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The good side of technology: How we can harness the positive potential of digital technology to maximize well-being

Edited by
John F. Hunter, Stephen Schueller, Lisa C. Walsh and Chi-Keung Chan

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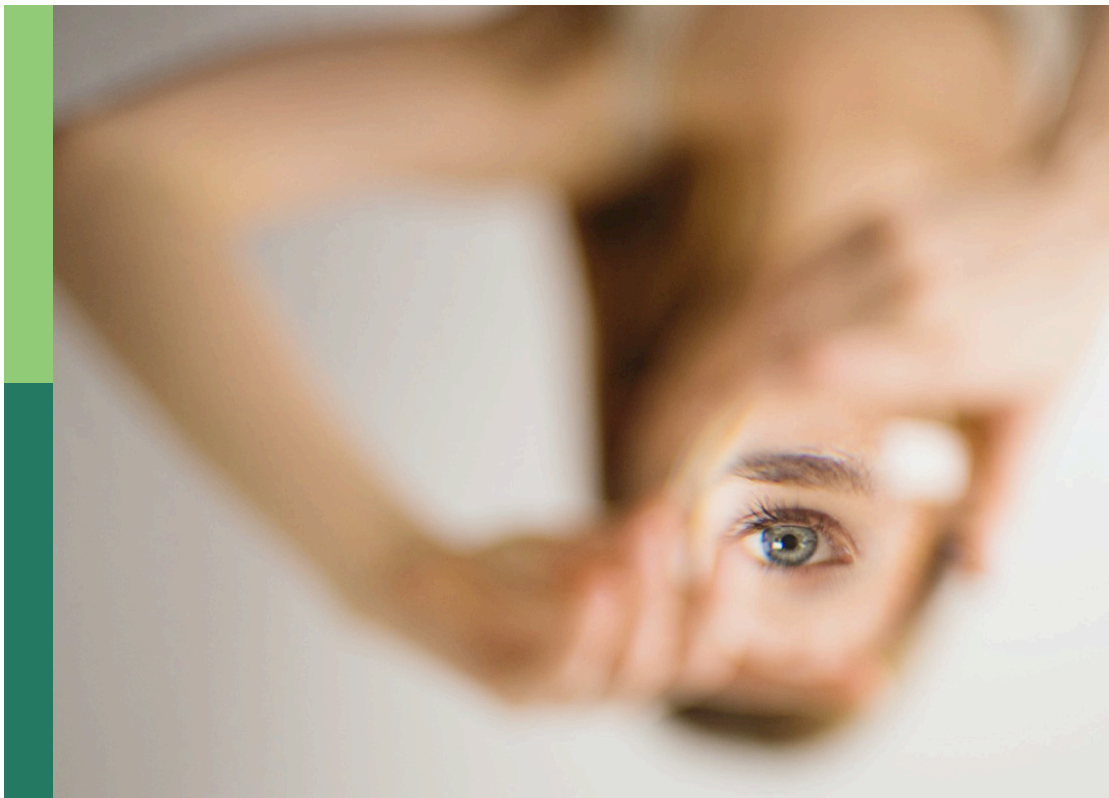

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The good side of technology: How we can harness the positive potential of digital technology to maximize well-being

Topic editors

John F. Hunter — Chapman University, United States
Stephen Schueller — University of California, Irvine, United States
Lisa C. Walsh — University of California, Los Angeles, United States
Chi-Keung Chan — Tung Wah College, Hong Kong, SAR China

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Sebastiaan Rothmann,
Optentia Research Unit, South Africa

*CORRESPONDENCE
John F. Hunter
✉ johnhunter@chapman.edu

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Editorial: The good side of technology: how we can harness the positive potential of digital technology to maximize well-being

John F. Hunter[1]*, Lisa C. Walsh[2], Chi-Keung Chan[3] and Stephen M. Schueller[4]

[1]Department of Psychology, Chapman University, Orange, CA, United States, [2]Department of Psychology, University of California, Los Angeles, Los Angeles, CA, United States, [3]School of Arts and Humanities, Tung Wah College, Hong Kong, Hong Kong SAR, China, [4]Department of Psychological Science, University of California, Irvine, Irvine, CA, United States

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Editorial on the Research Topic
The good side of technology: how we can harness the positive potential of digital technology to maximize well-being

The rapid advancement of digital technology has transformed society and undeniably impacted wellbeing. With the advent of smartphones and social media, a host of empirical articles, popular press pieces, non-fiction books, and documentaries have highlighted the potential negative effects of technology, such as addiction, loneliness, and depression (e.g., Alter, 2017; Twenge et al., 2018; Orlowski, 2020). While it is important to acknowledge and address the potentially detrimental effects of this increasing technological reliance, we believe that it is imperative that researchers, developers, and users embrace a more balanced approach that also recognizes the positive potential of digital technology to support wellbeing. This Research Topic demonstrates a variety of ways in which technological tools can be both designed and used to maximize wellbeing across a range of domains. These studies collectively emphasize a critical message: for the most part technology itself is neither good nor bad, but how technological affordances are harnessed determines their impact on wellbeing. While we cannot ignore potential pitfalls, recognizing and leveraging the positive potential of digital technology is a paramount endeavor as technology becomes further integrated in our lives.

Technological affordances (i.e., the potential actions technology affords to its human users), particularly in the realm of digital technology, have evolved considerably in the past few decades (Conole and Dyke, 2004; Parchoma, 2014). Leveraging these affordances appropriately may allow us to foster greater wellbeing and more social connection in various contexts. This approach is aligned with the perspectives of the positive technology movement that seeks to draw on technology and wellbeing science to optimize psychological and physical health (Riva et al., 2012; Gaggioli et al., 2019). The articles in this issue advance this approach by highlighting several areas in which technology may be a force for good. Rosič et al. unveiled the positive facets of youth digital interactions through the Digital Flourishing Scale, emphasizing areas like connectedness and authentic self-presentation. This counters the narrative that technology always inherently harms youth mental health.

Lee et al. introduced the concept of agentic social media use, establishing the importance of intentional, meaningful engagement. During the pandemic's enforced isolation, Heyman and Kushlev showed how smartphones ensured sustained connections and information access. Similarly, Petersen et al. emphasized how technology may be used to reduce loneliness, especially in older adults, who are more prone to isolation. Similarly, Chase et al. revealed that digital technology, when used for social ties, has minimal negative ramifications and can actually bolster mental health among emerging adults. Each of these contributions provide evidence to suggest that purposeful socially-motivated online behavior is positively associated with indicators of wellbeing.

Many of the studies in this issue also demonstrate the potential of digital technology to reach traditionally underserved and marginalized populations (Schueller et al., 2019) by illustrating how these tools are particularly well-suited for tailoring culturally-sensitive interventions that can impact populations across the lifespan and around the world. Liu et al. explored the positive outcomes of smartwatch use on user reciprocity through expanding users' social relationships and increasing their social engagement in mainland China. Marciano and Viswanath provided evidence that certain social media activities can enhance Swiss adolescents' flourishing by fulfilling their basic needs. Zhong et al. showed that internet use can be beneficial for Chinese residents if used appropriately. Wu et al. study also echoed the positive use of social media when coupled with strong digital skills on the wellbeing of Chinese residents. Shi and Khoo demonstrated the positive changes in self-disclosure and social networks through an online health community for Chinese users with depressive symptoms. These studies exhibit how digital technology is a universally impactful factor around the globe, especially in regard to how it can address the need for belongingness by building avenues that supplement social interaction. The continued integration of cross-cultural perspectives in the development and use of technology will enrich our understanding of the positive potential of these tools.

One challenge with understanding the positive potential of technologies is that doing so requires expertise and content knowledge that draws from diverse fields—psychology and wellbeing science, technology and human-computer interaction, evaluation, and clinical methodologies—and coordination across industry, academia, policymakers, and other invested parties. The papers in this Research Topic emphasize this need for work that engages interdisciplinarily and thus create frameworks and models to advance this space. For example, Villamil and Heshmati propose an Engagement in the Good with Technology (EGT) Framework with implications for digital technology research and design. One research implication of the EGT Framework is to consider not just positive or negative use, but to understand the ratio of positive to negative interactions with technology. Such an approach highlights that neither positive nor negative use take place in isolation and each individual has to balance the potential benefits and risks. Also, when research measures both positives and negatives, it provides the opportunity for researchers to understand the relative impact on each. From a design perspective, EGT provides an additional design target. In their development, the functionality of technologies is considered, not their impact. Elevating "good" as a design feature may lead to the development of features that can function optimally with positive impact.

This interdisciplinary perspective is especially important to consider in light of the evolving regulatory discussions around technologies. The apparent harms of social media and possible risks of artificial intelligence implementation present challenges for policy and regulation. Technologies are constantly changing and regulatory perspectives, focused on using punishments (or "sticks") to shape technologies, will likely always lag behind technology development and fail to motivate companies to develop better products. A positive framework for technology development could identify ways to incentivize companies (using "carrots") and provide actionable insights to team with companies to create wellbeing promoting products. Aligned with this thinking, we need design frameworks that specify how to design for wellbeing, like Liedgren et al. liminal design in this Research Topic, and evaluation frameworks that help demonstrate the success of the design.

Industry teams are traditionally not siloed by discipline in the same way that academic teams are divided by traditional disciplines like psychology, computer science, and public health. Interdisciplinary journals, like this one, conferences, and projects are beginning to create spaces to engage in this dialogue. One major challenge, however, in deeper interdisciplinary research is ensuring that research teams from different disciplines can engage on a research level. That is ensuring that technologists are not merely included to "build the stuff" that psychologists want to use to deliver their experiences or evaluate and that psychologists are not merely included to identify clinical areas of need or evidence-based interventions. A truly collaborative and transdisciplinary approach will be necessary to ensure that the future of technological development is undertaken ethically, efficiently, and effectively.

The articles in this Research Topic not only enrich our intellectual and practical knowledge about the good side of digital technology to support mental health, but also serve as a call to others to shift their perspective and embrace the responsibility of working together to design and use technology to maximize wellbeing. We are not advocating that everyone blindly support the inevitable immersion of technology ever deeper into our lives with optimistic ignorance. Rather, we urge others to acknowledge the permanence of digital technology as a mainstay in our future so that we can work collaboratively and constructively to harness its positive potential for the advancement of human wellness. In the coming years, artificial intelligence, immersive interfaces (e.g., virtual and augmented reality), and a series of yet-to-be imagined technologies will continue to reshape the dynamics of human interaction and wellbeing. As researchers designing and studying these tools, and as users relying on and interacting with these technologies, we are faced with a critical decision about how we proceed. Do we fight against the inevitable tide of development with doomsday predictions and laments of misguided trends? Or do we collectively embrace the gifts of the digital age to foster social relationships and

build connective bridges, address inequities and inefficiencies in our industries and societies, and develop new paths forward that will allow us to thrive and flourish with technology in hand?

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EDITED BY
Stephen Schueller,
University of California, Irvine,
United States

REVIEWED BY
Iraida Delhom,
Valencian International University,
Spain
Khadija Shams,
Shaheed Benazir Bhutto Women
University, Pakistan
Haruna Danladi Musa,
Federal University of Technology
Minna, Nigeria

*CORRESPONDENCE
Fusen Zhao
zhaofs3311@163.com

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The impact of Internet use on the subjective well-being of Chinese residents: From a multi-dimensional perspective

Jiawei Zhong[1], Wenbo Wu[2] and Fusen Zhao[2]*

[1]Jing Hengyi School of Education, Hangzhou Normal University, Hangzhou, China, [2]College of Business, Shanghai University of Finance and Economics, Shanghai, China

As cyberspace has become an important factor in modern-day life, the impact of the Internet on residents has also attracted more attention. Based on the data of China Family Panel Studies (CFPS), this study empirically examines the impact of Internet use on Chinese residents' subjective well-being (SWB) from a multi-dimensional perspective. The research found that Internet use had a significant impact on residents' SWB, which was mainly reflected in job satisfaction, happiness, social ties, and future confidence. The impacts of the Internet's different application fields are not consistent. Applying its use more in studying, working, socialize and commercial activities has a stronger effect, but has no significant impact on entertainment. Further heterogeneity tests also found that the marginal effect of Internet use increases with age, male and low-income groups can obtain greater benefit from the Internet, and there is almost no difference between urban and rural areas. This research provides micro evidence of the social effects of Internet use and provides enlightenment for how to further promote the quality of Internet use to better benefit people.

KEYWORDS

Internet use, SWB, Chinese residents, multi-dimensional, heterogeneity

Introduction

The pursuit of subjective well-being (SWB) is the goal of economic development and people's lives. Residents' SWB not only reflects the satisfaction of individuals with their material and spiritual life, but also reflects the progress of a society. Since its reform and opening, China's economy has continued to grow and people's material living standards have been continuously improved. However, under the traditional development mode of pursuing economic growth, Chinese residents' SWB has not increased significantly with the rapid economic growth. The World Happiness Report in 2022 gives the happiness index ranking of 146 countries and regions in the world. Among them, Finland has been rated as the happiest country in the world for five consecutive years by virtue of its proximity to nature, safety,

and availability of services, while China ranks 72nd, only in the middle of the ranking. For this reason, in recent years, the Chinese government has attached great importance to the cultivation of residents' SWB and regarded the construction of a happy society as one of the important tasks of China's current economic and social development[1]. In the government work reports from 2016 to 2021, the Chinese government has mentioned "improving people's SWB and making the people have more happiness and sense of gain" for many years[2]. At this stage, how to improve residents' SWB has become an important topic in all sectors of society.

At the same time, with the advent of the era of the digital economy, a new generation of information technology represented by the Internet is being integrated into all walks of life, resulting in unprecedented changes to people's productivity and lives. Thus, the following question arises: Does Internet use have a significant impact on residents' SWB? In response to this issue, scholars in different fields have conducted extensive discussions (Morrell et al., 2004; Valkenburg et al., 2006; Brooks, 2015; Niu et al., 2018). On the one hand, Internet use helps to improve the happiness of residents. For example, the Internet enriches daily life, improves communication efficiency, creates consumption value, and increases income (Purcell et al., 2013; Campante et al., 2018). On the other hand, the use of the Internet may also have negative effects. For example, the Internet will reduce the scale of individuals' offline social circle, increase depression and loneliness (Kraut et al., 1998), reduce offline emotional interaction, and reduce individuals' enthusiasm to participate in social activities (Sabatini and Sarracino, 2017). Overall, there is no unified agreement as to whether Internet use is beneficial to the improvement of residents' SWB. Most of the relevant studies have focused on developed countries, while there are relatively few studies of emerging countries. In recent years, the Internet has made great progress in China. According to the latest report released by the China Internet Network Information Center, by December 2021 the number of Internet users in China had reached 1.032 billion, and the Internet penetration rate had reached 73.0%. China has become the premier Internet country. At present, there are still few similar studies on whether Internet use has improved Chinese residents' SWB, which undoubtedly restricts the effectiveness of constructing China's happy society in the Internet age.

In view of this, this study uses the CFPS2018 study to explore the relationship between Internet use and residents' SWB. Specifically, this study aims to examine the following questions: does Internet use affect residents' SWB? Is the effect different due to individuals, family factors, and so on? Is there heterogeneity in the impact of different dimensions of Internet use (such as learning, work, entertainment, etc.) on residents' SWB? Compared with the existing literature, the marginal contributions of this study are as follows. First, whether Internet use is beneficial, harmful, or indifferent for residents' well-being is still inconclusive in developed countries. Based on Chinese practice, this study pays attention to the impact of Internet development on individuals in transition countries, and finds evidence that Internet use is conducive to improving Chinese residents' well-being, which is an important supplement to the research field of the relationship between the Internet and individual SWB. Second, this study defines individual SWB from different dimensions, and comprehensively investigates its impact on individual SWB in combination with different fields of Internet use. Existing literatures mostly use single dimension indicators, such as life satisfaction or happiness, to represent SWB, and it is difficult to achieve a comprehensive investigation of the impact of the Internet on SWB. However, our research found that the effect of Internet use on SWB of different dimensions is not consistent, and at the same time, different purposes of Internet use also have a heterogeneous effect on SWB, which expands some static research results in developed countries. The findings are significant, and provides new empirical evidence for how Internet use affects residents' SWB. Finally, against the background that informatization and human capital are increasingly important for future economic development (Heckman and Kautz, 2012; Yushkova, 2014; United Nations Conference on Trade and Development [UNCTAD], 2019), exploring the relationship between Internet use and individual SWB will not only help to deeply understand the evolution of individual subjective feelings in the information society, but also provide targeted enlightenment for the further deepening and popularization of Internet use.

The study is organized as follows. The first section reviews the progress of research into SWB. Then, Chinese and non-Chinese studies of the relationship between Internet use and residents' SWB are reviewed. Next, the data, variables, and research methods are introduced, followed by the empirical results and discussions. Finally, the study provides the main research conclusions and enlightenment.

Literature review

Subjective well-being

Classical liberalism believes that SWB is an important indicator of economic measurement, which has the same utility

1 At the first session of the 12th National People's Congress of China in 2013, President Xi emphasized the close relationship between people's SWB and the Chinese dream; The report at the 19th National Congress of the Communist Party of China (CPC) in 2017 also indicated that we should pay more attention to the SWB of ordinary people and take the people's yearning for a betterr life as the goal of the Communist Party of China. At the Fourth Plenary Session of the 19th Central Committee of the CPC in 2019, President Xi also closely linked the SWB with the goal of achieving common prosperity.

2 http://www.gov.cn/gongbao/2022/issue_9766.htm

as welfare. It is the great goal of all human efforts (Ng, 1996). In fact, the discussion of what constitutes SWB has a long history in China. Confucianism believes that "worry is joy and turn from worry into joy," while Taoism adheres to "settle down in life outside worry and don't turn worry into joy" (Cai, 1982; Chen, 2008). Until now, people have never reached a unified conclusion about the essence of SWB, but this does not affect the fact that SWB has become an eternal pursuit and a new topic of interest. In the 1950s, as society paid greater attention to residents' welfare, psychologists and sociologists in Europe and America tried to study SWB for its disciplinary characteristics, and it quickly attracted the attention of a large number of scholars. In 1974, American economist Easterlin put forward the famous Easterlin paradox, and then increasing numbers of economists began to study SWB (Salanova et al., 2004; Purcell et al., 2013; Campante et al., 2018; Li and Zhou, 2021).

At present, the research on SWB has involved many fields, and different disciplines have different understandings. Psychologists study SWB from the perspective of behavioral science and have put forward three standards of the definition of SWB: "external standard," "internal emotion," and "individual self-evaluation" (Ryff, 1989). Among them, positive and negative emotions are important components of SWB, which are clearly different from each other but are significantly related (Diener et al., 2009). Positive emotions can improve individuals' psychological function and provide effective protection for individuals to achieve a higher sense of SWB, while negative emotions have the opposite effect (Hicks et al., 2013). Correspondingly, sociologists have proposed "social well-being" and "psychological well-being" (Winkelmann, 2009). They are more concerned about the individual's sense of satisfaction and recognition in social activities, that is, the social realization value, such as the social support and social trust (Rehdanz and Maddison, 2008; Prati et al., 2016). Economists' research on SWB takes "rational people" as the premise, equates SWB with maximum utility, and usually uses more specific indicators such as life satisfaction and job satisfaction (Clark et al., 2008). Such studies often link SWB with economic indicators (Easterlin et al., 2010). For example, in a model for measuring SWB constructed by Branch (2004), the SWB index is set as the actual utility welfare, income level, emotion and Eigenfunctions associated with individuals.

In summary, SWB is a concept with multiple dimensions, and although there are different conceptual descriptions of SWB across disciplines, they are only different literally, empirical results using the self-report research method show that the internal structures of different concepts are consistent (Ryan and Deci, 2001; Nave et al., 2008). At the same time, there is a common core connotation in different concepts, that is, as a subjective experience, SWB is the overall emotional and cognitive evaluation and feeling of the quality of life made by individuals according to their standards, including their so-called happiness, life satisfaction, and so on (Diener, 1994; Ryff and Singer, 2008; Diener et al., 2017). In real life, individuals have various understandings of SWB, which is caused by various ideal aspirations, life attitudes, economic conditions and social environments. At this time, if individual's SWB is only investigated from a single dimension, it is impossible to accurately judge and compare the possible heterogeneous effects of Internet use in different scenarios such as life, work, and self-evaluation. This study examines individual SWB from a multi-dimensional perspective, which can more comprehensively take into account the deviations caused by individual differences, so as to achieve a more scientific research and evaluation.

The relationship between Internet use and subjective well-being

In the era of the digital economy, information technology represented by the Internet not only affects the operation of the whole national economy, but also affects all aspects of residents' lives. Many researchers have begun to study the impact of the Internet on economic growth and residents' lives. At the macro level, the Internet can eliminate market friction (Choi and Yi, 2009), promote the transformation of traditional enterprises (Pisano et al., 2015), and promote business innovation (Paunov and Rollo, 2016) and financial development (Xie et al., 2016). At the micro level, the Internet can change household or individual consumption decisions (Song and Zahedi, 2005), employment patterns (Feldman and Klaas, 2002), and timing (Tokunaga and Rains, 2010).

At present, the research on the relationship between Internet use and residents' SWB has been widely involved in the fields of psychology, sociology, and economics, but no consistent conclusion has been reached. One research view holds that there is a "network gain effect," that is, people can promote social participation and social capital accumulation through the Internet, and then improve their SWB (Morrell et al., 2004). Many studies have found that Internet use increases positive effects such as social communication, creating consumption value, and increasing income, thus verifying the network gain effect (Hong, 2007; Sabatini and Sarracino, 2017). Moreover, from a multi-dimensional perspective, Internet use has improved people's positive feelings and life satisfaction (Sabatini, 2011; Martin and Omrani, 2015; Ganju et al., 2016; Lu and Kandilov, 2021). In terms of social networking, Internet platforms such as Facebook, QQ, and WeChat have played an important role in expanding interpersonal relationships, strengthening the accumulation of personal social capital, and finally improving users' SWB (Steinfield et al., 2008; Graham and Nikolova, 2013; Niu et al., 2018). In terms of production and work, Internet use can promote workplace change at any time, such as a move to a home office or entrepreneurship, improve the processing efficiency of work data and daily life

information, promote the improvement of the frequency of communication between individuals and colleagues, and finally improve individual SWB (Cilesiz, 2009; Castellacci and Vinas-Bardolet, 2019). In terms of daily life, on the basis of enriching people's lifestyles, such as shopping, leisure, and entertainment, the popularity of the Internet has also improved the degree of information asymmetry, promoted the improvement of price discovery mechanisms, and reduced transaction costs, thus reducing commodity prices and significantly improving the welfare level of consumers (Hong, 2007; Long and Yi, 2019).

