 2020). As machine translation technology improves, the cost of multilingual updates will also continue to decline. The institutionalization of multilingual updates is a concrete manifestation of our open, transparent, and responsible attitude.

(e) Strengthening crisis management training and improving the hard and soft crisis communication skills of crisis management teams. The study finds that localities show different levels of management of epidemic communication and reflect local governments' governance and innovation capacity. While some provinces are more aware and capable of crisis communication and can innovate on their own, using a combination of innovative ways of outbreak updates, including digital visualization, nearly

a quarter of provinces have only a single way of communication. This requires strengthening crisis communication training for crisis management teams at all levels and providing guidance on using the abovementioned crisis communication toolkit to improve crisis communication awareness, enrich crisis communication, and optimize crisis communication effectiveness as a psychological intervention.

Data availability statement

The original contributions presented in this study are included in this article/supplementary material, further inquiries can be directed to the corresponding author.

Author contributions

SZ contributed to the conception, data analysis, and manuscript writing of the study. WY contributed to parts of literature obtaining and manuscript writing. XT performed the psychological coupling and analysis with constructive discussions of the study. XL contributed to parts of the conception and coding. All authors contributed to the article and approved the submitted version.

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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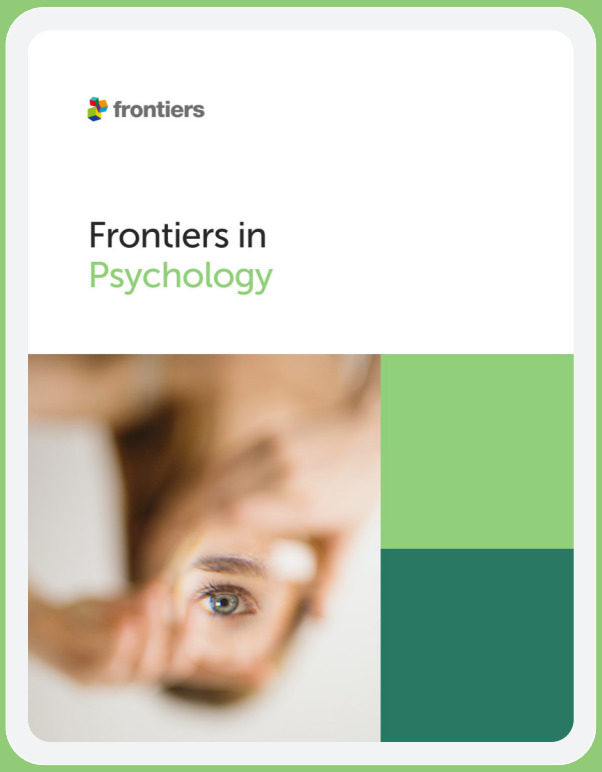

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