Another view is that Internet use reduces people's face-to-face interpersonal interactions and social communication, thus reducing people's trust value, triggering negative emotions, such as loneliness and fear, and then reducing SWB. This view is called the "substitution effect of presence" (Pénard et al., 2013; Hage et al., 2016). Brooks (2015) used the workplace as an example to verify existence of the "substitution effect of presence." On the one hand, telecommuting may reduce the face-to-face interaction between colleagues or leaders, resulting in poor information communication. On the other hand, the use of social media at work can disrupt work order and reduce productivity, which can lead to lower job satisfaction. Antonucci et al. (2007) investigated the negative impact of Internet on SWB from life field. They believed that although Internet use provided online interaction opportunities for different individuals, it reduced the frequency and quality of face-to-face communication among family members, resulting in unfamiliar family relations, and disharmonious family relations often led to a reduction in quality of life and life satisfaction. Beyond that, based on the perspective of social comparison theory, the generation of individual SWB is often not only based on its own goal, but also compared with multiple standards to obtain information. When individuals compare themselves with those around them, if they feel that their working ability and income level are better than others, they will obtain higher SWB (Fujita and Diener, 1997; Park and Baek, 2018). According to Clark and Senik (2010), Internet use has expanded the reference group to which people can compare themselves. The reference object goes beyond the boundary of daily life and can be easily compared with others online from any country and any background. This comparison reduces the individual's subjective positioning of their relative income, more seriously, the comparison behavior based on this will bring a sense of psychological loss and relative deprivation, which will undoubtedly lower people's judgment of life satisfaction.

In the existing literature, the relationship between Internet use and SWB has been discussed more internationally, and the research perspectives are quite diverse, which provides an important reference for our research (Kraut et al., 1998; Valkenburg et al., 2006; Steinfield et al., 2008; Martin and Omrani, 2015; Castellacci and Vinas-Bardolet, 2019). In contrast, such literature using China as the sample still lags. Although a few studies have discussed the relationship between Internet use and residents' SWB (Zhu and Leng, 2018; Long and Yi, 2019; Zhou and Zhang, 2021), the following problems still exist. First, the relevant literature has mostly used happiness to measure individual SWB. Few studies have comprehensively investigated the impact of Internet use on different dimensions of residents' SWB (including job satisfaction, life satisfaction, happiness, social ties, and future confidence) under an analytical framework. Second, the method of measuring Internet use is relatively simple, and few studies have comprehensively investigated the possible heterogeneous impact of different areas of Internet use on residents' SWB. Based on the above research gap, this study attempts to analyze the relationship between Internet use and residents' SWB from a multi-dimensional perspective, and explores the heterogeneous impact caused by individual, family, and urban and rural factors in order to provide a supplement to the existing research.

Data and method

Data

The data used in this study was mainly obtained from the CFPS2018 study. The data was collected by the Institute of Social Science Survey Center of Peking University. The sample covered 25 provinces/cities/autonomous regions in China. The target sample size was 16,000 households. The survey objects included all family members in the sample households. It is nationally representative, micro-individual data in China. This study mainly focused on the impact of adult (individuals aged 16 and above) Internet use on individual SWB. Among them, Internet use, SWB, and demographic characteristic variables were taken from the CFPS2018 personal database, and a few other control variables were derived from the CFPS2018 family economic database. In the process of sample data processing, the samples with incomplete key data and abnormal values were eliminated, and finally 10,943 effective individual samples were obtained for benchmark testing.

Estimation methods

In order to investigate the impact of Internet use on residents' SWB, this study set the following benchmark empirical model:

$$SWB_i = C_i + \alpha Internet_i + \beta Control_i + u + \varepsilon_i \quad (1)$$

In the model, *SWB* is the explanatory variable; *Internet* is the core explanatory variable, which indicates the degree of individual use of the Internet; α is the influence coefficient of the core explanatory variable; *Control* represents a series of control variables that may affect residents' SWB, including individual characteristics, family characteristics, and other factors; *i* represents individual residents; *u* represents the fixed effect at the county level, and ε is a random perturbation term.

Variable description

Subjective well-being measures

Subjective well-being is a subjective feeling of people involving multiple dimensions. The existing research has not formed a unified standard for measurement of SWB. Based on the existing research (Brockmann et al., 2009; Hicks et al., 2013; Li and Zhou, 2021), this study measured individual SWB from five dimensions: job satisfaction, life satisfaction, happiness, social ties, and future confidence. This multi-dimensional comprehensive index is suitable for different categories of people and is more universal. According to the CFPS2018, these five dimensions correspond to five questions: "how satisfied are you with your work?," "how satisfied are you with your life?," "how happy are you?," "how good are your relationships?" and "how confident are you in your future?" The answers to each question from "very low" to "very high" were scored on a scale of 1 to 5 points, respectively. Considering that individual SWB reflects a comprehensive and coordinated feeling, it was more appropriate to investigate it from an all-round perspective. Therefore, the research mainly used the equal weight method to construct a comprehensive SWB index.

These multi-dimensional indicators formed by these questions have sufficient theoretical basis for measuring SWB, and the method is generally applicable internationally. Theoretical evidence shows that the definition of SWB is becoming more and more diverse, and a single dimension of satisfaction cannot fully explain SWB, but should also include social relationships, self-esteem, and emotions (Morrell et al., 2004; Diener et al., 2009; Easterlin et al., 2010; Brooks, 2015; Niu et al., 2018). Ryff and Singer (2008) described SWB from six dimensions, including purpose of life, personal growth, positive relations with others, environmental mastery, autonomy, and self-acceptance. Recent review literatures, Çikrıkci (2016), Castellacci and Tveito (2018) summarized that SWB consists of different elements[3]. These views coincide with our understanding of SWB. Methodologically, judging from the existing literature, the databases on residents' SWB in different countries can provide strong evidence for our research[4]. The measurement method of SWB in the national-level database we used is commonly used internationally (Alesina et al., 2004; Dolan et al., 2008; Pénard et al., 2013). The above facts can provide important evidence for our research. In this study, these dimensions we selected almost include the factors that are generally concerned in existing research, and can reasonably represent the Chinese residents' SWB. Not only that, the Cronbach alpha value of our SWB scale is 0.726, indicating that it has sufficient reliability in terms of internal consistency.

Internet use

The main explanatory variable of this study is Internet use. In CFPS2018, the measurement of Internet use mainly includes five levels, corresponding to five questions, asking frequency of using Internet to studying, working, socialize, entertainment, and commercial activities. The answer options include "almost every day," "3–4 times a week," "1–2 times a week," "2–3 times a month," "once a month," "once every few months," and "never." The different options were assigned a score on a scale of 1 to 7, respectively. Here, a comprehensive index able to reflect the degree of Internet use was obtained through the following steps. First, considering that the original assignment method presents a negative correlation between the higher the score and the lower the intensity of Internet use, in order to facilitate understanding, the scores were inverted so that the scores showed a positive correlation with the degree of Internet use. Second, through the correlation analysis of the indicators at five levels, it was found that the correlation coefficients of different indicators were mostly below 0.3, indicating that the collinearity relationship between different indicators is low. Finally, based on the degree of Internet use reflected by the five questions, each has its own focus, and the collinearity relationship between them is low. In order to better reflect the comprehensiveness of Internet use, the equal weight method was also used to construct comprehensive Internet use.

Control variables

In order to scientifically evaluate the impact of Internet use on SWB, this study selects the following variables for analysis based on existing research (e.g., Brooks, 2015; Castellacci and Vinas-Bardolet, 2019; Zhou and Zhang, 2021): individual age, gender, education level, health status, marital status, household registration, work experience, religious belief, and family income. Age is one of the important factors affecting SWB. Existing studies generally believe that due to work pressure, life expectations and other reasons, SWB may first decline and then rise with age (Ferrer-I-Carbonell and Gowdy, 2007). Gender and marital status are common influencing factors in happiness research literature. On average, men's SWB is significantly lower than that of women (Alesina et al., 2004); Studies in different regions have found that the SWB of married residents is higher (Dolan et al., 2008). The level of education also has a direct or indirect impact on the individual's SWB. The reason is that education level is an important factor affecting individual development. Education provides

3 Firstly, hedonistic dimension, it's an assessment of their own life by the individual in terms of obtaining satisfaction; secondly, psychological dimension, it deals with the potential of the individual to enter interactions with others using abilities and communication skills and the responsibilities of all these processes in terms of life aims; thirdly, dimensions of self-esteem, it comprises all internal beliefs of the individual about themselves.

4 In United States General Social Survey (GSS), Euro-barometer Survey Series, European Value Survey (EVS), World Values Survey (WVS), UK's Annual Population Survey (APS) and other national survey databases, it is not difficult to find that similar related problems, which are widely used to measure life satisfaction, job satisfaction, happiness, living conditions and social capital to represent SWB.

individuals with more opportunities to improve their income and social status, but it may also make people more reflective and thus generate more psychological stress, so the effect of education on SWB is uncertain (Clark and Oswald, 1994; Oshio and Kobayashi, 2010). It needs to be briefly explained here that in the evaluation of education, the scoring system was not completely continuous. A score from 3 to 9 indicated that the highest educational background of an individual was from primary school to doctoral level, 0 referred to illiterate/semi-illiterate, and 10 was never attended school. For convenience, the scores were adjusted from 0 to 5 to represent never attended school, primary school, junior middle school, high school, college, and undergraduate and graduate students, respectively. Health can significantly affect individual SWB. Generally, the better the physical health, the higher the SWB (Haller and Hadler, 2006). In addition, because the evaluation of health status also adopted the reverse scoring mechanism, that is, the higher the individual's health level, the lower the score, the individual health scores were positively standardized in order to facilitate understanding. Work experience will have an important impact on people's psychological endurance, and will also increase the breadth of individual social relations, thus affecting individual subjective feelings (Antonucci et al., 2007). Household registration in China has special characteristics, generally, people who live in urban area often means that they can enjoy more social and public services, and their SWB may also be higher (Long and Yi, 2019). Religious belief is also one of the important factors affecting SWB. Many researchers believe that religious belief can help individuals build confidence to face reality and provide moral constraints for individual behavior, thus affecting SWB (Dolan et al., 2008). Most of the literature on happiness economics confirms that income is one of the important factors affecting SWB (Blanchflower and Oswald, 2004; Boyce et al., 2010), so it is necessary to include it as one control variable.

The descriptive statistical results of all variables are shown in **Table 1**.

Estimation results and discussion

Benchmark results' analysis

When using econometric models to estimate unknown parameters in linear regression models, the ordinary least square (OLS) method is the most common and basic estimation method in regression models (Angrist and Pischke, 2008). It minimizes the sum of squares of the differences between the real dependent variables and the predicted dependent variables to obtain the best linear unbiased estimator. Because the OLS estimation results are intuitive and easy to interpret, many literatures on SWB directly use the OLS method (Brockmann et al., 2009; Knight et al., 2009; Zhou and Zhang, 2021). This study also used the OLS method to estimate the relationship between Internet use and residents' SWB by gradually adding control variables. At the same time, considering the data characteristics of the explained variables, we also use the order probit model for estimation. It can be seen from the results that the influence of Internet use on SWB is significantly positive, but the R^2 of OLS model is higher, which means that the OLS model is more suitable for this study, so we mainly use the results of OLS model for interpretation. The results are shown in **Table 2**. The results in column (1) do not include other control variables, and then in column (2) the individual and family variables are included. It can be seen that the coefficients of Internet use are positive and significant at the level of 1%. This means that Internet use has a positive impact on residents' SWB. Column (3) controls the county-level fixed effect based on the inclusion of all control variables. The result is still significantly positive, indicating that the above results have good robustness. Overall, although previous studies on the effect of internet use on SWB have produced inconclusive results, the China case suggests that Internet use has a positive impact on residents' SWB. In addition, after adding control variables and county-level fixed effects, the R^2 of the model was greatly improved, which indicates that it is necessary to add control variables.

TABLE 1 Variable description and descriptive statistics.

Variable name	Variable meaning	Mean value	Standard error	Minimum value	Maximum value
SWB	Residents' SWB	3.880	0.659	1	5
Internet	Degree of Internet use	0.358	0.193	0.143	1
lnage	Natural log of residents' age	3.651	0.380	2.773	4.625
gender	Man = 1, woman = 0	0.547	0.498	0	1
marriage	Married = 1, unmarried = 0	0.616	0.486	0	1
education	Educational background	1.503	1.577	0	5
health	Health condition	0.420	0.237	0	1
residence	Rural residents = 0, urban residents = 1	0.236	0.425	0	1
work	Currently employed = 1, otherwise = 0	0.665	0.472	0	1
religion	Religious = 1, otherwise = 0	0.288	0.453	0	1
lnincome	Natural log of family per capita hourly income	1.109	0.642	0	4.772

TABLE 2 Basic results of Internet use on SWB.

	OLS			Oprobit		
	(1)	(2)	(3)	(4)	(5)	(6)
Internet	0.221***	0.258***	0.276***	0.352***	0.470***	0.529***
	(8.07)	(8.14)	(8.06)	(7.22)	(7.87)	(8.09)
lnage		−3.062***	−3.198***		−5.522***	−6.068***
		(−6.74)	(−6.79)		(−6.57)	(−6.90)
lnage_sq		0.443***	0.462***		0.802***	0.879***
		(6.88)	(6.93)		(6.72)	(7.05)
gender		−0.016	−0.011		−0.026	−0.017
		(−1.49)	(−0.96)		(−1.33)	(−0.82)
marriage		0.177***	0.174***		0.319***	0.329***
		(10.75)	(9.90)		(10.71)	(10.25)
education		−0.001	−0.001		−0.006	−0.005
		(−0.21)	(−0.15)		(−0.57)	(−0.47)
health		0.761***	0.725***		1.422***	1.418***
		(28.58)	(26.09)		(27.90)	(26.50)
work		0.008	0.023*		0.012	0.029
		(0.65)	(1.66)		(0.48)	(1.12)
residence		0.025**	0.028*		0.042*	0.050*
		(1.98)	(1.88)		(1.82)	(1.79)
religion		0.027**	0.029**		0.053***	0.059***
		(2.43)	(2.48)		(2.60)	(2.71)
lnincome		0.018**	0.034***		0.027*	0.058***
		(2.00)	(3.03)		(1.68)	(2.77)
_cons	3.770***	8.490***	8.727***			
	(315.24)	(10.74)	(10.57)			
county_FE	*No*	*No*	*Yes*	*No*	*No*	*Yes*
N	10943	10943	10943	10943	10943	10943
R^2	0.005	0.097	0.175	0.001	0.023	0.043

***, **, and *, respectively, mean significant at 1%, 5%, and 10% levels, and *t* values in bracket is clustered.

According to the results of column (3) including all control variables, the coefficient of Internet use on residents' SWB is 0.276. Hence, providing other conditions remain unchanged, an increase of 10% of Internet use can promote residents' SWB by about 2.76%. From the results of the control variables, individual characteristics and family factors also affect residents' SWB in different degrees, which is also consistent with the existing relevant research. There is a significant inverted U-shaped relationship between age and residents' SWB. Health condition, marital status, urban–rural differences, employed or not, and family income all have an important impact on residents' SWB.

Robustness test

Endogeneity

Endogeneity is the main problem to be solved in empirical analysis. This study examined the relationship between Internet use and residents' SWB, and there will inevitably be possible endogenous problems. On the one hand, unobservable factors, such as regional culture, circumstances, or other factors, will affect individual Internet use and SWB at the same time. As these factors are unobservable, it was difficult to fully include them in the estimation model. This possible omission of variables could lead to bias in the estimation results. On the other hand, the data used in this study was the cross-sectional data of a single year, and individual SWB is the subjective feeling observed during the survey, which may change with Internet use, resulting in reverse causality problems. Therefore, it was essential to solve the potential endogenous problems. The study used the following two methods to solve this problem.

(1) Instrumental variable method. Based on the existing literature, this study took the country-level Internet information infrastructure and the average degree of Internet use as the instrumental variables of individual Internet use. The reason for this was that, on the one hand, the usage of information technologies such as the Internet often have a peer effect. According to the way the Internet transmits information, the residents' Internet use is often closely related to the local information infrastructure, in which computers and mobile phones are the most common hardware tools. On the other hand, as a macro level factor, the computer or mobile phone utilization rate at the county level is hardly affected by the Internet usage frequency at the micro individual level. Therefore, this study constructed two instrumental variables from the county level. First, the average level of computer utilization in the county, which was expressed by the ratio of the total number of respondents using computers to the total number of respondents in the county. Second, the average level of Internet use in the county, expressed by the average level of Internet use of all respondents in the county where the individual is located. Table 3 reports the results. It can be seen that there is an obvious positive correlation between the instrumental variables and Internet use, which means that they meet the correlation hypothesis, and the coefficient of Internet use is still significantly positive. This result is consistent with the result of benchmark testing.

(2) Introduction of lagged Internet use. Considering the possible reverse causality between variables when using cross-sectional data analysis, this study replaced the key explanatory variables with the Internet use in CFPS2016 without changing the explanatory variables and control variables. Introducing lag explanatory variables can show that Internet use is earlier than SWB, and this can solve the possible reverse causality problem to a certain extent. According to the results in column (2) of Table 3, after the reverse causality problem was solved by introducing the lag explanatory variable, the coefficient of Internet use is still significantly positive, which verifies the benchmark test results again.

Other robustness tests

(1) Propensity Score Matching (PSM) method. This method can analyze the causal relationship between Internet use and SWB based on the observed data and can alleviate possible selective errors. The basic process was as follows. First, the conditional probability of individuals entering the experimental group (high-frequency Internet use group) was obtained through a Probit model, that is, the so-called propensity

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TABLE 3 Robustness test results.

	Instrumental variable method	Introduce lagging Internet use	PSM method		Replace explanatory variable
	(1)	(2)	(3)	(4)	(5)
Internet	0.259***		0.059***	0.056***	
	(8.23)		(3.23)	(3.16)	
*Internet*_2016		0.152***			
		(3.22)			
*Internet*1					0.066***
					(11.59)
lnage	−3.092***	−3.703***	−3.024***	−3.024***	−0.014
	(−5.12)	(−5.38)	(−3.25)	(−3.25)	(−1.31)
lnage_sq	0.463***	0.532***	0.453**	0.453**	0.170***
	(5.10)	(5.43)	(2.09)	(2.09)	(9.70)
gender	−0.015	−0.003	−0.139***	−0.139***	0.004
	(−1.07)	(−0.21)	(−2.68)	(−2.68)	(0.70)
marriage	0.159***	0.156***	−0.116	−0.116	0.720***
	(6.96)	(7.08)	(−1.52)	(−1.52)	(26.03)
education	−0.002	0.010	0.533***	0.533***	0.019
	(−0.10)	(1.36)	(11.43)	(11.43)	(1.35)
health	0.709***	0.720***	−0.060	−0.060	0.029*
	(10.72)	(19.45)	(−0.46)	(−0.46)	(1.96)
work	0.025	0.032*	0.579***	0.579***	0.028**
	(1.10)	(1.77)	(8.25)	(8.25)	(2.38)
residence	0.044	0.031*	0.515***	0.515***	0.035***
	(1.36)	(1.70)	(7.82)	(7.82)	(3.15)
religion	0.027**	0.027*	0.050	0.050	8.962***
	(2.44)	(1.84)	(1.34)	(1.34)	(10.80)
lnincome	0.032**	0.037***	0.083***	0.083***	−0.014
	(2.00)	(2.63)	(7.90)	(7.90)	(−1.31)
_cons	3.720***	9.623***	−1.404***	−1.404***	0.170***
	(10.56)	(8.05)	(−2.78)	(−2.78)	(9.70)
*IV*1	0.609***				
	(25.76)				
*IV*2	0.068***				
	(8.48)				
First stage *F* value	473.75				
county_FE	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*
N	10943	6771	10404	10404	10943
R^2	0.175	0.182	0.254	0.254	0.184

***, **, and *, respectively, mean significant at 1%, 5%, and 10% levels, and *t* values in bracket is clustered.

score. In this study, a series of control variables in the benchmark test model were selected as explanatory variables for the Probit model. Second, the experimental and control groups were matched according to the propensity score, and a balance test was performed. If the test is passed, there is only significant difference between the two groups in the key variables, and there is no difference in other control variables. Here, the minimum nearest neighbor matching method and radius matching method were used. Finally, observing the differences between different groups of samples obtains the average treatment effect. If the effect is still significant and positive, the above test results can be verified. The results of the balance test show that after propensity score matching, there is no systematic difference between different groups. The results in columns (3) and (4) in Table 3 show that the coefficients of Internet use obtained by different matching methods are consistent and significantly positive.

(2) Replace explanatory variable. In the previous calculation of Internet use, this study fully considered the situation of using the Internet in different fields and constructed a comprehensive

index. In CFPS2018, there is also a single dimension index that can be used to indirectly measure the degree of individual Internet use. The corresponding question is "the importance of the Internet to your access to information," and the corresponding answers are assigned scores of 1 to 5 from "very unimportant" to "very important," respectively. Obviously, individuals believe that the importance of using the Internet to obtain information can reflect their degree of Internet use to a certain extent. Therefore, this study used this index to replace the comprehensive index of Internet use in the previous article. Combined with the results in column (5) of **Table 3**, after replacing the explanatory variables, Internet use still has a positive effect on residents' SWB.

From the above results, it can be seen that after solving endogeneity problem and robustness tests, the influence coefficient of Internet use on SWB is still significantly positive, which indicates that Internet use significantly improves the SWB of Chinese residents. Such results validate the "network gain effect," which corresponds to Hong (2007), Sabatini and Sarracino (2017)'s research, that is, Internet use has increased social communication, created consumer value, increased income and other positive effects. So far, this study has solved a basic problem, that is, whether the Internet has improved the SWB of Chinese residents, but we still need to solve a deeper problem, that is, from a multi-dimensional perspective, what aspects of the Internet will affect SWB? The previous literature review shows that the Internet will not only enhance people's social circle, but also may be conducive to improving people's work efficiency. At the same time, it will also have an important impact on daily life. Therefore, we need to do more analysis work.

Multi-dimensional test

Through the above analysis and the variable construction process, the SWB constructed in this study included five dimensions, which, respectively, reflect the individual's job satisfaction, life satisfaction, happiness, positive relationship with others, and confidence in the future. The question then arises: what dimensions of SWB are affected by Internet use? The comprehensive index of Internet use includes different aspects of learning, work, entertainment, social and business activities. Is there a significant difference in the impact of individuals' Internet use in different fields on SWB? Next, this study further explored the impact of Internet use on residents' SWB from the perspective of different dimensions of SWB and different dimensions of Internet use.

Different dimensions of subjective well-being

The comprehensive indicators used to measure SWB were sub-divided into five sub-indicators for testing. This multidimensional study responds the review points of Çikrıkci (2016), Castellacci and Tveito (2018), they believe that SWB consists of different elements. Firstly, SWB is assessed under the hedonic dimension of well-being. It's an assessment of their own life by the individual in terms of obtaining satisfaction; secondly, psychological well-being develops on the basis of the eudaimonic dimension of SWB. It deals with the potential of the individual to enter interactions with others using abilities and communication skills and the responsibilities of all these processes in terms of life aims; thirdly, self-esteem is also the component of SWB, it comprises all internal beliefs of the individual about themselves. This study measured individual SWB from five dimensions: job satisfaction, life satisfaction, happiness, social ties, and future confidence. These views coincide with our understanding of SWB. According to the results of the impact on different dimensions of well-being in **Table 4**, there are certain differences in the impact of Internet use on different dimensions of SWB. Specifically, Internet use has significantly promoted residents' job satisfaction, happiness, social ties, and future confidence, but has no significant impact on life satisfaction. The possible reason is that, on the one hand, the efficient matching mode brought by the Internet enables people to choose their own work according to their work preferences, and the workplace and working methods are more diversified. At the same time, the instant messaging function of the Internet solves communication problems caused by distance (Purcell et al., 2013), which makes individuals benefit from the Internet. On the other hand, while increasing online communication, Internet use also reduces face-to-face communication between family members and reduces the quality of face-to-face interaction, resulting in tension in family relations (Sabatini and Sarracino, 2017). Disharmonious family relations will lead to the decline of quality of life and life satisfaction. We also used Oprobit model for analysis, and the conclusion is consistent. See **Appendix Table A1** for the test results.

Different perspectives of Internet use

Internet use was divided into five sub-areas, which represent Internet use for learning, work, social, entertainment, and business activities. For now, the Internet has profoundly changed society, and has pervaded every corner of people's lives. According to previous researches, the influence effects brought by Internet are different or even opposite, which may be related to people's application of Internet to different fields (Ganju et al., 2016; Lu and Kandilov, 2021). As mentioned above, on the one hand, Internet improves work efficiency, which may improve SWB of individuals to a certain extent (Purcell et al., 2013; Campante et al., 2018). On the other hand, Internet may make people deeply immersed in online social interaction, thereby reducing face-to-face communication with family members, which is not conducive to SWB (Sabatini and Sarracino, 2017). Therefore, when Internet is used in different fields, it may have different effects on SWB, at this

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TABLE 4 Results of different dimensions of SWB.

	Job satisfaction	*Life satisfaction*	*Happiness*	*Social ties*	*Future confidence*
	(1)	**(2)**	**(3)**	**(4)**	**(5)**
Internet	0.422***	0.013	0.409***	0.378***	0.292***
	(7.61)	(0.23)	(3.51)	(7.71)	(5.92)
lnage	−6.766***	−3.917***	−15.743***	−2.933***	0.825
	(−8.97)	(−5.03)	(−9.38)	(−4.30)	(1.11)
lnage_sq	0.979***	0.561***	2.148***	0.445***	−0.137
	(9.17)	(5.11)	(9.10)	(4.63)	(−1.30)
gender	−0.079***	−0.033*	0.067*	0.009	0.061***
	(−4.37)	(−1.84)	(1.75)	(0.59)	(3.56)
marriage	0.068**	0.353***	1.122***	0.096***	0.179***
	(2.42)	(11.65)	(17.27)	(3.85)	(6.51)
education	0.021**	−0.006	0.058***	0.015*	−0.034***
	(2.25)	(−0.66)	(2.86)	(1.78)	(−3.71)
health	0.662***	0.877***	1.877***	0.474***	0.887***
	(14.42)	(19.49)	(18.91)	(11.91)	(20.65)
residence	0.121***	−0.046**	0.059	0.007	−0.013
	(5.30)	(−2.04)	(1.23)	(0.37)	(−0.62)
work	0.087***	0.070***	0.097*	−0.014	−0.031
	(3.73)	(2.89)	(1.91)	(−0.67)	(−1.36)
religion	0.042**	−0.003	0.008	0.025	0.051***
	(2.22)	(−0.15)	(0.21)	(1.52)	(2.86)
lnincome	0.055***	0.034*	0.054	0.021	0.026
	(3.02)	(1.84)	(1.35)	(1.34)	(1.51)
_cons	14.561***	9.949***	34.182***	8.064***	2.335*
	(11.02)	(7.24)	(11.54)	(6.70)	(1.80)
county_FE	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*
N	10943	10943	10943	10943	10943
R^2	0.132	0.149	0.176	0.104	0.139

***, **, and *, respectively, mean significant at 1%, 5%, and 10% levels, and *t* values in bracket is clustered.

time, it is necessary to analyze the heterogeneity. Table 5 reports the empirical results. It can be seen that there are also significant different effects of SWB brought about by the application of the Internet in different fields. Among them, the higher the frequency of using the Internet for studying, working, socialize, and commercial activities, the stronger the promotion effect on residents' SWB, corresponding regression coefficients are 0.139, 0.123, 0.090 and 0.045, respectively, and the above coefficients have passed the significance test at the 5% level. Comparing the results in different fields, it can be seen that the use of Internet for learning has the strongest effect on improving SWB, followed by the use of Internet for work, and finally the use of Internet for business activities, while the frequent use of the Internet for entertainment did not have an obvious promotion effect. This demonstrates that there is also "quantity" and "quality" in the field of Internet use. Using the Internet for their own reasons and then obtaining knowledge to improve individual skills will help cultivate residents' SWB. On the contrary, being controlled by the Internet and indulging in entertainment will not have a positive effect on individuals' SWB. We also used Oprobit model for analysis, and the conclusion is consistent. See Appendix Table A2 for the test results.

Heterogeneity test

From the above analysis, it is apparent that Internet use has played an important role in promoting residents' SWB. The question that needs to be given attention is: will there be some differences in this impact due to individual, family, and other factors? Next, this study investigated heterogeneity from three aspects: individual age, family income, and urban–rural differences. We use OLS and Oprobit model to analyze respectively, and the results are consistent. The Oprobit model's results can be seen in Appendix Table A3.

TABLE 5 Results of different areas of Internet use.

	(1)	(2)	(3)	(4)	(5)
Internet for studying	0.139***				
	(7.85)				
Internet for working		0.123***			
		(7.45)			
Internet for socialize			0.090***		
			(4.70)		
Internet for entertainment				0.021	
				(1.22)	
Internet for commerce					0.045**
					(2.05)
lnage	−3.132***	−3.188***	−3.338***	−3.254***	−3.273***
	(−6.65)	(−6.76)	(−7.02)	(−6.87)	(−6.91)
lnage_sq	0.450***	0.458***	0.483***	0.468***	0.471***
	(6.74)	(6.87)	(7.17)	(6.99)	(7.02)
gender	−0.016	−0.010	−0.010	−0.012	−0.012
	(−1.45)	(−0.94)	(−0.91)	(−1.09)	(−1.08)
marriage	0.172***	0.173***	0.171***	0.170***	0.170***
	(9.78)	(9.84)	(9.70)	(9.64)	(9.64)
education	0.003	0.001	0.010*	0.011*	0.009
	(0.55)	(0.09)	(1.76)	(1.86)	(1.64)
health	0.724***	0.727***	0.725***	0.726***	0.725***
	(26.06)	(26.11)	(26.02)	(26.02)	(26.01)
residence	0.020	0.011	0.023*	0.026*	0.025*
	(1.45)	(0.81)	(1.68)	(1.85)	(1.81)
work	0.028*	0.026*	0.036**	0.038**	0.037**
	(1.89)	(1.75)	(2.39)	(2.57)	(2.51)
religion	0.028**	0.029**	0.030***	0.030**	0.029**
	(2.37)	(2.51)	(2.58)	(2.56)	(2.49)
lnincome	0.038***	0.036***	0.041***	0.045***	0.044***
	(3.43)	(3.17)	(3.68)	(3.99)	(3.94)
_cons	8.689***	8.782***	8.948***	8.883***	8.921***
	(10.51)	(10.62)	(10.75)	(10.69)	(10.75)
county_FE	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*
N	10943	10943	10943	10943	10943
R^2	0.174	0.174	0.172	0.170	0.170

***, **, and *, respectively, mean significant at 1%, 5%, and 10% levels, and *t* values in bracket is clustered.

Comparative analysis of different age groups

Age is an important factor affecting SWB (Ferrer-I-Carbonell and Gowdy, 2007). Are there differences in the impact of Internet use on SWB among different age groups? Generally, young people are accustomed to using Internet for communication, work and study, and they will use Internet more frequently. On the contrary, the Internet is a new thing for the elderly, and their cognition of Internet is still being explored. Considering the differences of different age groups' understanding and user experience of the Internet, this study divided the groups according to the age of the residents. Individuals aged 30 and below were regarded as the youth group, individuals aged 30–45 were regarded as the youth and middle-aged group, and individuals aged 45 and above were categorized as the middle-aged and above group. According to the results in Table 6, Internet use can significantly promote the SWB of different groups. For the youth group, the influence coefficient of Internet use on SWB is 0.217. For the youth and middle-aged group, the influence coefficient is 0.314. For the middle-aged and above group, the influence coefficient is 0.384. Compared with the increase of age, the promotion of Internet use on SWB is also increasing, that is, Internet use has the strongest effect on SWB in the middle-aged and above group, and the weakest effect in the youth group. We may be able to find possible reasons for this with sample data, and it shows that the middle-aged group and below prefer to use Internet more for study and work, while the middle-aged and above group use the Internet more for business activities and study. It means youth group are a generation growing up with the Internet, while enjoying the convenience of Internet, they also bear more pressure on study and work. For the middle-aged and above, the Internet appeared in the latter half of their lives, so it is more special, and they can obtain a greater marginal effect. At the same time, we provide interaction effects of age with internet use in **Appendix Table A4**, it shows that interaction effect is still significantly positive, which can verify above results.

Comparative analysis of different family incomes

In this study, those whose family income was below the average value were regarded as low-income family groups, and those whose family income was above the average value were regarded as high-income groups. According to the results of columns (4) and (5) in Table 6, the coefficient of Internet use on the SWB of low-income families is 0.367, which is significant at the level of 1%. The coefficient of Internet use on the SWB of high-income families is 0.185, which is only significant at the level of 5%. This result shows that compared with high-income families, Internet use plays a more significant role in improving the well-being of low-income families. To some extent, this reflects the complementary effect of the Internet and the advantages of new generation technologies such as the Internet. Specifically, China is a society of human relations and resources. In the period in which the Internet was underdeveloped, wealthy families often had more social resources and opportunities to obtain better work and lives. The rapid development of the Internet provided more opportunities for fair competition. Moreover, it also had the function of social supervision, which enabled poor families to obtain more benefits.

Comparative analysis of urban and rural areas

Considering the inherent dual structure of urban and rural areas in China, Internet use may have different effects on the SWB of residents in different regions. Therefore, this study used urban residents' samples and rural residents' samples for comparative analysis. According to the test results of columns (6) and (7) in Table 6, the impact of Internet use on the

TABLE 6 Heterogeneity test results.

	Different age groups			Different income groups		Different regional groups		Different gender groups	
	Age 30 and below	Age 30–45	Age 45 and above	Low-income	High-income	Urban	Rural	Female	Male
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Internet	0.217***	0.314***	0.384***	0.367***	0.185***	0.232***	0.316***	0.198***	0.347***
	(3.68)	(5.99)	(4.30)	(7.20)	(3.80)	(4.40)	(6.73)	(3.78)	(7.26)
lnage	−1.219	−0.508	9.064	−2.713***	−3.548***	−3.588***	−3.131***	−1.848**	−3.947***
	(−0.43)	(−0.09)	(1.17)	(−4.55)	(−4.30)	(−3.64)	(−5.62)	(−2.13)	(−6.74)
lnage_sq	0.153	0.079	−1.036	0.396***	0.509***	0.507***	0.454***	0.276**	0.567***
	(0.35)	(0.11)	(−1.07)	(4.70)	(4.35)	(3.68)	(5.75)	(2.23)	(6.86)
gender	0.001	−0.002	−0.060**	−0.024	0.005	0.006	−0.020	0.000	0.000
	(0.07)	(−0.13)	(−2.42)	(−1.62)	(0.28)	(0.32)	(−1.43)	(.)	(.)
marriage	0.154***	0.175***	0.235***	0.137***	0.214***	0.197***	0.166***	0.161***	0.179***
	(6.08)	(5.16)	(4.68)	(5.56)	(8.15)	(6.38)	(7.57)	(5.55)	(7.61)
education	0.007	−0.024**	0.042**	−0.012	0.013	0.008	−0.008	−0.001	0.004
	(0.53)	(−2.37)	(2.14)	(−1.47)	(1.43)	(0.85)	(−0.98)	(−0.14)	(0.48)
health	0.742***	0.783***	0.652***	0.746***	0.662***	0.690***	0.727***	0.719***	0.740***
	(14.14)	(17.58)	(12.10)	(21.32)	(13.73)	(13.16)	(21.84)	(16.31)	(19.74)
work	0.037	−0.007	0.033	0.024	0.012	0.014	0.016	0.013	0.027
	(1.36)	(−0.33)	(1.21)	(1.46)	(0.44)	(0.44)	(1.03)	(0.59)	(1.41)
residence	0.048*	0.046*	−0.022	0.051**	−0.007	0.000	0.000	0.013	0.044**
	(1.82)	(1.88)	(−0.69)	(2.33)	(−0.33)	(.)	(.)	(0.54)	(2.13)
religion	0.037*	0.037**	0.003	0.049***	−0.001	−0.002	0.045***	0.026	0.035**
	(1.76)	(2.01)	(0.10)	(3.18)	(−0.07)	(−0.12)	(3.07)	(1.43)	(2.15)
lnincome	0.000	0.055***	0.041*	0.036	0.068***	0.045**	0.031**	0.043**	0.022
	(0.01)	(2.95)	(1.67)	(1.61)	(2.88)	(2.35)	(2.09)	(2.42)	(1.44)
_cons	5.731	3.886	−16.325	7.881***	9.276***	9.359***	8.602***	6.284***	10.018***
	(1.29)	(0.40)	(−1.06)	(7.51)	(6.43)	(5.37)	(8.84)	(4.14)	(9.72)
county_FE	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*
N	3461	4611	2871	6773	4170	3338	7605	4674	6269
R^2	0.264	0.218	0.194	0.183	0.244	0.234	0.190	0.198	0.214

***, **, and *, respectively, mean significant at 1%, 5%, and 10% levels, and *t* values in bracket is clustered.

SWB of urban residents is 0.232, and the coefficient of rural residents' SWB is 0.316, both of which are significant at the level of 1%. This shows that Internet use has an important impact on residents' SWB in different regions, and there is little difference. This is partly due to the popularity of mobile Internet in China. According to the above data, China's Internet penetration rate had reached 73.0% in 2022. In recent years, the Chinese government has continuously promoted the construction of "Broadband Countryside," "Digital Finance" and other projects in order to achieve common prosperity and achieve the overall goal of a moderately prosperous society. Consequently, there is no significant difference in the popularity of the Internet between towns and villages. Therefore, there is no substantive difference in the SWB of residents in different regions.

Comparative analysis of different gender groups

Gender is one of the important factors affecting SWB, and the basic test results also verify this view. Is there a difference in the impact of Internet on the SWB of different genders? To examine this issue, this study divides the research sample into female group and male group. According to the results of columns (8) and (9) in Table 6, the coefficient of Internet use on the SWB of the female group is 0.198, and the coefficient in male group is 0.347. This result shows that Internet use has a greater effect on the improvement of males' SWB. Considering the possible reasons, in China, males tend to bear more pressure from work and family life with the traditional family and social values, and they need to spend most of their energy on studying, living and working, so their SWB is generally lower than that of

women (Basic results can verify this fact), Internet use provides them with convenience in work, study and life, so they gain more marginal effects. In addition to this, we provide interaction effects of gender with internet use in **Appendix Table A4**, it shows that interaction effect is still significantly positive, which can verify above results.

Conclusion

With the deep integration of information technology in many aspects of people's work, life, and entertainment, the impact of Internet use on micro individuals is increasingly becoming an important issue of concern for all sectors of society. SWB is not only an eternal goal pursued by people, but also an important indicator of social progress. Using the data of CFPS2018, this study discussed the impact of Internet use on residents' SWB, which provides an important basis at the micro level for evaluating the economic and social effects of the Internet. The conclusions of this study are as follows: (1) Internet use has played a significant role in promoting residents' SWB. This conclusion is still valid after solving endogenous problems and a series of robustness tests. (2) The promotion effect of Internet use on residents' SWB is mainly reflected in job satisfaction, happiness, social ties, and future confidence, but the effect on life satisfaction is not significant. Individuals use the Internet more in the fields of studying, working, and socialize activities, which has a significant effect on the improvement of residents' SWB, while using the Internet more for entertainment has no significant impact. (3) The promoting effect of Internet use on residents' SWB is heterogeneous due to individual and family factors, and there is no significant difference between urban and rural areas. Specifically, Internet use has a stronger promoting effect on the SWB of older, male groups and has a more obvious impact on the SWB of low-income families.

This study examined the micro effects of Internet use, not only by analyzing the relationship between Internet use and residents' SWB from the perspective of different dimensions, but also by exploring the heterogeneity of Internet use affecting residents' SWB. This provides beneficial enlightenment for further improving residents' SWB and deepening Internet application.

The policy implications of this study are as follows. First, with the rapid development of the digital economy, when building a digital society and a network-based power, the government should fully consider the impact of the Internet on micro individuals, so as to grasp "hard power," on the one hand, by expanding the construction of network infrastructure and "soft power," on the other hand, by helping people master more Internet skills, so that more people can deeply enjoy achievements gained through Internet use. Second, individuals' correct understanding of the Internet should be established, and they should be actively guided to use it rationally. Only scientific and effective Internet use will have a more positive effect on micro individuals. This is particularly relevant for youth groups, because they are the source of human capital in the future. They should be guided to use the Internet reasonably and scientifically for study, work, and other aspects of life that can improve their skills or knowledge, and they should try to avoid indulging in online games and too much virtual social networking, so as to lay a foundation for the improvement of the quality of human capital in the future. Finally, the applicability of the Internet in different fields and regions should be deepened and expanded. The online classroom should be promoted for students, expanding the diversification of subjects and types of online education, and encouraging them to participate widely in online learning. For working groups, digital labor platforms can be promoted to explore the potential of the Internet for improving work efficiency and flexibility. In addition, equality of Internet resources between urban and rural areas should be promoted.

Data availability statement

Publicly available datasets were analyzed in this study. This data can be found here: http://www.isss.pku.edu.cn/cfps/.

Author contributions

JZ contributed to the writing – original draft, methodology, visualization, and resources. FZ contributed to the writing – review and editing, methodology, and formal analysis. 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

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Appendix

APPENDIX TABLE A1 Results of different dimensions of SWB (Oprobit model).

	Job satisfaction	*Life satisfaction*	*Happiness*	*Social ties*	*Future confidence*
	(1)	**(2)**	**(3)**	**(4)**	**(5)**
Internet	0.547***	−0.006	0.187***	0.552***	0.385***
	(7.70)	(−0.08)	(2.82)	(7.80)	(5.56)
Control variables	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*
county_FE	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*
N	10943	10943	10943	10943	10943
R^2	0.057	0.065	0.052	0.049	0.069

***, **, and *, respectively, mean significant at 1%, 5%, and 10% levels, and *t* values in bracket is clustered.

APPENDIX TABLE A2 Results of different areas of Internet use (Oprobit model).

	(1)	**(2)**	**(3)**	**(4)**	**(5)**
Internet for studying	0.270***				
	(8.06)				
Internet for working		0.240***			
		(7.71)			
Internet for socialize			0.168***		
			(4.71)		
Internet for entertainment				0.032	
				(1.00)	
Internet for commerce					0.081**
					(1.98)
Control variables	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*
county_FE	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*
N	10943	10943	10943	10943	10943
R^2	0.043	0.043	0.042	0.042	0.042

***, **, and *, respectively, mean significant at 1%, 5%, and 10% levels, and *t* values in bracket is clustered.

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APPENDIX TABLE A3 Heterogeneity test results (Oprobit model).

	Different age groups			Different income groups		Different regional groups		Different gender groups	
	Age 30 and below	Age 30–45	Age 45 and above	Low-income	High-income	Urban	Rural	Female	Male
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Internet	0.476***	0.623***	0.683***	0.393***	0.185***	0.501***	0.597***	0.380***	0.683***
	(3.97)	(6.15)	(7.27)	(3.95)	(3.80)	(4.61)	(6.85)	(3.79)	(7.51)
Control variables	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*
county_FE	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*
N	3461	4611	2871	6773	4170	3338	7605	4674	6269
R^2	0.072	0.055	0.047	0.044	0.066	0.047	0.063	0.051	0.054

***, **, and *, respectively, mean significant at 1%, 5%, and 10% levels, and *t* values in bracket is clustered.

APPENDIX TABLE A4 The interaction effects of age, gender with Internet use.

	OLS		Oprobit	
	(1)	(2)	(3)	(4)
Internet	0.256	0.162***	0.454	0.294***
	(0.67)	(3.62)	(0.62)	(3.48)
Internet_lnage	0.181*		0.321**	
	(1.78)		(2.40)	
Intennet_gender		0.202***		0.416***
		(3.65)		(3.97)
lnage	−3.205***	−3.265***	−6.095***	−6.211***
	(−6.52)	(−6.92)	(−6.62)	(−7.04)
lnage_sq	0.463***	0.472***	0.882***	0.900***
	(6.77)	(7.06)	(6.89)	(7.20)
gender	−0.011	−0.083***	−0.017	−0.166***
	(−0.96)	(−3.44)	(−0.83)	(−3.68)
marriage	0.174***	0.173***	0.329***	0.328***
	(9.84)	(9.88)	(10.18)	(10.22)
education	−0.001	0.000	−0.005	−0.003
	(−0.14)	(0.01)	(−0.46)	(−0.29)
health	0.725***	0.728***	1.418***	1.426***
	(26.09)	(26.22)	(26.49)	(26.63)
work	0.017	0.018	0.029	0.031
	(1.24)	(1.32)	(1.11)	(1.19)
residence	0.028*	0.029*	0.050*	0.053*
	(1.87)	(1.96)	(1.77)	(1.88)
religion	0.029**	0.028**	0.059***	0.057***
	(2.48)	(2.40)	(2.70)	(2.61)
lnincome	0.034***	0.034***	0.058***	0.057***
	(3.03)	(2.98)	(2.76)	(2.70)
_cons	8.743***	8.880***		
	(9.90)	(10.72)		
county_FE	*Yes*	*Yes*	*Yes*	*Yes*
N	10943	10943	10943	10943
R^2	0.175	0.176	0.043	0.044

***, **, and *, respectively, mean significant at 1%, 5%, and 10% levels, and *t* values in bracket is clustered.

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EDITED BY
Stephen Schueller,
University of California, United States

REVIEWED BY
Linda Charmaraman,
Wellesley College, United States
André Luiz Monezi Andrade,
Pontifical Catholic University of Campinas, Brazil

*CORRESPONDENCE
Jasmina Rosič
jasmina.rosic@kuleuven.be

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Positive digital communication among youth: The development and validation of the digital flourishing scale for adolescents

Jasmina Rosič[1]*, Sophie H. Janicke-Bowles[2], Luca Carbone[1], Bojana Lobe[3] and Laura Vandenbosch[1]

[1]School for Mass Communication Research, Faculty of Social Sciences, KU Leuven, Leuven, Belgium, [2]School of Communication Research, Chapman University, Orange, California, United States, [3]Center for Methodology and Informatics, Faculty of Social Sciences, University of Ljubljana, Ljubljana, Slovenia

Research has extensively studied the negative effects of digital communication on adolescents' well-being. However, positive digital experiences and behavior in adolescence are still poorly understood. The recently developed Digital Flourishing Scale addresses this gap and focuses on the positive perceptions of a user's experiences and behaviors in digital communication among adults. In this paper, we developed an adolescent version of this scale. Study 1 demonstrated the internal consistency of the scale and the same factor structure for adolescence as for adulthood: connectedness, civil participation, positive social comparison, authentic self-presentation, and self-control. Study 2 confirmed the identified factor structure with a second sample of adolescents and established measurement invariance across genders. The construct validity of the scale was confirmed by investigating associations with related constructs, including the basic psychological needs from self-determination theory (competence, autonomy, and relatedness), secure attachment to a close friend, Internet aggression, social media-induced inspiration, authenticity of posted positive content, and social media self-control failure. The results indicated that not all adolescents flourish equally online. Differences occurred depending on the adolescents' gender and socioeconomic status. The paper concludes that the newly developed scale is a valid and reliable measure for assessing adolescents' perceptions of digital thriving and digital empowerment.

KEYWORDS

scale development, digital flourishing, digital communication, positive media psychology, well-being, adolescents

1. Introduction

The influence of digital communication technologies, such as social media and smartphones, on the well-being and mental health of adolescents has received considerable research attention. Several instruments have been developed to assess negative perceptions of technology use, including problematic Internet, social media, or mobile use (1–3) and the fear of missing out (4). However, users' positive

perceptions of their technology use are much less explored (5). Several studies have measured the positive effects of digital communication on user well-being using concepts such as self-esteem (6), self-affirmation (7), and, most often, social capital and support (8). Such variables can be considered indicators of perceived positive technology use, yet they do not measure perceived positive digital communication directly or comprehensively.

Thus, while instruments exist that try to identify users who perceive themselves as experiencing harm from digital technology use, we lack a conceptualization and measurement of perceived positive digital experiences and behaviors (i.e., those that thrive in digital communication). This is specifically relevant to adolescents' technology use. This age group (from 13 to 17 years) is not only using digital communication the most (9) but has also been described in the popular press as the most negatively affected age group, even though new evidence suggests that these negative mental health and well-being effects are highly person-specific (10, 6).

Moreover, not only do effects vary on an individual level, but they are also dependent on the type of use and its measurement (5, 11, 10). Existing scales of perceived communication technology typically measure behaviors or experiences tied to a particular device (e.g., smartphone), application (e.g., social media and email), or feature (e.g., status update and private messenger) rather than experiences or behaviors that are communication centered and thus shared across devices, applications, and features (11, 12). To address these shortcomings in existing measures, the Digital Flourishing Scale (DFS) (13) has recently been proposed, which focuses on perceived digital communication rather than on specific devices or applications. The DFS has been used to study the adult population and has not yet been evaluated in adolescent research. The present research adapted the existing measure to specifically capture digital communication that is perceived to be positive by adolescents. The measure thus introduced a new assessment of the positive perceptions of young media users' digital communication into the literature. This measure will be henceforth referred to as the Digital Flourishing Scale for Adolescents (DFSA); its validity and reliability were tested in different samples of adolescents. The specific aims of the present research were to (a) identify the factor structure of the newly proposed scale *via* exploratory factor analysis in the first sample of adolescents, (b) evaluate the internal consistencies for the subscale scores, (c) confirm the factor structure with another sample of adolescents *via* confirmatory factor analysis, (d) examine the DFSA for measurement invariance, (e) investigate the construct validity of the DFSA scores with the existing measures, and (f) offer some first results of how the DFSA relates to adolescents' identity by exploring the relationships of its subscales with demographic variables (i.e., gender, age, education track, paternal and maternal education level).

2. Defining digital flourishing

According to Janicke-Bowles et al. (13), digital flourishing is defined as the positive perceptions of an individual's experiences and behaviors in digital communication. To measure this concept, an instrument was developed for adults that consists of five internally valid digital flourishing dimensions: connectedness (level of perceived connectedness with one's online network), civil participation (level of considerate digital communication), positive social comparison (level of inspiration from positive online comparisons), authentic self-presentation (level of authentic presentation of the self in digital communication), and self-control (level of control over one's digital communication).

In general, the DFS captures high digital flourishing as users' multi-faceted perceptions of the benefits of digital communication. These include individuals feeling closely connected to and supported by their online community, their considerate and reflected interactions with others, knowing how to present themselves consistently and authentically in digital arenas, feeling inspired when compared with others, and being in control of when to start and when to stop interacting online.

The DFS and its background have several characteristics that make this scale a unique instrument in the current literature. First, Janicke-Bowles et al.' (13) conceptualization of digital flourishing is based on the notion of digital communication, also termed computer-mediated communication, which is defined as "an inclusive umbrella term for multimodal human-to-human social interaction mediated by information and communication technologies (ICT's)" (11, pp. 2–3, 12). Such digital communication includes interpersonal and masspersonal "active" communication (e.g., instant messaging and posting status updates) as well as more "passive" social attention (e.g., browsing through social media) (14). Research has converged on the preliminary conclusion that the effects of social media on well-being depend strongly on the interactional qualities of its use, specifically whether the use entails active communicative or passive consumptive elements of social interaction (15, 11). Given this centrality of digital communication for well-being—rather than the time spent on the device or other channel-related aspects (16)—the digital flourishing scale focuses on this communication level.

Second, the scale focuses on the positive aspects of mental health, specifically flourishing. Flourishing (17, 18) was first conceptualized in positive psychology and is understood as "feeling well," which is generally operationalized as subjective well-being (19), and "doing well," which is also referred to as eudaimonic well-being (20).

Theoretically, it has been argued that flourishing (i.e., subjective and eudaimonic well-being) is determined by the satisfaction of three basic psychological needs: competence, relatedness, and autonomy, as exemplified in self-determination theory (SDT) (21). Furthermore, Gudka et al. (5) referred to these basic psychological needs as important conditions for

flourishing within the context of social media. Therefore, the DFS (13) uses SDT as an organizing framework to identify and organize the core facets of digital flourishing. According to SDT, humans are intrinsically motivated to act in the world because doing so will satisfy their basic psychological needs for competence, relatedness, and autonomy, which are essential for short-term hedonic well-being and long-term eudaimonic growth (21). Competence is related to perceiving oneself as effective in manipulating the environment in a way that results in valued outcomes; relatedness involves a sense of connection, care toward others, and feeling cared for by others; and autonomy refers to having a sense of control, volition, or freedom when engaging in an activity (21).

In a first validation study of the DFS scale in adults, the authors (13) found that the five individual subscales of digital flourishing were significantly associated with the satisfaction of the basic psychological needs. This supports the overall notion that the flourishing dimensions are relevant to competence, relatedness, autonomy, and, ultimately, well-being.

3. Digital flourishing in adolescence

Adolescence is a life stage with several psychosocial and cognitive developmental changes that clearly distinguish it from other life stages (22). Psychosocial changes include continuous emotional separation from parents and the increased importance of socializing with peers and other socialization agents (23). Cognitive changes include improved cognitive self-regulation, increased emotion regulation, and impulse control (24).

These psychosocial and cognitive changes affect the satisfaction of the basic psychological needs (i.e., relatedness, competence, and autonomy), as defined by SDT (21). First, the need for relatedness leads adolescents to bond more strongly with peers (rather than parents) (23). Second, the need to feel competent leads them to take up more challenging cognitive tasks in line with their growing cognitive skills (24). Third, psychosocial and cognitive changes also lead adolescents to satisfy their need for autonomy in different ways than in preadolescence (e.g., striving toward more advanced tasks that satisfy the feeling of independence) (25).

The changed ways in which adolescents meet their basic psychological needs are also expressed in adolescents' differential uses of digital communication (i.e., connecting with friends, self-presentation, social comparison, civil participation, and controlled use). These uses provide unique opportunities to satisfy adolescents' basic psychological needs and flourish online (26). In adolescence, digital communication is, for instance, a more central way of communicating and connecting with peers and others than in other life stages (27).

More precisely, psychosocial changes prompt adolescents to engage in digital communication, as digital communication offers a multitude of opportunities to build stronger connectedness with online and offline peer communities (28). Research has demonstrated that adolescents seize online opportunities and engage in digital communication to strengthen their bonds with existing friends and build new friendships online (29). Behaviors such as posting images on public social media (30), privately exchanging messages and photos, or sharing everyday information and small signs of affection throughout the day often extend adolescents' offline communication and strengthen their relationships with their peers (31).

In addition to enhancing connectedness, digital communication allows adolescents to self-present and become more autonomous individuals. In this view, adolescents have stressed the importance of remaining authentic in their self-presentation when sharing information about themselves (32, 33). Such authentic self-presentation is sometimes challenged, given that positivity norms and platform features, such as filters, invite adolescents to present the best (but not necessarily true) version of themselves (34, 35). Yet, presenting one's true self online is known to be beneficial for adolescents' psychological development, leading to increased self-esteem (36), which is, in turn, important for well-being.

Digital communication also invites adolescents to participate in social comparison processes that inform them about how competent they are in relation to their peers. Noon and Meier (37) argued that most studies on digital social comparison particularly focused on whether upward comparisons evoked jealousy, malicious envy, anxiety, and increased depressive symptoms among adolescents. Recent research has also indicated that positive social comparisons (i.e., comparisons to authentic and similar others) occur in adolescence and may evoke feelings of motivation, inspiration, enjoyment, and benign envy; this motivates adolescents to self-improve (37, 33).

Similarly, research has focused on uncivil online participation in adolescence, mostly in the context of cyberbullying, but has neglected the advantages that come with civil online participation (38). Civil participation may be especially relevant for adolescents, as psychosocial changes toward stronger bonding with peers encourage them to engage more actively in online discussions; thus, civil participation can address their increased need for relatedness (39). Cognitive changes in emotion regulation and impulse control make it possible for these online discussions to be conducted in a respectful, polite, mindful, responsible, and civil manner (40). Some research has shown that adolescents are mindful of civil participation in online communities (41).

Lastly, cognitive changes contribute more to increased self-control over digital communication in adolescence than in younger ages (children aged 11 years and younger) (42). The digital flourishing dimension of self-control is particularly relevant to contemporary adolescents who are constantly connected to their digital devices. They are more challenged to control when and how often they connect, and thus how autonomous they feel in their digital connection. Having such

self-control has been related to positive outcomes, including positive well-being (15) and increased cognitive performance (43).

In sum, research has focused on the relationship between digital communication in adolescents and digital flourishing. Yet, digital flourishing has never been systematically examined as a comprehensive concept among adolescents. Most studies have also focused on the negative effects of digital behaviors on adolescents, leaving positive aspects often unconsidered.

4. The current study

To date, we lack an instrument that captures digital flourishing in adolescence. Therefore, the present research adapted the existing Digital Flourishing Scale (13) to adolescents' (DFSA) digital communication experiences and behaviors. Two cross-sectional studies were organized among adolescents to explore and confirm the factor structure of the new instrument, to test for measurement invariance, and to establish the construct validity of the scale (as a whole and for respective subscales). An overview of the included validation concepts is given below.

4.1. The satisfaction of basic psychological needs

The concept of digital flourishing is grounded in SDT (21). According to SDT, adolescents with satisfied basic psychological needs of autonomy, competence, and relatedness are more likely to act prosocially and have higher well-being (25). The authors of the DFS (13) used the psychological need satisfaction scale (21) in their validation study and found that all five flourishing dimensions were significantly associated with the satisfaction of basic psychological needs. As such, we tested whether positive correlations could be found between the three satisfied basic psychological needs and the newly developed DFSA.

4.2. Technology interference

Technoference refers to interruptions to offline social interactions due to technology use (44). The concept is based on the premise that during an offline social interaction, one interaction partner uses (or starts using) technology, keeps this content to themself, and thus interrupts the conversation (45). Experimental research demonstrated that technoference among strangers and close friends (emerging adult dyads) was related to decreased feelings of closeness, lower interpersonal connectedness, reduced quality of interactions, and decreased friendship intimacy (46, 47). Accordingly, we expected that higher rates of technoference in adolescents would be negatively correlated with the DFSA dimension(s) of feeling connected to close and distant others online.

4.3. Posting positive social media content

Adolescents are often exposed to positivity bias on social media. Consequently, some adolescents feel pressured to post socially desirable (positive) portrayals of their lifestyles online (34, 35). Schreurs and Vandenbosch (34) identified three main types of positively biased content posted by adolescents on social media: attractive appearance, happy and interesting social life, and (professional) achievements. These contents are not always authentic, especially when adolescents frequently post positively biased posts (34). Accordingly, we assumed that higher rates of posting positively biased social media content would be negatively related to the DFSA dimension(s) of being authentic in one's self-presentation online.

4.4. Social media-induced inspiration

Prevalent positive presentations of users on social media prompt adolescents to compare themselves with the achievements of others posted online (i.e., upward comparisons). These upward comparisons can evoke positive feelings of inspiration (48). One study showed that the more adolescents compared themselves online, the more inspiration they experienced. In addition, comparisons were more inspiring when adolescents compared themselves to similar others who authentically presented themselves online (i.e., positive social comparison) (37). Therefore, we expected that a positive relationship would emerge between social media-induced feelings of inspiration and the DFSA dimension(s) related to positive social comparisons in digital communication.

4.5. Aggressive digital communication

Internet aggression refers to intentional online aggressive behavior toward others. It comprises rude, embarrassing, threatening, or harassing comments, unwanted sexual comments, and exclusion (e.g., blocking someone's messages) (49). This concept stands in strong contrast to online civil participation. The latter concept refers to responsible, mindful, open, and polite digital communication, which includes discussions between people with different points of view (13). Internet aggression is the opposite of civil participation; therefore, we expected a negative correlation between Internet aggression and the DFSA dimension(s) of civil participation.

4.6. Social media self-control failure

Social media users sometimes fail to control their temptation to use social media when it conflicts with other goals and obligations.

Digital interruptions (e.g., notifications) typically conflict with pursuing other goals (e.g., professional or educational achievements), making efficient use of time, and performing important tasks (50). It can be assumed that adolescents who fail to self-control social media use are also challenged by controlling other digital communication (e.g., texting) (51). Hence, we expected that social media self-control failure would negatively correlate with the DFSA dimension(s) of self-control.

5. General method

We followed the methodological standards of the scale development literature to develop the DFSA (52). First, the DFS was adapted to apply to adolescents. The DFS begins with an introduction explaining the term 'digital communication'. Within the DFSA, the original introduction was adapted by using language suitable for adolescents and adding specific examples of digital communication platforms (e.g., having an interaction on social media was illustrated with the example of "posting, commenting or liking posts on SnapChat, Instagram, TikTok or YouTube"). Moreover, as the methodological literature recommends using 5-point scales and not 7-point scales with adolescents (53), the original response format of the DFS (i.e., a 7-point Likert scale) was adapted to a scale ranging from 1 (not at all true of me) to 5 (very true of me) with an option "not applicable to me". The original Likert scale to measure agreement was discouraged to be used by the authors of DFS because it assesses general (dis)agreement with the statements (13) rather than how true each behavior or experience is for the person. Therefore, we used "true-of-me" answer options (53). Additionally, authors have recommended using more concrete time periods as unspecified timeframes cause confusion more easily (13). As such, adolescents were asked to assess each item as it had applied to them in the last month.

In line with the DFS, the newly proposed DFSA also contained a 25-item scale with 5 expected subscales including 5 items each. These subscales were intended to measure the dimensions of connectedness, civil participation, positive social comparison, authentic self-presentation, and self-control. Each subscale in the newly developed DFSA started with an introductory sentence in the child-friendly language (e.g., the civil participation subscale began with "The following statements are about how you express your opinion online. When assessing the statements think about the past month."). The existing items were adapted to be suitable for contemporary adolescents in terms of the language used and their developmental level. For example, we used simpler terms and included several specific examples in items. For instance, "When I interact with others about politics online, I know how to have a civil discussion." was changed to "When I talk to others online about politics (e.g., about the government, the President, elections), I know how to do it politely."

After these changes, the newly developed DFSA was prepared to be tested in two samples of adolescents. Given the researchers' accessibility to Slovenian adolescents, the English version of the scale was translated to Slovenian by two English-Slovenian bilinguals using a forward-and-back translation procedure (54). Next, two of the authors that are native Slovenian speakers reviewed the forward-and-back translations. The discrepancies between the Slovenian and English versions of the novel scale were resolved. Semantic, idiomatic, experiential, and conceptual equivalence between these two versions was achieved and consensus on the finalized Slovenian version was reached.

Following this translation, the readability and clarity of the scale were tested in a cognitive interview using a hybrid model (55) with one 15 years old female adolescent. Based on the feedback of this interview, we adapted the instructions (e.g., by adding Viber and TikTok as examples) and some items to be more suitable for early, middle, and late adolescents. For instance, a concrete example of acquaintances was added in the item: "I could turn to people who I connect with online (e.g., acquaintances) if I needed advice on a problem." The interviewed adolescent also confirmed she found the use of the "true-of-me scale" clear and supported the idea of using a time frame for assessing the items. An online **Supplementary Appendix A** in OSF presents the adaptation of DFS to DFSA.

In the next step, two cross-sectional surveys were organized. Study 1 examined which exploratory factor structure emerged in the adolescent population and determined the internal consistency of the newly developed DFSA. The purpose of Study 2 was to confirm the factor structure of the DFSA with a different sample of adolescents and examine measurement invariance across gender. Across the two studies, we also examined the associations between the newly identified digital flourishing dimensions with the constructs outlined above to explore the construct validity of the DFSA.

Supplementary Appendixes B and E in OSF display the initial and final items in English and Slovenian used in both studies. Data and other supplementary materials of both studies are also available online (https://osf.io/9wuyb/?view_only = 9e64aa7358ed40a0823a8cb75c49c3ae). Both studies were approved by the ethical commission of KU Leuven, Belgium, and University of Ljubljana, Slovenia.

6. Study 1

6.1. Method

6.1.1. Sample and procedure

For the first cross-sectional online survey a combined purposive sample of Slovenian adolescents (aged between 16 and 19) was recruited in June-August 2021. Four different recruitment strategies were applied. First, several secondary schools from different regions and educational tracks were

contacted and five agreed to participate. Schools presented the aims of the study and provided adolescents with information brochures and parental consent forms (*via* an online link or paper versions). For adolescents younger than 16, parents completed an active consent form, for adolescents aged 16 and older, passive parental consent was requested. Participants gave active consent to participate before the start of the survey. A total of 144 adolescents were recruited *via* the schools. The majority of participants [$N = 131$] completed the survey in class, and 13 completed it at home. Second, the sample was further extended by recruiting adolescents *via* 20 youth organizations (youth centers and scout movement organizations; the latter organizations are youth movements organizing practical outdoor leisure activities for youth aged 6–30 years old). These organizations invited their adolescent members aged 16–19 to participate in the study by providing them with information brochures, active consent sheets, and informing them of the passive parental consent procedure. Third, Facebook advertising was used by targeting the parents of adolescents aged 16–20 years and asking them, after giving passive consent, to invite their children to participate in the study. Again, adolescents were informed *via* information brochures and gave active consent. A total of 31 adolescents were recruited *via* youth organizations and Facebook advertising. Lastly, the first author also invited adolescents from her personal network [$N = 7$]. Adolescents were informed *via* information brochures and active/passive parental consent was requested depending on the age of the adolescent. They also gave active consent to participate before entering the survey. Participants were rewarded with a 5-euro voucher. Adolescents outside the age range of 11–20 years, without parental consent, and non-smartphone users could not participate. A total of 182 participants took part in the survey. Participants who had missing data on all items of the new scale were deleted [$N = 35$]. The final sample consisted of 147 participants aged 12–20 ($M_{age} = 17.90$, $SD = 1.24$, 59.18% girls). Based on the Slovenian secondary school system division, 72.80% followed the general education in which they were being prepared for college education, 19.73% followed the professional-technical education in which they were being taught primarily technical and professional skills, and 3.40% followed the vocational education leading to professions (e.g., merchant, carpenter); 4.08% were in elementary schooling or in higher education. The majority (67.35%) described their ethnicity as only central European (Slovenian). Within the sample, 49.66% of participants' mothers had a university degree and 46.94% of fathers had secondary education.

6.1.2. Measures

Measures were translated from English to Slovenian following a forward-and-back translation procedure. Half of the scales used to estimate construct validity were displayed to one subsample and the other half to the other subsample to avoid survey fatigue. Some of the validation scales (and the DFSA) offered an option "not applicable to me". Respondents who answered this option were coded as having a missing value. Because of the varying number of respondents, the exact number of respondents for each variable is reported in **Table 2**. Reliability of scales was interpreted as acceptable if Cronbach's $\alpha \geq 0.7$, as good if $\alpha \geq 0.8$, and as excellent if $\alpha \geq 0.9$ (56). The online **Supplementary Appendix B** in OSF displays full items of the used scales.

6.1.2.1. Demographic variables

Adolescents reported their age (2021–birth year), gender (1 = boy, 2 = girl, 3 = other, 4 = prefer not to say; categories 3 and 4 were coded as a missing value), educational track (1 = vocational, 2 = professional-technical, 3 = general education), a parental education level (measured separately for mother or female guardian and father or male guardian with 5 categories; educational categories were coded as < 4 = secondary education and lower, labeled low education, and >= 4 = post-secondary education, labeled high education), and ethnicity [with the categories allowing to choose multiple options (e.g., Central European, West European, South-East European)].

6.1.2.2. Digital flourishing in adolescence

The 25-item Slovenian DFSA ranging from 1 (not at all true of me) to 5 (very true of me) with an option "not applicable to me" was used.

6.1.2.3. The satisfaction of basic psychological needs

To measure self-determination in adolescence, we used the Satisfaction of Basic Psychological Needs in Adolescents questionnaire (25) with a 5-point scale ranging from 1 (not at all true of me) to 5 (very true of me). The scale consists of 12 items (e.g., "I feel good at doing many things.") with three subscales. The subscales yielded acceptable to good internal consistencies: Autonomy ($\alpha = 0.76$, 4 items, $M = 3.9$, $SD = 0.70$), Relatedness ($\alpha = 0.83$, 4 items, $M = 3.9$, $SD = 0.65$), Competence ($\alpha = 0.74$, 4 items, $M = 3.9$, $SD = 0.64$).

6.1.2.4. Technology interference

We used the modified version of the Technoference Scale (57). The original word "parents" was replaced with "friends" to align the content with our scale. Respondents rated three statements (e.g., "I ignore my friends when I am on my tablet/cell phone") on a 5-point scale ranging from 1 (not at all true of me) to 5 (very true of me), with higher scores indicating higher levels of technoference. The scale displayed average reliability considering it only included 3 items ($\alpha = 0.58$, 3 items, M = 2.1, SD = 0.68).

6.1.2.5. Posting positive social media content

We used the Posting Positive Social Media Content short form scale (34). Answers ranged from 1 (never) to 5 (very often), with the option "not applicable to me". The scale consisted of 8 items

(e.g., "How often do you post on most public applications, such as social media, posts in which you look beautiful.") and three subscales: Attractive Appearance (correlation between 2 items: $r = 0.69$, $p < 0.001$, $M = 2.1$, $SD = 1.0$), Happy (Social) Life ($\alpha = 0.90$, 5 items, $M = 2.5$, $SD = 1.0$), (Professional) Achievements (1 item, $M = 2.0$, $SD = 0.97$).

6.1.2.6. Social media-induced inspiration

We used the two items of the Social Media-Induced Inspiration Scale (48): "When I use social media I am inspired by the posts of other users to do something [new]." and "When I use social media I experience inspiration." The word "Instagram" was replaced with "social media". Answers ranged from 1 (strongly disagree) to 5 (strongly agree) with the option "not applicable to me". A strong correlation between the two items was found ($r = 0.70$, $p < 0.001$, $M = 3.0$, $SD = 0.98$).

6.1.2.7. Aggressive digital communication

We used the 4-item Internet Aggression Scale (49) (e.g., "I used the Internet to play a joke or annoy someone I was mad at."). Answers ranged from 1 (never) to 4 (5 or more times) with the option "not applicable to me". This scale displayed acceptable reliability ($\alpha = 0.77$, 4 items, $M = 1.2$, $SD = 0.47$).

6.1.2.8. Social media self-control failure

We used the three items of the Brief Measure of Social Media Self Control Failure (50) (e.g., "How often in the past month did you give in to a desire to use social media even though your social media use at that particular moment made you use your time less efficiently?"). Answers ranged from 1 (never) to 5 [very often (10 or more times)] with an option "not applicable to me". The scale displayed good reliability ($\alpha = 0.85$, 3 items, $M = 3.1$, $SD = 0.97$).

6.1.3. Analytical strategy

We followed the analytical strategy applied in prior scale development literature (e.g., 52, 34, 65) and first explored the factor structure of the DFSA. First, a principal component analysis (PCA) was conducted on the 25 items in R (version 4.0.4) to evaluate the number of components. The number of components to extract was determined on the basis of the Kaiser's criterion (eigenvalue > 1), examining the scree plot, percentage of variance accounted for per component [total cumulative variance explained (50%)], and parallel analysis (52). Second, we run an exploratory factor analysis (EFA) based on the number of factors selected through PCA and looked at the loadings of the items on each factor. Given that a correlation between sub-factors was expected, an oblique rotation (Promax method) was used. Items were removed due to either (a) item-factor loading below 0.5 on a primary factor, (b) factor loadings on multiple factors (above 0.3) or on a theoretically wrong factor, or (c) low communalities (below 0.4) (58). After omitting items, the process of running the EFA was repeated until item loadings were satisfactory, as factor loadings and structure can change after removing items.

After exploring the factor structure of the DFSA, internal consistency of the subscales was assessed by calculating Cronbach's alpha values for each identified (sub)factor with three or more items.

Finally, bivariate Pearson correlations were computed between the newly developed (sub)factors and selected construct validity variables to investigate construct validity as well as between the DFSA (sub)factors and demographic variables (i.e., gender, education track, paternal and maternal education level). Correlations were considered weak if values of r 0.10 $\leq$ 0.30, moderate r 0.30 $\leq$ 0.50, and strong $r \geq 0.50$ (59).

6.2. Results

6.2.1. EFA

The size of the Kaiser-Meyer-Olkin measure of sampling adequacy (KMO = 0.75) and Barlett's test of sphericity, $\chi^2(300) = 1757.086$, $p < 0.001$, suggested that the data was factorable.

In line with the original DFS, the initial factor structure results of the EFA also suggested a five-factor structure explaining 56.3% of variance. Also, a sudden drop in the scree-plot was seen after five factors were reached, and a parallel analysis supported this factor structure. The items that clustered on the same factors showed that factor 1 represented authentic self-presentation (eigenvalue = 6.60, 13.5% of the variance, 5 items, $M = 3.4$, $SD = 0.87$), factor 2 represented positive social comparison (eigenvalue = 3.40, 11.4% of additional variance, 5 items, $M = 3.2$, $SD = 0.83$), factor 3 represented civil participation (eigenvalue = 2.85, 11,1% of additional variance, 5 items, $M = 4.0$, $SD = 0.70$), factor 4 represented connectedness (eigenvalue = 2.05, 10.9% of additional variance, 6 items, $M = 3.2$, $SD = 0.75$), and factor 5 represented self-control (eigenvalue = 1.95, 9.4% of additional variance, 4 items, $M = 3.7$, $SD = 0.67$).

Four items were deleted after the initial inspection of factor scores (i.e., three items due to low factor loadings and one item due to conceptual incoherence with its primary factor: an item on self-control loaded on the connectedness factor) (see **Supplementary Appendix C** in OSF for a table with an initial examination of factor structure).

An EFA after deleting these items confirmed a five-factor model with improved results, explaining 60.8% of the variance with a total of 21 items and the same factors ($M = 3.4$, $SD = 0.49$). **Table 1** shows the final items and their factor loadings, communalities, eigenvalues, explained variance, and descriptive statistics. A five-dimensional factor structure with five separate, yet related latent factors was thus confirmed.

Factor correlations ranged between $r = 0.21$ to 0.54, indicating that the subscales represent distinct dimensions of

TABLE 1 Number of respondents, communalities, rotated factor loadings, reliability and descriptive statistics of the final DFSA items (study 1)..

	N	Communalities	Factor 1 Authentic self-presentation	Factor 2 Civil participation	Factor 3 Positive social comparison	Factor 4 Connectedness	Factor 5 Self-control
1. I show my true self online.	131	0.524	0.789				
2. When communicating online, I feel comfortable presenting the person I am.	131	0.599	0.771				
3. What I post online reflects who I really am.	126	0.493	0.781				
4. I feel comfortable presenting who I truly am online, in the same way I do offline.	133	0.665	0.794				
5. I allow people who I connect with online to see who I really am.	130	0.533	0.799				
6. When I talk to others online, I know how to share my point of view without offending them.	134	0.332		0.614			
7. When I communicate online, I am careful to adapt my comments and behaviors to be appropriate for whoever will read them (e.g., my friends, my teacher, my parents, younger children).	138	0.530		0.847			
8. When I talk to others online about something important to me, I know how to stand for it in a polite manner.	135	0.378		0.602			
9. When I talk to others online about politics (e.g., about the government, the President, elections), I know how to do it politely.	100	0.604		0.818			
10. When something that others say or do online makes me feel angry, I am able to respond in a calm way.	129	0.482		0.711			
11. Seeing others' achievements online inspires me to do better.	138	0.565			0.847		
12. Seeing how others present themselves online motivates me to make changes in my own life.	137	0.745			0.882		
13. Comparing myself to others online motivates me to accomplish the things I want in life.	138	0.616			0.684		
14. I compare my life to those people online (e.g., peers, influencers) who are going to push me to be better.	134	0.439			0.649		
15. I feel part of a group when I communicate with others online.	139	0.741				0.880	
16. I find my online communication (e.g., chatting with peers, playing online games with others) very important.	141	0.580				0.844	
17. I feel closely connected to the groups I connect with online.	139	0.431				0.682	
18. I feel in control of when to start and when to stop spending time on online communication.	134	0.409					0.626
19. For the most part, I feel in control of how much time I spend communicating with others online (e.g., chatting with friends, posting on Instagram, playing online games with others).	135	0.414					0.756
20. When I browse through online content, I feel in control of how I spend my time.	138	0.278					0.632
21. I am able to disconnect from my online communication when I need a break.	136	0.422					0.688
Eigenvalues			5.813	3.281	2.752	1.687	1.513
% of variance			15.6	13.3	12.1	10.3	9.5
M (SD)			3.4 (0.87)	4 (0.70)	3.2 (0.86)	3.1 (0.94)	3.7 (0.67)
Cronbach's α			0.86	0.81	0.85	0.80	0.70

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digital flourishing (see **Supplementary Appendix D** in OSF for correlations table).

6.2.2. Internal Consistency

Cronbach's α's for the final factors were 0.86 for authentic self-presentation, 0.85 for positive social comparison, 0.81 for civil participation, 0.80 for connectedness, and 0.70 for self-control. These findings support the internal consistency of the DFSA's scores.

6.2.3. Construct Validity

The flourishing dimensions correlated significantly with the bulk of the validation constructs included (see **Table 2**; no correlations are reported in text; all can be found in **Table 2**). First, all subscales were moderately but significantly associated with at least one if not more basic SDT needs (i.e., competence, relatedness, autonomy). The connectedness subscale correlated with all three needs, most significantly with relatedness. The civil participation subscale and the self-control subscale were the most significantly associated with autonomy. Finally, the positive social comparison and authentic self-presentation subscales most significantly correlated with competence.

As expected, the civil participation scale was moderately negatively correlated with the Internet Aggression Scale. The subscale of positive social comparison correlated strongly with the Social Media-Induced Inspiration items. A moderate negative association was found between the subscale on self-control and the Brief Measure of Social Media Self-Control Failure.

However, the subscale on connectedness did not correlate with the proposed Technoference Scale. We also did not find correlations between the subscale of authentic self-presentation with the proposed subscales of the Posting Positive Social Media Content Scale.

The relationships between the DFSA subscales and the demographic variables were also explored. There was a significant moderate correlation between the civil participation subscale and gender, indicating that girls demonstrated higher scores on civil participation than boys (see **Table 2**). The civil participation subscale was also significantly moderately correlated with adolescents' secondary education track. Adolescents following general education demonstrated higher scores than adolescents following professional-technical and vocational education.

6.3. Brief discussion of study 1

The results of Study 1 preliminary confirmed the five distinct dimensions of DFSA and indicated good reliability of all the identified subscales.

As for validity, the five flourishing subscales were significantly associated with the satisfaction of basic psychological needs. The subscales of civil participation, positive social comparison, and self-control were also validated by showing correlations with scales of Internet aggression, social media-induced inspiration, and social media self-control failure, respectively.

Yet, authentic self-presentation was not related to posting positive content on social media. The reason for this result might be that the measure of positive posts does not allow to distinguish whether the posts with positive content are (in) authentic (34). The measure asks, for instance, how often adolescents post content on social media in which they look beautiful, or do something fun. For some adolescents, this type of self-presentation is a genuine reflection of their lives. For other users, these posts might be strategically selected to present the best and therefore also a biased and more unauthentic version of the self. The measure of positive content on social media thus does not allow making a claim on the authenticity/inauthenticity of the adolescents' online self-presentation. Therefore, in Study 2 an alternative measure that could distinguish the authenticity of posted positive content was used. Finally, we did not find the expected negative relationship between technoference with friends and online connectedness. The possible explanation for this non-significant finding might lie in the changed norms of technology use in offline conversations. Using devices for digital communication during offline conversations has become more socially accepted (60) and adolescents indicate to perceive technology use during face-to-face conversations as a complementary extension of the ongoing conversation (61). To validate the connectedness subscale in Study 2, we, therefore, searched for another validation concept in the attachment literature. Individuals with a secure attachment are reasoned to be more likely to form close social connections with others online (62) and to use digital communication more often to satisfy their need for relatedness (63). We thus expected that adolescents with a secure attachment to their peers would experience higher levels of connectedness with people online.

7. Study 2

7.1. Method

7.1.1. Sample and Procedure

The preregistered Study 2 was conducted in September-November 2021 as the first wave of a larger, three-wave longitudinal study of the 'MIMIc Project', focusing on media and well-being.[1] A quota sample of 1,168 adolescents was

[1]More information about the project can be found on the website: https://www.projectmimic.eu/.

TABLE 2 DFSA construct validity and correlations with demographic variables (study 1).

	Connectedness		Civil participation		Positive social comparison		Authentic self-presentation		Self-control	
	N	r	N	r	N	r	N	r	N	r
Autonomy	68	0.25*	54	0.36*	59	0.13	61	0.33**	66	0.27*
Competence	68	0.24*	54	0.26	59	0.31*	61	0.40***	66	0.23
Relatedness	68	0.29*	54	0.30*	59	0.28*	61	0.26*	66	0.19
Technoference	63	−0.08								
Internet aggression			51	−0.33*						
Social media-induced inspiration					60	0.66***				
PPSMC: happy and interesting (social) life							51	0.17		
PPSMC: attractive appearance;							49	0.16		
PPSMC: (professional) achievements							59	−0.19		
Social media self-control failure									63	−0.41***
Gender (girls is ref.category)	132	−0.08	94	0.32**	129	−.07	118	0.03	131	−0.04
Education track (vocational is ref.category)	129	0.05	95	0.30**	126	.04	114	−0.17	126	−0.17
Education track (vocational)	5	10.6 (2.51)[a]	5	16.8 (4.60)[a]	5	12.20 (2.77)[a]	4	21.5 (2.65)[a]	4	17.5 (1.91)[a]
Education track (technical)	28	8.46 (2.53)[a]	20	18.35 (3.38)[a]	26	12.46 (3.17)[a]	27	17.3 (3.82)[a]	25	14.8 (2.61)[a]
Education track (general)	96	9.44 (2.91)[a]	70	20.34 (3.39)[a]	95	12.74 (3.72)[a]	83	16.64 (4.63)[a]	97	14.4 (2.63)[a]
Education father (high is ref.category)	121	0.03	87	0.02	115	−0.00	108	−0.18	120	−0.04
Education father (low)	72	−0.06	51	0.17	68	0.08	65	−0.04	74	0.04
Education father (high)	49	−0.11	36	0.28	47	0.01	43	−0.04	46	−0.04
Education mother (high is ref.category)	123	0.08	89	−0.01	119	−0.19	110	−0.03	122	−0.04
Education mother (low)	44	0.07	29	−0.26	43	−0.19	42	−0.10	44	−0.09
Education mother (high)	79	−0.03	60	0.06	76	−0.17	68	0.01	78	0.11

Note. *$p < 0.05$, **$p < 0.01$, ***$p < 0.001$.
PPSMC: Posting positive social media content.
[a]Means instead of correlation.
Low education: secondary and lower; high education: post-secondary.

recruited through 27 elementary and secondary schools in Slovenia, considering a stratified distribution of participants' age, gender, educational track, and region of residence. The schools were selected from an overview of all existing schools provided by the government and were initially contacted with the request to participate in the study. Participating schools next presented the aims of the study to participants, provided parental consent forms to their pupils, and helped with the dissemination of the online survey link and active consent sheet. The majority of the participants [$N = 727$] completed the survey in class, and 441 participants completed it at home. Participants and their parents were informed of the confidentiality and anonymity of the data collection. Active (< 16 years) or passive parental consent (≥ 16 years) was collected prior to the data collection, and active consent of the adolescents themselves at the moment of the data collection. Participants were rewarded with a 10-euro voucher. Adolescents aged outside the range of 11–20 years and without parental consent could not participate. Respondents who failed or had missing data on the attention check [$N = 101$] or had missing data on all items of the DFSA [$N = 25$] were excluded. The attention check question is available in **Supplementary Appendix E** in OSF. The final sample consisted of 1,046 adolescents (11–18 years, $M_{age} = 15.28$, SD = 1.79, 49.1% boys). Based on the Slovenian secondary school system division, 18.83% followed general education, 28.20% followed professional-technical education, and 20.27% followed vocational education; 32.7% were in elementary schooling. The majority (75.62%) described their ethnicity as only central European (Slovenian). Within the sample, 39.20% of participants' mothers had a university degree and 42.73% of fathers had secondary education.

7.1.2. Measures

The measures were translated from English to Slovenian following a forward-and-back translation procedure. The online **Supplementary Appendix E** in OSF displays full items of the used scales.

7.1.2.1. Demographic variables

Adolescents' age, gender, educational track, ethnicity, and parental education level, were measured using the same scales as Study 1.

7.1.2.2. Digital flourishing in adolescence

The 21-item Slovenian DFSA ranging from 1 (not at all true of me) to 5 (very true of me) with an option "I don't know/Not applicable to me" was used ($\alpha = 0.83$, $M = 3.5$, $SD = 0.48$). All subscales yielded acceptable to good internal consistency: Connectedness and Civil Participation ($\alpha = 0.75$, $M_{connectedness} = 3.2$, $SD_{connectedness} = 0.84$, $M_{civil} = 3.7$, $SD_{civil} = 0.71$), Self-Control ($\alpha = 0.80$, $M = 3.6$, $SD = 0.74$), Positive Social Comparison ($\alpha = 0.81$, $M = 3.3$, $SD = 0.82$), Authentic Self-Presentation ($\alpha = 0.87$, $M = 3.4$, $SD = 0.83$).

7.1.2.3. Secure attachment with a close friend

We used the Secure Attachment Style subscale of the short form of the Adolescent Friendship Attachment Scale (e.g., "I can trust my friend") (64). Participants thought of the peer that they feel closest to and rated 5 items on a 5-point Likert scale ranging from 1 (strongly disagree) to 5 (strongly agree). The scale displayed good reliability ($\alpha = 0.88$, 5 items, $M = 3.5$, $SD = 0.67$).

7.1.2.4. Authenticity of posted positive content

Drawing on the virtual self subscale of Psycho-Social Aspects of Facebook Use (65) one item was developed to evaluate how often respondents had the impression that their posts and stories with positive content on social media showed who they really are. A 5-point Likert scale ranging from 1 (never) to 5 (very often) was used ($M = 3.0$, $SD = 1.27$).

7.1.3. Analytical Strategy

A confirmatory factor analysis (CFA) was conducted in R (version 4.0.4) using the "lavaan" package to confirm the five-factor measurement model of the 21-item DFSA. A Maximum Likelihood estimation was used for exact fit and four goodness-of-fit-indices (i.e., RMSEA, CFI, TLI, and SRMR) for approximate fit (66). Generally, CFI and TLI values between 0.90 and 0.95 and RMSEA values between 0.05 and 0.08 indicate an acceptable model fit, and CFI and TLI values above 0.95 and RMSEA values below 0.05 indicate good model fit (67). SRMR values below 0.08 indicate an acceptable model fit (66) and SRMR values below 0.05 indicate a good model fit (68). The latent sub-factors were allowed to correlate with each other.

Next, measurement invariance across gender (i.e., boys vs. girls) was examined by conducting a multigroup structural equation modeling using Maximum Likelihood as an estimation method. If measurement invariance can be demonstrated, then girls and boys interpret the items and the underlying latent factor, in the same way. First, the five-factor-solution model was tested in each group separately to see if the model solution fitted well the data for each group separately. Second, configural, metric, and scalar invariance were considered to test differences between boys and girls. Configural invariance indicates the same factor structure, metric invariance indicates the same factor structure and loadings, scalar invariance indicates the same factor structure and loadings, and the same item intercepts. The $\chi 2$ and the AIC of the previous model were constantly compared to those from the following model. Non-significant ($p > 0.05$) $\chi 2$-differences confirm the invariance of the model.

Internal consistency, construct validity, and correlations with demographic variables were investigated by following the same procedure as in Study 1.

7.2. Results

7.2.1. CFA

The CFA indicated a good model fit for the five separate but correlated factor structure [χ^2 (179) = 420.661, $p < 0.001$; RMSEA = 0.045, CFI = 0.951, TLI = 0.942, SRMR = 0.048]. The correlation between the latent variables ranged from $r = 0.10$ to 0.30 (see **Supplementary Appendix F** in OSF for correlations table).

7.2.2. Measurement Invariance

The five-factor solution showed an acceptable model fit when being tested separately among boys [χ^2 (179) = 382.682, $p < 0.001$; RMSEA = 0.060, CFI = 0.913, TLI = 0.898, SRMR = 0.064] and girls [χ^2 (179) = 277.266, $p < 0.001$; RMSEA = 0.041, CFI = 0.960, TLI = 0.953, SRMR = 0.052]. Next, the configural invariance between boys and girls was confirmed [χ^2 (358) = 659.948, $p < 0.001$; RMSEA = 0.051, CFI = 0.937, TLI = 0.926, SRMR = 0.055]. Then we achieved an acceptable model fit for metric invariance [χ^2 (374) = 684.419, $p < 0.001$; RMSEA = 0.051, CFI = 0.935, TLI = 0.927, SRMR = 0.057]. The χ^2-difference test between the configural model and the metric invariance model was not significant [χ^2 (16) = 24.471, $p = 0.078$]. We therefore tested for scalar invariance which indicated an acceptable model fit [χ^2 (390) = 721.245, $p < 0.001$; RMSEA = 0.052, CFI = 0.931, TLI = 0.926, SRMR = 0.058]. The $\chi 2$-difference test between the metric model and the scalar invariance model was significant [χ^2 (16) = 36.826, $p = 0.002$]. Also, the AIC values were the lowest for the model testing metric invariance ($AIC_{conf} = 32{,}199$, $AIC_{metric} = 32{,}192$, $AIC_{scalar} = 32{,}197$. These results indicate metric invariance across gender.

To establish partial scalar invariance the equality constraints on the intercept parameters for three items were sequentially released for items 12 and 13 of the positive social comparison subscale and item 20 of the self-control subscale (see **Table 1** for the meaning of these items). The adapted scalar invariance model fit was acceptable [χ^2 (387) = 701.326, $p < 0.001$; RMSEA = 0.050, CFI = 0.935, TLI = 0.929, SRMR = 0.058]. The χ^2-difference test between the metric model and the adapted scalar invariance model was insignificant [χ^2 (13) = 16.907, $p = 0.204$] and the AIC value was also the lowest for

the adapted model 2 (AIC = 32,185). Thus, partial scalar invariance for gender was established.

7.2.3. Construct validity

The authentic self-presentation subscale correlated strongly with the item on authenticity of posted positive content (no correlations are reported in the text; all can be found in Table 3). The connectedness subscale was weakly correlated with the Adolescent Friendship Secure Attachment subscale.

Table 3 shows the correlations between the DFSA scales and demographic variables (i.e., gender, age, educational track, paternal and maternal education level). There was a significant correlation between gender and the civil participation subscale, indicating that the mean score of girls in the civil participation subscale is higher than that of boys. Gender was also significantly correlated with the authentic self-presentation subscale, indicating that girls demonstrate higher scores for authentic self-presentation than boys. Adolescents' secondary educational track was significantly correlated with the authentic self-presentation subscale, the connectedness subscale, and the civil participation subscale respectively. Adolescents following general education demonstrated higher scores for the three latter subscales than adolescents following professional-technical and vocational education. In all these correlations, higher socioeconomic status signaled higher scores on the digital flourishing dimensions. However, paternal low education was significantly correlated with the civil participation subscale, indicating that adolescents with less-educated fathers demonstrated higher scores on civil participation than the ones with highly educated fathers. No other significant relationships were found (e.g., the relationships between maternal educational status and the DFSA subscales were non-significant).

7.3. Brief discussion of study 2

Study 2 finalized the process of validating the scale. The two remaining dimensions were validated with already existent constructs (i.e., authentic self-presentation with the authenticity of posted positive content, and connectedness with secure attachment to a close friend). This study also confirmed the five-dimensional structure of DFSA with a larger sample of adolescents. Furthermore, partial scalar invariance indicates that the majority of the item intercepts do not differ across gender. Thus, DFSA can be used among samples of adolescent boys and girls, as the measurement is invariant across gender.

8. General discussion

Scholars have substantially focused more on the negative effects of digital communication than on its positive effects (16). Until the conceptualization of digital flourishing and the

TABLE 3 DFSA construct validity and correlations with demographic statistics (study 2).

	Connectedness		Civil participation		Positive social comparison		Authentic self-presentation		Self-control	
	N	r	N	r	N	r	N	r	N	r
Authenticity of posted positive content							854	0.51***		
Secure attachment with a close friend	922	0.10**								
Gender (girls is ref.category)	912	−0.04	730	0.16***	888	.04	831	0.12***	914	−0.04
Age	946	0.02	756	−0.01	921	−0.05	857	0.04	946	−0.04
Age (11–15)	458	0.00	344	−0.06	434	−0.01	412	−0.04	454	−0.03
Age (16–20)	488	0.00	412	0.06	487	0.00	445	0.01	492	0.00
Education track (vocational is ref.cat)	651	0.17***	539	0.19***	637	0.05	595	0.10*	654	−0.02
Education track (vocational)	189	9.08 (2.24)[a]	167	17.62 (3.31)[a]	189	12.67 (2.88)[a]	186	16.63 (3.91)[a]	189	14.46 (2.79)[a]
Education track (technical)	279	9.71 (2.34)[a]	233	18.26 (3.37)[a]	270	12.99 (3.17)[a]	255	16.72 (3.99)[a]	276	14.48 (2.85)[a]
Education track (general)	183	10.16 (2.58)[a]	139	19.38 (3.76)[a]	178	13.10 (3.61)[a]	154	17.73 (3.88)[a]	189	14.34 (3.20)[a]
Education father (high is ref.category)	821	0.03	647	0.07	801	0.05	743	−0.06	822	−0.03
Education father (low)	451	−0.05	365	0.14**	441	0.07	413	0.03	449	0.02
Education father (high)	370	−0.07	283	0.03	360	0.04	330	−0.01	373	−0.02
Education mother (high is ref.category)	877	0.05	694	0.06	854	0.04	794	0.05	876	−0.02
Education mother (low)	328	0.03	263	−0.05	321	−0.05	302	0.01	319	0.00
Education mother (high)	549	−0.02	431	0.02	533	−.03	492	0.05	557	−0.01

Note. *$p < 0.05$, **$p < 0.01$, ***$p < 0.001$.
[a]Means instead of correlation.
Low education: secondary and lower; high education: post-secondary.

development of the Digital Flourishing Scale (DFS), a communication-centered measurement instrument that comprehensively captures the positive perceptions of an individual's experiences and behaviors in the context of digital communication was absent (13). Research on such an instrument in the context of adolescents' digital communication use is still lacking. To address this gap, we developed the Digital Flourishing Scale for Adolescents (DFSA). This scale considers the developmental context of adolescence (22) and provides a practical tool for examining adolescents' perceived flourishing and empowerment when engaging in digital communication.

The current study provides evidence that the 21-item DFSA is a reliable and valid tool that systematically and comprehensively captures digital flourishing in adolescence. The exploratory and confirmatory factor analyses demonstrated the same five-dimensional factor structure of digital flourishing for adolescents and adults (i.e., connectedness, civil participation, positive social comparison, authentic self-presentation, and self-control). Digital flourishing can be investigated as a composite score of all subscales, or its five dimensions can be individually investigated. The subscales can help to inspire research in different subdimensions (a) to examine more positive online behaviors and (b) to complement existing qualitative research with quantitative research. For instance, research on online social comparisons has largely focused on the negative outcomes of these comparison processes in adolescence (37). Our novel subscale may help to foster a new direction of research into the potential positive outcomes of such processes. Similarly, the benefits of self-controlled digital communication have largely been neglected in the field (42). Furthermore, some domains of digital communication have especially been examined qualitatively as no validated scales in adolescents existed to explore these subjects quantitatively. One of these domains is the subfield of online authentic self-presentation, which for now has especially been qualitatively studied in adolescents (32–34).

The results demonstrated the construct validity of the DFSA. The five flourishing dimensions were significantly associated with one or more scales for the satisfaction of basic psychological needs in adolescence (25). Moreover, the five flourishing dimensions were validated by showing significant relationships with related constructs of digital communication in Study 1 and Study 2 (e.g., a negative relationship occurred between Internet aggression and civil participation).

Further, DFSA was found to be largely invariant across genders. Future research should take into account that three items were found to differ between boys and girls ("Seeing how others present themselves online motivates me to make changes in my own life.", "Comparing myself to others online motivates me to accomplish the things I want in life.", and "When I browse through online content, I feel in control of how I spend my time."), as only partial scalar invariance was established after eliminating variance in these three items across gender.

Both studies demonstrated high mean scores for digital flourishing in the adolescents' samples. On average, adolescents scored the highest on civil participation, followed by self-control, authentic self-presentation, positive social comparison, and connectedness. Since the DFSA is a self-reported measure, adolescents could have assigned higher scores for more socially desirable online behaviors, such as civil participation. Thus, the results also potentially reflect adolescents' norms of digital flourishing practices (69).

Despite the overall high mean scores for digital flourishing, the results also indicated that not all groups of adolescents thrive online equally. First, gender differences were found in DFSA. Girls scored higher on civil participation than boys. This finding supports previous literature, as girls have been reported to score higher than boys for respect and civic engagement online (41). The potential explanations for our results could be that girls are likely to be socialized to be more "kind" than boys and to act prosocially more often than boys (70). In contrast with earlier qualitative findings (35), girls demonstrated significantly higher scores on authentic self-presentation than boys in Study 2. Girls attach more importance to self-presentation than boys (35). Moreover, recent literature indicates that authentic self-presentation is nowadays considered normative (32). Potentially, the normative expectancy to present oneself as authentic, combined with the higher importance attached to self-presentation by girls, explains the reported gender difference.

Second, our study offers some initial insights into the role of socioeconomic status (SES) in digital flourishing. According to the digital divide literature, adolescents with a lower SES exhibit a significantly lower level of digital skills and outcomes (71). Adolescents' SES can be predicted by parental education level (72), which is strongly related to the secondary track choice of adolescents (73). Correlations between the adolescents' education track and several digital flourishing subscales in Study 2 (and in Study 1 to some extent) demonstrated that the mean scores for civil participation, authentic self-presentation, and connectedness were significantly lower among adolescents in vocational and professional-technical education than among adolescents in the general education track. Meanwhile, adolescents with less-educated fathers demonstrated significantly higher scores on positive social comparisons than adolescents with highly educated fathers. The results regarding mother's education were surprisingly not significant. These findings highlight that further research is needed on how parental educational status relates to digital flourishing across adolescents. On average, mothers and fathers report similar levels of digital skills though in different domains (e.g., mothers report more advanced skills in information search and in privacy management but fathers report more advanced skills in coding and content editing) (74). Potentially, mothers and fathers might also differ in their digital flourishing skills and communicate these skills to their children differently according to their SES. Research may further examine this reasoning. Additionally, the digital divide literature has

typically focused on the negative outcomes of information and communication technology use. Our newly developed scale will help research how disadvantaged adolescents lack empowered digital communication and the positive outcomes these digital communication skills bring (71).

Moreover, the DFSA focuses on digital communication in general. Further studies could adjust the scale (or its subscales) to refer to different technological contexts (e.g., different social media platforms such as Instagram vs. Snapchat) (13). Such research may explore whether users' digital flourishing skills may differ depending on different digital communication tools.

9. Limitations

Although Study 1 and Study 2 supported the reliability and validity of the scale, they had some limitations. First, in Study 1, the sample of adolescents was rather small ($N = 147$), and the validity measures were divided into and distributed among two sub-samples. The low sample size can be explained by the COVID-19 pandemic and the period of data collection (i.e., at the end of the school year, adolescents' motivation to participate was low, and access to participants through schools was limited). Second, the sample used in Study 1 primarily included adolescents between 16 and 19 years of age. These participants also mainly followed a general education track and originated from families with a high SES. Study 2 covered a more diverse sample ($N = 1{,}046$) spanning a larger age range (11–18 years) and including more adolescents from different educational tracks and families with diverse SES. Third, Studies 1 and 2 were conducted using Slovenian samples, which limits the representativeness of the findings to other cultures. Additional research is needed to further validate the scale. The DFSA should be employed in different countries and languages. Such cross-cultural validation could allow for a wider application of the scale.

Finally, similar to the bulk of quantitative measurements, DFSA is a self-reported measure that offers insights into adolescents' perceptions of their experiences and behaviors in digital communication. Therefore, it is likely that adolescents provide socially desirable responses (69). Future studies should consider using a combination of self-reporting and more "objective" tools that measure adolescents' digital behavior (75) (e.g., coding actual online posts).

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 below: https://osf.io/9wuyb/?view_only=9e64aa7358ed40a0823a8cb75c49c3ae.

Ethics statement

The studies involving human participants were reviewed and approved by Social and Societal Ethics Committee (SMEC), KU Leuven and Workplace Ethics Committee, Faculty of Social Sciences, University of Ljubljana. Written informed consent to participate in this study was provided by the participants' legal guardian/next of kin.

Author contributions

JR, LV, SJB, and BL contributed to the conceptualization and design of the study. JR collected the data and organized the database. LC and JR performed the statistical analysis. JR wrote the first draft of the manuscript. SJB wrote the first section of the manuscript. LV 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.

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John F. Hunter,
Chapman University,
United States

REVIEWED BY
Yi-Man Teng,
Yango University, China
Don Donghee Shin,
Zayed University,
United Arab Emirates
André Luiz Monezi Andrade,
Pontifical Catholic University of Campinas,
Brazil

*CORRESPONDENCE
Jiawei Yang
y2362146000@gmail.com

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How smartwatch use drives user reciprocity: The mediating effects of self-expansion and self-extension

Rong Liu, Jiawei Yang* and Junwen Yao

School of Economics and Management, Nanchang University, Nanchang, China

People are increasingly using smartwatches in their daily lives. Scholars have focused on the drivers of the initial and continued use of smartwatches, while few studies have dealt with the outcomes of smartwatch use. Therefore, this study explores the impact of smartwatch use on user experience (self-expansion and self-extension) and user reciprocity (user loyalty and user influence) based on service-dominant logic. Data were collected through a questionnaire survey of 343 smartwatch users in China. Structural equation modeling and the bootstrapping method were applied to test the theoretical hypotheses. The results show that smartwatch use positively affects self-expansion and self-extension, both self-expansion and self-extension positively affect user loyalty and user influence, and smartwatch use affects user loyalty and user influence through self-expansion and self-extension. This research deepens our understanding of the outcomes of smartwatch use, and provides insights for smartwatch manufacturers to create more value from user reciprocity.

KEYWORDS

smartwatch use, self-expansion, self-extension, user reciprocity, service-dominant logic

Introduction

The wearable technology market has experienced steady growth in recent years and is expected to reach USD118.16 billion by 2028 (Grand View Research, 2021). Wearable technologies are generally seen as personal computing devices that can be worn by users and connected to the Internet, including smartwatches, smart glasses, and smart clothing (Basha et al., 2022). Smartwatches, in particular, have been widely commercialized and are considered to be one of the most popular wearable technologies (Bolen, 2020a). People can use smartwatches to garner various benefits, such as receiving and responding to notifications, playing music, monitoring users' health, and making mobile payments. These benefits cover many scenarios in people's daily lives (e.g., work, entertainment, sports, and shopping; Bolen, 2020b).

As people have begun to notice and accept smartwatches, scholars have carried out a great deal of research on smartwatches. When smartwatches first appeared on the market, the initial use of smartwatches was the main research topic (Wu et al., 2016). Studies have revealed that the initial use of smartwatches can be affected by perceived value (Choi and Kim, 2016; Hsiao and Chen, 2018), and user attitudes (Wu et al., 2016). When smartwatches moved beyond the initial adoption stage, researchers shifted their focus to the continued use of smartwatches (Dehghani et al., 2018). For example, Nascimento et al. (2018) extended the expectation confirmation model and stated that habit is the most important factor influencing the continued use of smartwatches, while Chuah (2019) found that perceived benefits and previous lifestyle incongruence influence users' intention to continue using smartwatches through inspiration and well-being. Moreover, Shin and Biocca (2018) expanded the understanding of smartwatch users and found that upgrading behavior is not influenced by perceived usefulness, but is related to identity formation.

Although smartwatch use have become a common phenomenon among people and is considered to have major effects on people's lives (Ogbanufe and Gerhart, 2018), little is known about the impact of smartwatch use on smartwatch users or manufacturers. To fill this research gap, this study focuses on the outcomes of smartwatch use based on service-dominant logic (S-D logic hereafter). Specifically, we argue that smartwatch use may affect user experience (self-expansion and self-extension), which further motivates smartwatch users to create value for smartwatch manufacturers through two forms of reciprocity (user loyalty and user influence).

According to S-D logic, value is not embedded in the tangible products provided by a manufacturer (i.e., value in exchange), but is co-created by the user and the manufacturer in the process of using the product (i.e., value in use; Vargo and Lusch, 2004). In this process, the users integrate their own resources with those of the manufacturers to gain benefits and experience, thus co-creating value with the manufacturers (Baumann et al., 2017). Value co-creation occurs over time and needs to be built on long-term and deep interactions (Shulga et al., 2021). Given this, when a smartwatch is used frequently and favorably, the user and the manufacturer are both likely to realize value co-creation.

Based on S-D logic, value is determined by the experience that users get while using a product (Vargo and Lusch, 2008). Self-expansion and self-extension are two key forms of experience that users can acquire when using smart products in their daily lives (Hoffman and Novak, 2018). Self-expansion refers to a person's perception of increased self-awareness after he or she acquires new resources, knowledge, or identities from interaction with another party (Mao et al., 2019). Smartwatch use is essentially interaction between a user and a smartwatch through which the user can enhance their abilities and perceive self-expansion. Furthermore, if an object plays a role in constructing people's self-identity, people can see the object as part of the self, thus achieving self-extension (Park and Kaye, 2019). Specifically, people who use smartwatches are likely to enrich their self-identity and experience self-extension. Thus, users can derive experiential value from smartwatch use in the form of self-expansion and self-extension.

S-D logic highlights that value co-creation is reciprocal, and a user who derives value from consuming a manufacturer's product may provide inputs that directly or indirectly benefit the manufacturer (Vargo, 2009). Accordingly, people who get favorable experiences from using smartwatches are likely to contribute value to manufacturers in return. Thus, smartwatch users that get extraordinary experiences may make repeat purchases and exhibit user loyalty, providing direct value to manufacturers (Cetin, 2020). In addition, people may share their positive experiences with others online and create user influence, providing indirect value to manufacturers (Kumar et al., 2010).

Therefore, this study considers smartwatch use as an important activity of value co-creation and explores the impact of smartwatch use on user experience (self-expansion and self-extension) and user reciprocity (user loyalty and user influence). Specifically, we hypothesized the positive effects of smartwatch use on self-expansion and self-extension, the positive effects of self-expansion and self-extension on user loyalty and user influence, and the mediating effects of self-expansion and self-extension. We collected data of 343 smartwatch users in China through an online survey, and adopted structural equation modeling and the bootstrapping method to test the theoretical hypotheses.

The research findings contribute to the literature on smartwatches in three ways. First, unlike the literature focusing on the antecedents of smartwatch use, this study focuses on the effects of smartwatch use on users and manufacturers, expanding the streams of research into smartwatches. Second, studies have focused on the technology- and fashion-related perceptions surrounding smartwatches, such as perceived interactivity (Basha et al., 2022) and visual aesthetics (Cho et al., 2019). However, this study explores self-perceptions generated by smartwatch use. Finally, while the literature has only focused on user- and product-related variables, this study investigates variables related to manufacturers and other users beyond the focal users and products, such as user loyalty to the manufacturer and user influence on other users.

Literature review

Smartwatch use

Initial and continued use of smartwatches has been the focus of researchers. Many studies have shown that the initial use of smartwatches could be affected by the benefits or values provided by smartwatches and the attitude of users. In terms of the benefits or values provided by smartwatches, social value (Wu et al., 2016), perceived self-expressiveness (Choi and Kim, 2016), emotional value (Hsiao and Chen, 2018) all positively enhance users' intention to adopt smartwatches. In addition, users' attitudes toward using smartwatches were consistently found to promote initial use of

smartwatches (Choi and Kim, 2016; Wu et al., 2016; Hsiao and Chen, 2018; Krey et al., 2019). Bolen (2020a) found that users would compare smartwatches to traditional wristwatch. In this scenario, relative advantages and financial switching costs influence users to switch from traditional wristwatch to smartwatches.

Similar to initial use, continued use of smartwatches is influenced by smartwatch-related and user-related factors. In terms of smartwatch-related factors, perceived benefits (Chuah, 2019), perceived usefulness (Nascimento et al., 2018) and aesthetic appeal (Dehghani et al., 2018) all contribute to the continued use of smartwatches. In addition, the continued use of smartwatches is also related to the perceptions and traits of users. For example, Nascimento et al. (2018) found that habit is the most critical factor in explaining the continued use of smartwatches. User satisfaction is also an important antecedent that drives users to continue using smartwatches (Ogbanufe and Gerhart, 2018). In addition, Hong et al. (2017) revealed the relationship between user innovativeness and continued use of smartwatches, and argued that user innovativeness affects continued use of smartwatches through hedonic value and utilitarian value.

It can be seen that the existing studies have advanced our understanding of the antecedents of initial and continued use of smartwatches. However, knowledge about the outcomes of smartwatch use is scarce. According to the service-dominant logic, product use is essentially a process of value co-creation. For researchers and managers, it is necessary to explore the value that smartwatch use brings to users and manufacturers.

Service-dominant logic

Vargo and Lusch first proposed the S-D logic in Journal of Marketing in 2004 to replace the traditional goods-dominant (G-D) logic. The S-D logic asserts that service is a process in which an actor uses their own resources (knowledge and skills) to benefit another actor (Vargo and Lusch, 2008). In light with S-D logic, customers become co-creators of value and important sources for firms to gain competitive advantage. Therefore, firms no longer simply regard customers as marketing objects, but as an operant resource. Customers have made unprecedented contributions to firms' marketing processes; firms no longer simply manufacture products or services, but help customers gain experience in the process of value creation; firms no longer simply focus on the specific value delivery, but emphasize the creation and refinement of value proposition; firms no longer simply produce and sell products, but create value together with customers. In addition, value co-creation is the creation of customer experience jointly by firms and customers (Vargo and Lusch, 2004). Customers can even gain their own experience in consuming products and services. It is now critical for firms to deliver favorable experience along the customer journey (Lemon and Verhoef, 2016). Therefore, the viewpoints of S-D logic support the influence chain of "product use—user experience—value creation," which provides the rationale for our research model.

Research model and hypothesis development

Smartwatch use and user experience

Self-expansion theory contains two core components: motivation for self-expansion, which is an intrinsic motivation, and the inclusion of others in the self, which is a cognitive process (Aron and Aron, 1996). Self-expansion motivation is a core human motivation that drives people to acquire new resources, ideas, and identities to enhance their self-efficacy for achieving desired goals (Aron et al., 2006). Self-expansion is the individual perception of enhanced self-awareness after one party acquires new resources, ideas, or identities from another party (Mao et al., 2019). Studies have shown that customers are highly likely to realize self-expansion in the process of interacting with specific brands, thus leading to positive customer behaviors (Gorlier and Michel, 2020). Therefore, we argue that users will likewise achieve self-expansion in their interaction with smartwatches. First, as an innovative product, smartwatches have many novel features. Therefore, when users interact with their smartwatches, they can achieve self-expansion by acquiring new resources, ideas, and identities (Carpenter and Spottswood, 2013). Second, participating in creative activities is one of the effective ways for people to gain self-expansion (Hoffner et al., 2016). Using smartwatches itself is a highly novel and creative activity through which users can also gain self-expansion. We hypothesize the following:

> *H1*: Smartwatch use positively affects self-expansion.

Self-extension refers to the subjective feeling that a person considers an object as part of the self (Belk, 1988; Ferraro et al., 2011). Self-extension theory suggests that if an object plays a role in the construction of a person's self-identity, that person can see that object, such as property (Roster et al., 2016), as being part of the self, thus achieving self-extension (Park and Kaye, 2019). According to self-extension theory, we believe that users may realize self-extension in using smartwatches. First, the more a person uses a smartwatch, the greater the degree to which the user controls or masters the smartwatch. Mastery or control of an object is one of the ways in which people achieve self-extension (Belk, 1988), so using smartwatches may help them achieve self-extension. Second, the more a person uses a smartwatch, the more comprehensively and deeply the user knows the smartwatch. Knowing an object is another way for people to achieve self-extension (Belk, 1988), so using smartwatches may help them achieve self-extension. We hypothesize the following:

> *H2*: Smartwatch use positively affects self-extension.

Self-expansion and user reciprocity

Self-expansion plays an important role in building and maintaining relationships (Harasymchuk et al., 2021). In an ideal

relationship, people may gain new resources and knowledge, thus achieving self-expansion and benefiting from intimacy (Harasymchuk et al., 2020). They tend to maintain such relationships to gain continuous self-expansion (Mattingly et al., 2019). In addition, self-expansion makes people hold positive feelings toward others with whom they have a satisfying relationship, enhancing the quality of the relationship (De Kerviler and Rodriguez, 2019). For high-quality relationships, people are willing to maintain and sustain them (Han et al., 2021). Thus, after achieving self-expansion through smartwatch use, users would maintain their connection with the smartwatch and show user loyalty.

In addition, user self-expansion may affect user influence. First, after achieving self-expansion through using a product, a person develops positive feelings toward the product (De Kerviler and Rodriguez, 2019). This enhances the quality of the user's relationship with the product (Gordon and Luo, 2011), making the user more likely to talk about the product on the Internet and influence the activities of other users. Second, self-expansion may improve people's self-efficacy (Dys-Steenbergen et al., 2016). Therefore, after achieving self-expansion, smartwatch users would become more confident in their product knowledge of smartwatches and more willing to share information about smartwatches online. In addition, self-expansion would enhance people's ability to complete tasks (Mao et al., 2019). After achieving self-expansion, smartwatch users are capable of sharing information about the smartwatch online. In summary, self-expansion may encourage users to share their smartwatches online, generating user influence. Therefore, we hypothesize the following:

> *H3*: Self-expansion positively affects user loyalty (H3a) and user influence (H3b).

According to S-D logic, using a product is a process of value co-creation (Vargo and Lusch, 2004). Moreover, value co-creation is inherently reciprocal (Vargo, 2009). All parties involved in value co-creation are beneficiaries and are able to obtain their desired value from value co-creation (Baumann et al., 2017). Using smartwatches could allow users to gain new resources, knowledge, and perspectives, and get value in the form of self-expansion. After reaping this value, users in turn create value for the manufacturer based on the principle of reciprocity in value co-creation. This user reciprocity can also be demonstrated through user loyalty and user influence. As such, it is hypothesized that:

> *H4*: Smartwatch use positively affects user loyalty (H4a) and user influence (H4b) through self-expansion.

Self-extension and user reciprocity

In the customer-brand relationship, customer self-extension usually results in positive outcomes for the brand, such as brand attachment (Rabbanee et al., 2020) and brand loyalty (Sprott et al., 2009). It is inferred that self-extension of smartwatch users also affects aspects of user reciprocity such as user loyalty and user influence. Seeking self-extension is a common means by which people come to know themselves (Ross and Bayer, 2021). Achieving self-extension enriches the self-concept, while losing self-extension undermines it (Israeli, 2022). To keep the integrity and continuity of their self-concept, people tend to maintain a sense of self-extension and stay connected to the object that is an extension of the self (Giordano et al., 2020). Thus, after achieving self-extension, users tend to maintain their relationship with the product and show user loyalty.

A person's self-extension can be enhanced by unique experiences that are concrete and public (Hornik and Diesendruck, 2017). Therefore, to achieve self-extension, people tend to concretize their experiences by recording them with the help of the Internet. At the same time, they can share their experiences with others through the Internet and make their experiences public (Belk, 2013). In the context of smartwatches, users may concretize and publicize their own experience of using smartwatches and engage in user influence to maintain a sense of self-extension. We hypothesize the following:

> *H5*: Self-extension positively affects user loyalty (H5a) and user influence (H5b).

According to S-D logic, the potential value of a product can be transformed into real value only when people use the product (Vargo and Lusch, 2004). Furthermore, value co-creation is inherently mutual and reciprocal (Vargo, 2009). All parties involved in the process of value co-creation will receive value (Baumann et al., 2017). People who use smartwatches come to see their smartwatches as part of themselves and experience value in the form of self-extension. After reaping this value, the users create value for the manufacturer in return based on the principle of reciprocity in value co-creation. This reciprocity of smartwatch users is reflected as their loyalty to the manufacturer and influence on other users. Therefore, smartwatch use affects self-extension, which further affects user reciprocity. We hypothesize the following:

> *H6*: Smartwatch use positively affects user loyalty (H6a) and user influence (H6b) through self-extension.

Based on the above discussion, we construct the following research model (Figure 1).

Materials and methods

Questionnaire

Before designing the formal questionnaire, two tasks were completed. First, researchers used smartwatches personally to get

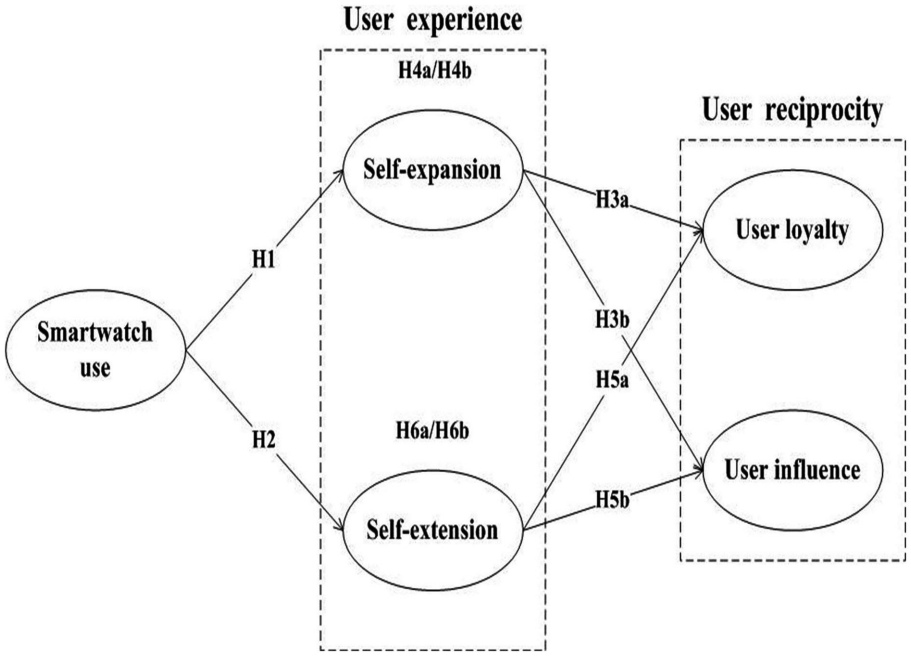

FIGURE 1
Research model.

familiar with smartwatches, such as functions of smartwatches. Second, we reviewed the relevant literature and drew on the research design of existing literature.

The questionnaire in our study is divided into a warm-up section, a main section, and a personal basic information section. In warm-up section, we firstly ask the respondents whether they have used a smartwatch. Then, we encourage them to recall the situation they used the smartwatch to further awaken their memories about smartwatch use. The main section includes the measurement of five key variables: smartwatch use, self-expansion, self-extension, user loyalty, and user influence. The personal basic information section contains gender, age, education level, and personal monthly budget.

Measurement

The measurement items for the five core variables in this study all derived from well-established scales in existing studies, with appropriate modifications. Smartwatch use was measured by three items adapted from Ram and Jung (1991). The scale of self-expansion included three items following suggestions of De Kerviler and Rodriguez (2019) and Lee et al. (2019). Self-extension was assessed using four items adapted from Roster et al. (2016). User loyalty was measured using three items based on studies of Wolter et al. (2017) and Ramaseshan et al. (2017). User influence was assessed using three items adapted from Kumar and Pansari (2016). Smartwatch use, self-expansion, self-extension, user loyalty, and user influence were all measured using a 5-point Likert scale, with 1 being strongly disagree and 5 being strongly agree. In addition, some demographic variables, such as user gender, age, education level, and personal monthly budget, were measured with 1 item.

Data collection

The respondents of our questionnaires are smartwatch users in China, and we surveyed them through an anonymous online survey. We collected data following two steps. First, we used "Wenjuanxing" platform to design online questionnaires and generated QR codes and web links for users to respond. Second, we posted questionnaires to online communities of smartwatch users and social networking sites to invite users to participate in the survey. To encourage smartwatch users to engage in the survey, we offered five CNY as an incentive to the respondents who finished the questionnaire.

To ensure that respondents are real smartwatch users, we set the first question as "Have you ever used smartwatches?" The respondents who replied "No" would skip the subsequent items and submit the questionnaires. As a result, 551 questionnaires were collected. Two hundred and eight invalid questionnaires were excluded following two criteria: (1) the respondents who had not used smartwatches; (2) they did not answer the questionnaire attentively. In the end, the valid questionnaires were 343. Demographic characteristics about the 343 respondents are shown in Table 1.

TABLE 1 Demographic characteristics of effective samples (*N*=343).

Category	Range	Number	Percentage (%)
Gender	Male	154	44.9
	Female	189	55.1
Age	18–25	103	30.0
	26–30	132	38.5
	31–40	97	28.3
	41–50	8	2.3
	51 and above	3	0.9
Education level	Elementary school	2	0.6
	Middle school	5	1.5
	High school	48	14.0
	Bachelor degree	256	74.6
	Graduate degree	32	9.3
Personal monthly budget	1,500 CNY and below	16	4.7
	1,501–2000 CNY	114	33.2
	2001–2,500 CNY	71	20.7
	2,501–3,000 CNY	82	23.9
	3,001 CNY and above	60	17.5

Personal monthly budget refers to the amount of spending in daily life each month (except for housing costs, which vary largely in different cities), including food, transportation, clothing, etc.

Results

Common method bias

Common method bias is a possible error due to the same data source and measurement approach, which may reduce the credibility of the data and even affect the model test (Podsakoff et al., 2003). So, this study controlled common method bias in the data through procedural and statistical remedies.

Procedural controls are the ways to eliminate or minimize common method bias in the research design, such as informing the respondents that the questionnaire is anonymous and that there are no right or wrong answers and making the questions clear, specific, and easy to understand (Podsakoff et al., 2012). We applied these procedural controls to the questionnaire design. In addition, this study also used two statistical controls. Technique 1 is Harman's one-factor test, which performs an exploratory factor analysis of all variables' items. The results showed that the variance explained by the first factor was 48.056%, which is under the critical value of 50%, indicating that the common method bias of the data is acceptable (Fuller et al., 2016). Technique 2 is checking the correlation coefficients between the variables. If the correlation coefficient is higher than 0.9, there is common method bias in the present study (Pavlou et al., 2007). The results of the analysis showed that the correlation coefficients between the variables all ranged from 0.486 to 0.688, which were below 0.9, revealing that the common method bias of the data was not significant. In conclusion, common method bias in our data is acceptable and the data is suitable for hypothesis testing.

To test whether there is multicollinearity in our data, the variance inflation factor (VIF) was estimated. The results showed that the VIF values ranged from 1.758 to 2.270, which were less than the threshold of 3.33, indicating that there was no obvious multicollinearity among the variables (Fan et al., 2022).

Reliability and validity test

The reliability test consists of internal consistency and composite reliability. As shown in Table 2, the Cronbach's α values of each variable range between 0.734 and 0.827, which are all above the recommended level of 0.7, indicating that the internal consistency of each variable is high. The composite reliability of each variable ranges between 0.735 and 0.827, which is above the critical value of 0.7, which indicates each variable has adequate composite reliability.

The validity of the variables can be assessed by convergent validity and discriminant validity. This study conducted a confirmatory factor analysis to test the convergent validity of all variables by employing Mplus 8.3. As shown in Table 2, the factor loadings of all items range from 0.671 to 0.799, most of them are above the cut-off value of 0.7. The average extracted variance (AVE) of all variables (except self-extension) is greater than 0.5, exceeding the recommended threshold. The results reveal that the measurement model fits well with the data ($\chi^2/df = 1.757$; SRMR = 0.029; RMSEA = 0.047; CFI = 0.975; TLI = 0.967). Thus, the scale of this study has strong convergent validity. The discriminant validity can be assessed by comparing the relationship between the square root of AVE and the correlation coefficients. As shown in Table 3, the square root of AVE of each variable is higher than the correlation coefficient of the variable with other variables, and the discriminant validity of the scale is good. In conclusion, the scale used in this study has adequate reliability and validity.

The main effects

This study applied Mplus 8.3 to test the main effects, and the results are shown in Table 4. In the model, we regressed smartwatch use on self-extension and self-extension, self-expansion on user loyalty and user influence, and self-extension on user loyalty and user influence, respectively. As shown in Table 4, the regression coefficients of smartwatch use on self-expansion and self-extension are 1.036 ($p < 0.001$) and 1.259 ($p < 0.001$), respectively, indicating that smartwatch use positively affects self-expansion and self-extension, and H1 and H2 are supported. The regression coefficients of self-expansion on user loyalty and user influence are 0.297 ($p < 0.05$) and 0.296 ($p < 0.05$), respectively, revealing that self-expansion would generate user loyalty and user influence, and H3a and H3b are supported. The regression coefficients of self-extension on user loyalty and user influence are 0.746 ($p < 0.001$) and 0.615 ($p < 0.001$), respectively,

TABLE 2 Test results for reliability and convergent validity.

Items	Factor loading
Smartwatch use Cronbach's $\alpha = 0.756$, CR = 0.757, AVE = 0.510	
After purchasing the smartwatch, I have used it frequently	0.690
After purchasing the smartwatch, I have used its many functions	0.709
After purchasing the smartwatch, I have used it in many situations (e.g., monitoring users' health and making mobile payment)	0.742
Self-expansion Cronbach's $\alpha = 0.784$, CR = 0.784, AVE = 0.548	
The smartwatch has enhanced my ability to accomplish things	0.748
The smartwatch has increased my knowledge	0.736
The smartwatch has made me a better person	0.737
Self-extension Cronbach's $\alpha = 0.734$, CR = 0.735, AVE = 0.481	
I have felt a personal connection between the smartwatch and me	0.690
I have considered the smartwatch to be a part of myself	0.719
The smartwatch have been an important indication of who I am	0.671
User loyalty Cronbach's $\alpha = 0.822$, CR = 0.822, AVE = 0.606	
I will be loyal to the manufacturer's smartwatch	0.785
I will purchase the manufacturer's smartwatch again	0.792
The manufacturer's smartwatch is my first choice for the future	0.758
User influence Cronbach's $\alpha = 0.827$, CR = 0.827, AVE = 0.615	
I will talk about the experience of using the smartwatch online	0.777
I will discuss the benefits that I get from the smartwatch with others online	0.777
I will mention the smartwatch in my conversations online	0.799
Model fit index: $\chi^2(80) = 140.596$, $\chi^2/df = 1.757$ SRMR = 0.029, RMSEA = 0.047, CFI = 0.975, TLI = 0.967	

TABLE 3 Test results for discriminant validity.

Variables	Smartwatch use	Self-expansion	Self-extension	User loyalty	User influence
Smartwatch use	0.714				
Self-expansion	0.486**	0.740			
Self-extension	0.650**	0.639**	0.694		
User loyalty	0.587**	0.606**	0.688**	0.778	
User influence	0.510**	0.579**	0.651**	0.645**	0.784
Mean	3.9815	3.7036	3.7444	3.7133	3.7765
Standard deviation	0.6504	0.7668	0.7172	0.8274	0.7765

**Suggests $p < 0.01$. The diagonal elements are the square root of average variance extracted (AVE). Off-diagonal elements are the correlations among variables.

illustrating that the deeper the degree of self-extension, the more likely user loyalty and user influence appear, and H5a and H5b are supported.

The mediating effects

This study employed Mplus 8.3 and used the bootstrapping method to test mediating effects of self-expansion and self-extension, and the results are shown in Table 5. In the model, we treated smartwatch use as the independent variable, user loyalty and user influence as the dependent variables, and self-expansion and self-extension as the mediating variables. Compared with the traditional three-step mediation test of Baron and Kenny (1986) and the Sobel mediation test, the bootstrapping method can be used to solve a wide range of inference problems

TABLE 4 Analysis results for the main effects.

Hypothesis	Estimate	Standard error	*t*-value	Results
H1	1.036	0.141	7.353***	Supported
H2	1.259	0.122	10.300***	Supported
H3a	0.297	0.142	2.090*	Supported
H3b	0.296	0.118	2.517*	Supported
H5a	0.746	0.140	5.329***	Supported
H5b	0.615	0.129	4.773***	Supported

*Suggests $p < 0.05$ and ***suggests $p < 0.001$.

and is particularly suitable in the absence of *a priori* information on the statistics (Zhao et al., 2010). For example, the bootstrapping method does not require the data to be normally distributed (Shin et al., 2022). All bootstrap analyses were performed using 5,000 replicate samples to generate bias-corrected 95% confidence

TABLE 5 Analysis results for the mediation effects.

Hypothesis	Estimate	Standard error	LLCI	ULCI	Results
H4a	0.308	0.153	0.046	0.650	Supported
H4b	0.307	0.126	0.106	0.595	Supported
H6a	0.940	0.204	0.611	1.407	Supported
H6b	0.775	0.179	0.477	1.160	Supported

intervals. If the confidence interval excludes 0, the corresponding effect is significant (Zhao et al., 2010).

From Table 5, the mediating effect of smartwatch use on user loyalty through self-expansion is 0.308 and the confidence interval excludes 0. The mediating effect of smartwatch use on user influence through self-expansion is 0.307 with a confidence interval excluding 0. The mediating effect of smartwatch use on user loyalty and user influence through self-extension is 0.940 and 0.775, respectively. And, their confidence intervals all exclude 0. None of the confidence intervals for the mediating effects includes 0. Therefore, the mediating effects are all significant and H4a, H4b, H6a, and H6b are supported.

Based on the above results, it can be seen that smartwatch use affects user loyalty and user influence through self-expansion. In addition, self-extension also mediates the relationship between smartwatch use, user loyalty and user reciprocity. These findings reveal the roles of self-expansion and self-extension of smartwatch users in value co-creation, which is significant for scholars and managers to understand the experiences and behaviors of smartwatch users.

Discussion

This study empirically examines the effects of smartwatch use on user experience (self-expansion and self-extension), and the effects of self-expansion and self-extension on user reciprocity (user loyalty and user influence). In addition, this study also regarded self-expansion and self-extension as mediating variables and inferred that smartwatch use would affect user reciprocity through self-expansion and self-extension. The results of the study are as follows.

First, smartwatch use positively affects self-expansion and self-extension. By using smartwatches, users can gain new knowledge, ability and identities and realize self-expansion. Meanwhile, they will see smartwatches as part of their self-awareness and experience self-extension. Therefore, the more a person uses a smartwatch, the more likely they are to experience self-expansion and self-extension. These findings provide empirical support for S-D logic. S-D logic argues that product use could create value for users (Vargo and Lusch, 2004) and that user experience is an important aspect to assess the value of product use (Vargo and Lusch, 2008). In our study, smartwatch use provides the experience of self-expansion and self-extension for users. Furthermore, similar to Ram and Jung's study, these findings emphasize the importance of product use. Ram and Jung (1991) focus on product use in the context of durable goods and found product use affects consumer satisfaction through use disconfirmation.

Second, self-expansion positively affects user loyalty and user influence, and plays a mediating role in the relationship between smartwatch use and user loyalty (or user influence). When users obtain the value of self-expansion, they will show user loyalty and user influence, giving back to the related manufacturer directly or indirectly due to the reciprocity principle in value co-creation. In addition, as a value co-creation activity, smartwatch use provides users with self-expansion and motivates them to contribute value to the manufacturer in return. Therefore, smartwatch use affects user loyalty and user influence through self-expansion. This is consistent with views of S-D logic. Smartwatch use is a process of value co-creation (Baumann et al., 2017). In this process, users gain self-expansion, while manufacturers reap direct and indirect value through user loyalty and user influence, respectively. Furthermore, similar to many studies, the present study introduces self-expansion in the individual-organization relationship and reveals the positive effects of self-expansion. For example, self-expansion is considered to strengthen relationship quality and consumer-brand identification in the context of luxury brands (De Kerviler and Rodriguez, 2019). Gorlier and Michel (2020) also argue that self-expansion mediates the positive effects of reward extraordinary on brand evaluation, recommendation, and identification.

Third, self-extension is positively related to user loyalty and user influence. Moreover, self-extension mediates the effect of smartwatch use on user loyalty and user influence. After achieving self-extension, based on the principle of reciprocity in value co-creation, smartwatch users would contribute value back to smartwatch manufacturers in the forms of user loyalty and user influence. Smartwatch use is a value co-creation process, in which smartwatch users can achieve self-extension and then provide value to smartwatch manufacturers directly or indirectly. Therefore, smartwatch use has an impact on user loyalty and user influence through self-extension. These findings echo the premises of S-D logic in the context of smartwatch use. Smartwatch use is a way for users and manufacturers to achieve value co-creation (Vargo and Lusch, 2004). Besides, it is not strange that users gain self-extension in using smartwatches. On the contrary, digital technologies provide more means for people to achieve self-extension (Belk, 2013). For instance, Ross and Bayer (2021) argue that people regard their mobile phone as an extension of the self. Schweitzer et al. (2019) also draw on self-extension theory to explore the relationship between users and voice-controlled smart devices.

Conclusion

This study focuses on the outcomes of smartwatch use and finds that smartwatch use positively affects self-expansion and

self-extension, which in turn affect user reciprocity (user loyalty and user influence). Based on S-D logic, this study reveals the process by which smartwatch use creates value for users and manufacturers, enriches the relevant literature on smartwatches, and can also provide useful insights for manufacturers to manage user value.

Theoretical contributions

First, this study enriches research on smartwatches and emphasizes the importance of smartwatch use. Existing research has mainly focused on the drivers of initial and continued use of smartwatches, neglecting the outcomes of smartwatch use. However, S-D logic emphasizes that using a product is a way to achieve value co-creation. To fill in this gap, we deal with the outcomes of smartwatch use, explores the direct impact of smartwatch use on user experience and the indirect impact on the value of manufacturers, and highlights the importance of smartwatch use.

Second, this study broadens the application context of self-expansion and self-extension theories. The literature has rarely examined the antecedents and consequences of self-expansion and self-extension in the relationship between smartwatches and users, and the context of the application of these theories is relatively limited. Thus, we innovatively utilize the theories of self-expansion and self-extension in the setting of smartwatch use, and find that self-expansion and self-extension are both important outcomes of smartwatch use and potential mechanisms for the effects of smartwatch use. These findings lead to richer contexts for the application of self-expansion and self-extension theories.

Third, this study provides empirical evidence to support S-D logic. S-D logic holds that using products is a source of value. Consistent with this view, this study finds that smartwatch use creates the experience of self-expansion and self-extension for users, which in turn drives user loyalty and user influence. Both users and manufacturers gain value from smartwatch use. In addition, S-D logic suggests that value co-creation is inherently reciprocal. This study shows that users can achieve self-expansion and self-extension by using the smartwatches provided by manufacturers. Meanwhile, in light with the principle of reciprocity in value co-creation, users also provide value to the manufacturers in the form of user loyalty and user influence.

Practical implications

First, smartwatch manufacturers should make efforts to increase and improve people's smartwatch use. To begin with, smartwatch manufacturers should provide users with detailed and easy-to-understand user manuals or set up a library of frequently asked questions (FAQ) on their official website, which may increase users' understanding of smartwatches. In this case, users are more likely to use smartwatches in their daily lives. In addition, smartwatch manufacturers should strengthen the training of after-sales service agents to ensure that they can answer users' questions about smartwatches timely. In this way, users would use smartwatches more smoothly and conveniently and thus improve the level of their smartwatch use.

Second, smartwatch manufacturers should pay attention to the management of user experience. First of all, smartwatch manufacturers should regularly upgrade the operating system of smartwatches. A high level of system quality may improve smartwatch users' experience. A constantly updated operating system may also enhance users' perception of the innovativeness of smartwatches. Furthermore, smartwatch manufacturers should focus on the establishment and management of user online communities and encourage users to share their experiences of using smartwatches with each other. The interaction between smartwatch users in online communities is also beneficial to the user experience. Finally, smartwatch manufacturers should enhance cooperation with other manufacturers of Internet of Things (IoT) devices, and improve the ability of smartwatches to connect with other IoT devices. This would increase the functions of smartwatches and enrich the users' experience of using smartwatches.

Limitations and future studies

First, this study does not explore the boundary conditions of the impact of smartwatch use on its outcomes. The impact of smartwatch use on user self-expansion and self-extension may vary for different smartwatch users. For example, it is revealed that people who are more similar with each other in a relationship are more likely to achieve self-expansion (Mao et al., 2019). Future research could investigate some potential variables, such as users' personality traits, that moderate the effect of smartwatch use on subsequent outcomes.

Second, our research findings are only based on the survey data of smartwatch users in China. Cultural and economic backgrounds may influence people's acceptance and use of smartwatches; therefore, the findings may not be generalizable to other countries. Future studies could be conducted in other societies to improve the generalizability of the findings.

Third, this study only focuses on the impact of a single type of wearable technology, smartwatches, on users and manufacturers. However, wearable technologies cover many other products, such as smart glasses and smart clothing, whose impact on society is still unknown. Therefore, it is necessary for other researchers to explore the impact of other devices on people to improve our understanding of wearable technologies.

Data availability statement

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

Requests to access these datasets should be directed to JY, y2362146000@gmail.com.

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

RL contributed to conceptualization, methodology, writing—review and editing, project administration, funding acquisition, and supervision. JiY contributed to conceptualization, methodology, and writing—review and editing. JuY performed conceptualization, methodology, writing—review and editing, funding acquisition, and supervision. 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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EDITED BY
Stephen Schueller,
University of California Irvine,
Irvine, United States

REVIEWED BY
Eduardo L. Bunge,
Palo Alto University,
United States
Luke Balcombe,
Griffith University,
Australia

*CORRESPONDENCE
Gregory E. Chase
gechase@uncg.edu

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Emerging adults' digital technology engagement and mental health during the COVID-19 pandemic

Gregory E. Chase*, Morgan T. Brown and Michaeline Jensen

Department of Psychology, University of North Carolina at Greensboro, Greensboro, NC, United States

Within the past decade, parents, scientists, and policy makers have sought to understand how digital technology engagement may exacerbate or ameliorate young people's mental health symptoms, a concern that has intensified amidst the COVID-19 pandemic. Previous research has been far from conclusive, and a lack of research consensus may stem in part from widely varying measurement strategies (including subjective and objective measurement) around digital technology engagement. In a cross-sectional study of 323 university students, the present study seeks to understand the ways in which youth engagement with digital technology – across subjective and objective measurements, weekday and weekend distinctions, and social and non-social uses – is associated with mental health (as measured by depression, loneliness, and multidimensional mood and anxiety). The present study also tested a differential susceptibility hypothesis to examine whether COVID-19 related social isolation might exacerbate the potential harms or helps of digital technology engagement. Results yielded few observed associations between digital technology engagement and mental health, with little evidence of detrimental effects of observed or perceived time spent on digital technology. Rather, those significant findings which did emerge underscore potential protections conferred by social connections with friends (both online and offline), and that the loneliest students may be the most likely to be reaching out for these types of connections. It is important that the field move beyond crude (largely self-reported) measures of screen time to instead understand how and to what effect youth are using digital technologies, especially during the social corridor of emerging adulthood.

KEYWORDS

digital technology, screen time, COVID-19, mental health, emerging adulthood

Introduction

Intersections between digital technology engagement and mental health are of great interest, with media attention and research on the topic skyrocketing within the last 14 years (Hancock et al., 2019; Reeves et al., 2020). These intersections are of even more importance within the past 2–3 years of the COVID-19 pandemic (Richtel, 2021; Shrier, 2021), during

which we have seen spikes in both frequency of digital technology engagement (Cielo et al., 2021; Kerekes et al., 2021) and psychological distress (Chen et al., 2021; Czeisler et al., 2021). Digital technology engagement has been recognized as both a protective and risk factor for mental health during the COVID-19 pandemic (Okabe-Miyamoto and Lyubomirsky, 2021), with recent work uncovering associations between technology engagement and poorer mental wellbeing (Smith et al., 2020; Li et al., 2021), as well as shining light on positive ways in which digital technology provided a valuable lifeline from widespread lockdowns and social distancing into the social, educational, and occupational worlds beyond one's front door (Beaunoyer et al., 2020; Juvonen et al., 2021). While popular media has loudly argued that digital technology engagement is widely harmful (e.g., Twenge, 2017), it is important to consider how digital technology can be used to maintain social connections and protect against the negative consequences of the pandemic (Marciano et al., 2022). Thus, the current study seeks to test ways that digital technology engagement may be facilitative of or deleterious to young adult's mental health during the pandemic.

The research to date on digital technology's potential impacts on mental health is somewhat fraught. Many argue and some research suggests that more time spent on screens is harming youths' mental health and potentially to blame for historical increases in depression, anxiety, and suicide since the advent of the smartphone (Twenge et al., 2018a,b; Twenge, 2020). However, a sizable body of studies using various methods (Nesi and Prinstein, 2015; Nesi et al., 2017; Jensen et al., 2019; Coyne et al., 2020), including meta-analyses and reviews (Appel et al., 2020; Odgers and Jensen, 2020; Tang et al., 2021) conclude that digital technology engagement has small, negligible, or mixed effects on youth mental health. It is important for us to sort through this apparent disorder in the literature and identify where (if anywhere) sizable risks and protections for mental health may occur, in service of staunching rising rates of psychological distress, especially amidst the pandemic when both screen time and mental health problems have had pronounced increases. It is likely that at least some of the lack of clarity in the literature to date stems from widely varying measurement strategies around digital technology engagement (Scharkow, 2016). Kaye et al. (2020) note that current methodological shortcomings include poor conceptualization of what is considered "screen time" and the use of non-standardized, self-report measures that are often underestimated by heavy users and overestimated by light users. Here we highlight three dimensions of measurement difference that are of potential interest: (1) Objective versus subjective (or perceived) measurement of digital technology engagement, (2) Weekday versus weekend measurement, and (3) Moving beyond monolithic assessments of general "screen time" to more nuanced *reasons* and *activities* young people engage in digital technology.

It is first important to consider objective versus subjective measurement of digital technology engagement. Though there is strong evidence indicating that self-reported frequency or duration of digital technology engagement is not a particularly accurate gauge of actual use (Boase and Ling, 2013; Parry et al., 2021), many studies continue to rely solely on self-reported digital technology engagement when determining links with mental health (Shaw et al., 2020). Admittedly, objective measurement of digital technology engagement (e.g., through device logs, systematic screenshots, or downloaded social media or message content; Andrews et al., 2015; Kaye et al., 2020) is considerably more onerous than gathering self-reports. However, these objective methods provide a more accurate metric of the actual time and activities one is engaged in online that is less impacted by participant's attitudes and beliefs toward smartphone and social media use (Ellis et al., 2019). Thus, objective measures provide a clearer lens through which to understand digital technology and mental health associations (Parry et al., 2021), which is integral to addressing methodological limitations presented by previous research (Kaye et al., 2020). In fact, those few studies using objective measures of digital media engagement have little evidence of sizable or robust associations with mental health (Rozgonjuk et al., 2018; Hodes and Thomas, 2021; Sewall et al., 2022).

The timing of digital technology engagement, including the day of the week, appears to also be an important consideration. In a seminal article by Przybylski and Weinstein (2017) using cross-sectional data from a representative sample of English adolescents, results indicated that the distinction between moderate and potentially harmful screen time was considerably higher and less variable on the weekend, suggesting that the potential negative consequences of screen time are at a lower threshold during the weekday than on weekends. This is consistent with other studies in China and the United Kingdom (Khouja et al., 2019; Liu et al., 2019) which together suggest that the *day of the week* that adolescents engage in screen time may be an important distinction when considering harms of digital technology, perhaps because weekday screen time may displace other enriching activities that are beneficial to development in a way that weekend screen time does not.

Lastly and most importantly, it is important to understand whether different *types* of digital technology engagement are differentially linked with positive mental health flourishing or negative mental health functioning. For instance, theories of social support and connection (Cole et al., 2017) would suggest that engagement with social media that facilitate authentic social connection and supportive interactions would likely benefit youth mental health and wellbeing, and indeed research does suggest that social screen time (especially one-on-one interactions, including amidst the pandemic) seems to be associated with fewer mental health symptoms (Fumagalli et al., 2021; Marciano et al., 2022). It is also likely that uses of digital technology for targeted purposes like education, creativity, and mastery could also be beneficial for mental health (Sanders et al., 2019; Granic et al., 2020). Conversely, passive types of use without a social component may be more consistently linked with poorer mental health, whether because they are displacing alternate enriching activities

that one *could otherwise* be engaging in, or because they serve as an avoidance strategy for internalizing youth (Kraut et al., 1998; Kim et al., 2020), though displacement may be less common amidst the pandemic when there were few face-to-face activities to displace. Overall, it is increasingly clear that rigorous research on digital technology engagement and mental health *must* respond to calls for more objective and nuanced assessment of the uses and affordances of different types of media use (Ellis et al., 2019; Kaye et al., 2020).

Not all young people experience the harms or the helps of social media in the same ways (Valkenburg and Peter, 2013). For instance, Orben et al. (2022) recently identified a window of sensitivity to social media effects at age 19 for both males and females, suggesting that the transition from adolescence to emerging adulthood may be an important developmental period to examine what ways social media may be protective or detrimental to wellbeing. Indeed, emerging adulthood (the period of study here) is a period when friendships are critical to development (Barry et al., 2016) and during which technology may be used in particularly satisfying ways to interact with friends.

Another potential point of differential susceptibility is the extent to which a young person is already struggling in their offline life (George and Odgers, 2015; Underwood and Ehrenreich, 2017). Here we focus on a salient struggle of the COVID-19 pandemic: Social isolation. Digital connection can serve as an important tool for social interaction and maintaining real-life social networks online (Mcmillan and Morrison, 2006), which may be especially pertinent during the COVID-19 pandemic when social isolation has prevented in-person connection (Juvonen et al., 2021). Thus, it is possible that those emerging adults who were the most isolated had the most to gain from digitally mediated social connection (a "poor get richer" hypothesis). There is also concern, however, that those emerging adults who were already struggling with social isolation induced by COVID-19 related lockdowns may have been particularly susceptible to the negative impacts of digital technology engagement on anxiety, depression, and loneliness during an already challenging time (consistent with the "the poor get poorer" hypothesis; Kraut et al., 2002).

The current study

Given the murky landscape of current research on the intersections between digital technology engagement and youth mental health (including amidst the pandemic, Marciano et al., 2022), the present study takes a comprehensive approach in seeking to understand the ways in which emerging adult engagement with digital technology—across subjective and objective measurement strategies, weekday and weekend distinctions, and social and non-social uses—is associated with mental health symptoms (indexed by multidimensional mood and anxiety, depression, and loneliness). Specifically, we test the hypothesis that specific types of digital technology engagement (i.e., overall screen time and passive screen time) may be associated with poorer emerging adult mental health whereas other types of digital technology engagement (i.e., digital media for social purposes (especially private/one-on-one communication) and creativity screen time) may be associated with better emerging adult mental health, with more robust associations hypothesized for subjective self-reports than objective measures. We further hypothesize that, if associations with objective measures do arise, they are more likely to be seen on weekdays than weekends. We hypothesize this given past research on differential levels of digital technology engagement and impacts across the week. Finally, we test a differential susceptibility hypothesis and examine whether COVID-19 related social isolation might exacerbate the potential harms of non-social digital activities (a "vulnerable reactive" interaction, consistent with the "poor get poorer" hypothesis) but might also amplify the potential benefits of social digital activities (a protective enhancing interaction, consistent with the "poor get richer" hypothesis).

Materials and methods

Participants and procedures

Participants for this study were recruited via the University's Psychology Department subject pool at a public, minority-serving university in the Southeastern United States in the Fall of 2020. In this semester, the university offered classes online, in-person, or in hybrid formats due to the COVID-19 pandemic. On-campus activities were extremely restricted at the time, and students were able to live on-campus in a limited capacity ($n = 177$; 54.8% of our sample). Participants had to be at least 18 years of age to participate. Eligible participants were routed to an online Qualtrics survey where they provided informed consent before completing the survey assessment, for which they were awarded course credit. All procedures, protocols, and measures were approved by the university's Institutional Review Board (approval #21-0139).

A total of 393 participants consented to the study, with 30 (7.6%) excluded from present analyses due to data quality issues (i.e., completing <20% of the full survey assessment, survey duration <1/5th of the average length of survey completion) and an additional 40 participants (10.2%) excluded due to not owning an iPhone (necessary for our objective screen time measurement). Of the resulting analytic sample ($N = 323$), most were first year university students (55.1%) and identified as female (74.6%). The sample was racially/ethnically diverse (43.7% White, not-Hispanic; 43.4% Black, not-Hispanic; 14.8% Hispanic/Latinx; 6.8% Asian, 2.8% American Indian or Alaskan Native, 1.2% Middle Eastern or North African, 0.9% Native Hawaiian, and 0.9% identified as another race or ethnicity).

Measures

Demographics

Participants reported on key demographics at the beginning of the Qualtrics survey. Covariates included within the current study were participant *Age* in years ($M = 19$, $SD = 2.13$), and *Gender Identity* which was dummy coded into *Male Identifying* (21.2%), *Female Identifying* (74.6%), and *Other Identifying* (2.2%).

Perceived COVID-19 related social isolation

The 109-item Epidemic-Pandemic Impacts of Inventory Adolescent Adaptation (EPII-A; Morris et al., 2020) was administered to assess whether the participant perceived that the "COVID-19 pandemic has impacted you in the way described" on a binary *yes* (1) or *no* (0) scale (with an option for "does not apply" recoded here as 0). The item querying whether the participant was "Separated from friend(s)" was used as a dichotomous measure of perceived COVID-19 related social isolation, to which 56.3% responded "*yes*."

Perceived time spent on technology

Perceived COVID-19 related increases in screen time

One item from the EPII-A (Morris et al., 2020) queried whether the participant had "Spent more time on screens and devices" (74.6% *yes*) amidst the COVID-19 pandemic.

Perceived social media and screen time

Participants were first asked to estimate the "average amount of time you spend on your phone daily" (*perceived screen time*) and "the average amount of time you spend on social media daily" (*perceived social media time*) in hours (range *0 = <1 h* to *23 = 23–24 h*). Participants' reports revealed an average of 6.46 h ($SD = 2.89$) of daily screen time, with an average of 4.29 h ($SD = 2.24$) spent on social media.

Perceived time spent online and offline for social connection

The Electronic Interaction Scale for Time (EIS_T; Nesi and Prinstein, 2015) queried the average amount of time participants use specific technologies to connect with their friends on a "typical day." Participants indicated "on a typical day in the last month, how much time do you spend…" engaging with friends (on a 7-point scale ranging from *0 = I do not use this, 1 = 1 h or less, 6 = 9 or more hours*) for *face-to-face communication* (i.e., time they are talking for fun or social reasons, not just sitting together in class; $M = 3.01$, $SD = 1.78$), *phone calls, FaceTime, and Skype* ($M = 2.61$, $SD = 1.61$), *text messaging* ($M = 3.07$, $SD = 1.72$), *private social media* (e.g., Snapchat, private messaging on Facebook or emailing; $M = 2.83$, $SD = 1.66$), and *public social media* (e.g., Facebook, Instagram, Twitter; $M = 2.04$, $SD = 1.62$).

Objective screen time

Given the limitations of subjective self-reports on screen time (Scharkow, 2016), we piloted a procedure for coaching participants through the use of their native smartphone screen time tracking app to report (more) objective screen time. Similar methods for obtaining objective screen time measures have recently been used in adult (Ohme et al., 2021) and emerging adult (Hodes and Thomas, 2021) samples. iPhone users ($N = 323$) were instructed step by step on how to access and use the native iPhone Screen Time app (with the aid of screenshots embedded within the Qualtrics survey showing where to click) to find the amount of time (in hours and minutes) spent on their phone for different uses: (1) *Social* (e.g., Instagram, Snapchat, Facebook, TikTok); (2) *Creativity* (e.g., Camera, Photos); (3) *Entertainment* (e.g., Netflix, YouTube, Spotify); (4) *Education* (e.g., Canvas learning management system); and (5) *Productivity* (e.g., notes, mail, calendar). Android users ($n = 40$) completed a similar procedure but given that the categories reported on by the two platforms' native screen time tracking apps differ, we focus here on the majority of the sample (88.98%) who were iPhone users. Screen time categories are determined by Apple's Screen Time application and vary slightly from participant to participant based on what applications they have downloaded on their phone and use. Given past studies which have highlighted differences in the quantity and impacts of weekend versus weekday screen time (Przybylski and Weinstein, 2017), we asked participants to report each of these amounts separately for the previous Wednesday (to capture *weekday screen time*) and the previous Saturday (to capture *weekend screen time*) prior to survey administration. Participants reported on objective measures of screen time after the perceived measures of screen time and social media variables so that the objective measures did not bias their perception of time spent online. Descriptive statistics of objective measures of screen time can be found in Table 1.

TABLE 1 Means and standard deviations of objective time spent on technology in hours.

Objective screen time (in hours)	*M*	*SD*	Min	Max
Social weekday	3.47	2.55	0.00	22.32
Creativity weekday	1.07	1.76	0.00	11.52
Entertainment weekday	1.62	2.10	0.00	12.83
Education weekday	0.54	1.27	0.00	15.00
Productivity weekday	0.38	0.69	0.00	4.55
Social weekend	3.42	2.60	0.00	17.55
Creativity weekend	0.98	1.69	0.00	12.75
Entertainment weekend	1.66	2.35	0.00	18.90
Education weekend	0.41	1.32	0.00	15.00
Productivity weekend	0.29	0.72	0.00	5.90

$N = 323$.

Mental health

Depressive symptoms

Participants reported on their past month depressive symptoms using the well-validated 13-item Short Mood and Feelings Questionnaire (SMFQ; Angold et al., 1995), in which participants are provided I-statements that describe depressive moods and behaviors (e.g., "I felt miserable or unhappy") on a 3-point Likert scale ranging from *0 = Not True to 2 = True*. The original timeframe for responding was adapted from *past two weeks* to *past month* to align with other study measures. A mean score of the 13 items was created ($M = 0.65$, $SD = 0.54$), which evidenced strong internal consistency in this sample ($\alpha = 0.93$).

Multidimensional mood and anxiety

Anxiety symptoms were assessed using the well-validated Mini Mood and Anxiety Symptom Questionnaire (Mini-MASQ; Casillas and Clark, 2000) which is composed of mean scores on three subscales of mood symptoms: Anhedonic depression (8-items; e.g., "Felt like nothing was very enjoyable;" $M = 2.40$, $SD = 0.63$; $\alpha = 0.81$), anxious arousal (10-items; e.g., "Hands were cold or sweaty;" $M = 0.23$, $SD = 0.41$; $\alpha = 0.85$), and general distress (8-items; e.g., "Felt tense or high strung;" $M = 0.46$, $SD = 0.65$; $\alpha = 0.91$). Participants were instructed to indicate the extent to which they experience each symptom on a 5-point Likert scale ranging from *0 = not at all to 4 = extremely*. The original timeframe of *past week* was adapted to tap *past month* symptoms in accordance with other study measures.

Loneliness

Loneliness was assessed using the UCLA Loneliness Scale, version 3 (Russell, 1996). This scale averages 20 items that measure subjective feelings of loneliness and social isolation (e.g., "I feel completely alone"; $M = 1.88$, $SD = 0.76$; $\alpha = 0.96$) using a 4-point Likert scale ranging from *0 = I never feel this way to 3 = I often feel this way*. The original timeframe of *lifetime* loneliness was adapted for *past month* loneliness.

Data analytic plan

All analyses were conducted in Mplus 8.7 (Muthén and Muthén, 1998–2021) with the help of Hallquist and Wiley's (2018) Mplus automation package. All models used a maximum likelihood estimator with robust standard errors (MLR) and full information maximum likelihood (FIML) for missing data handling (Enders and Bandalos, 2001). We regressed each indicator of mental health (depression, anhedonic depression, anxious arousal, general distress, and loneliness) on each indicator of technology engagement alongside age and gender as covariates. We also tested whether each of these associations between indicators of technology engagement and mental health were moderated by perceived COVID-19 social isolation. Indicators included in interaction terms were mean centered to facilitate interpretation (Aiken et al., 1991) and significant interactions were probed among the socially isolated and non-socially isolated participants. Given the many comparisons (180 total models) inherent in testing these many hypothesized associations, we used the Benjamini Hochberg False Discovery Rate (FDR) procedure to adjust significant tests for multiple comparisons (Benjamini and Hochberg, 1995). For transparency, we report traditional *p*-values in all tables, with those that meet FDR-corrected significance levels marked with an asterisk.

Results

Direct associations between digital technology engagement and mental health

Results from tests of associations between digital technology engagement and mental health can be found in Table 2.

Objective time spent on technology

As seen in Table 2, students' objective weekday and weekend reports of various screen time categories were mostly not related to past month mental health, with one exception: Higher weekday educational screen time was related to lower levels of anhedonic depression in the past month ($\beta = -0.13$), though this association did not meet FDR-corrected significance levels.

Perceived time spent on technology

Those students who reported perceiving more time on social media, more time on screens, and more COVID-19 related increases in screen time were mostly not significantly more or less likely to report experiencing mental health problems in the past month (Table 2), with one exception: Those students who perceived that the pandemic had caused their screen time to increase endorsed higher levels of anxious arousal in the past month ($\beta = 0.09$), though this association did not meet FDR-corrected significance levels.

Perceived time spent online and offline for social connection

Those students who perceived themselves as engaging in more face-to-face communication with friends during the pandemic endorsed lower levels of anhedonic depression ($\beta = -0.30$; met FDR-corrected significance levels) and general distress ($\beta = -0.18$; did not meet FDR-corrected significance levels). Students who used text messaging with their friends more also endorsed lower levels of anhedonic depression ($\beta = -0.13$), though this association did not meet FDR-corrected significance levels. Students who interacted with friends through private social media more endorsed fewer symptoms of anhedonic depression ($\beta = -0.16$) and general distress ($\beta = -0.13$), though neither of these associations met FDR-corrected significance levels. An interesting pattern emerged between students' perceived frequency of online

TABLE 2 Direct associations between digital technology engagement and mental health.

	Past month mental health									
	Anhedonic depression		Anxious arousal		General distress		Depressive symptoms		Loneliness symptoms	
	b (*SE*)	*p*	*b* (*SE*)	*p*	*b* (*SE*)	*p*	*b* (*SE*)	*p*	*b* (*SE*)	*p*
Objective time spent on technology										
Weekday										
Creativity	−0.03 (0.02)	0.160	0.01 (0.02)	0.724	−0.02 (0.02)	0.484	0.01 (0.02)	0.734	−0.02 (0.02)	0.283
Educational	**−0.07 (0.02)**	**0.005**	<0.01 (0.02)	0.877	−0.02 (0.02)	0.439	−0.04 (0.02)	0.061	<0.01 (0.03)	0.988
Entertainment	0.02 (0.02)	0.244	0.02 (0.01)	0.179	0.03 (0.02)	0.126	0.02 (0.02)	0.236	−0.04 (0.02)	0.122
Productivity	<0.01 (0.05)	0.991	0.01 (0.03)	0.772	−0.04 (0.04)	0.377	−0.02 (0.04)	0.678	−0.01 (0.06)	0.927
Social	0.02 (0.01)	0.184	0.01 (0.01)	0.152	0.02 (0.02)	0.250	0.01 (0.01)	0.301	<0.01 (0.02)	0.845
Weekend										
Creativity	−0.03 (0.02)	0.219	0.01 (0.02)	0.446	−0.01 (0.02)	0.655	0.02 (0.02)	0.480	−0.02 (0.03)	0.532
Educational	−0.03 (0.03)	0.244	0.01 (0.02)	0.471	>−0.01 (0.02)	0.850	−0.03 (0.02)	0.109	−0.06 (0.03)	0.055
Entertainment	0.01 (0.02)	0.609	0.02 (0.01)	0.189	0.01 (0.02)	0.469	0.01 (0.02)	0.373	−0.01 (0.02)	0.749
Productivity	−0.02 (0.05)	0.746	0.05 (0.05)	0.314	−0.01 (0.05)	0.811	−0.03 (0.04)	0.502	−0.10 (0.06)	0.110
Social	0.02 (0.01)	0.092	0.01 (0.01)	0.369	0.01 (0.02)	0.427	0.02 (0.01)	0.124	0.01 (0.02)	0.476
Perceived time spent on technology										
Screen time	<0.01 (0.01)	0.757	<0.01 (0.01)	0.738	0.01 (0.01)	0.598	0.02 (0.01)	0.100	<0.01 (0.02)	0.973
Social media time	<0.01 (0.02)	0.903	>−0.01 (0.01)	0.749	>−0.01 (0.02)	0.785	0.01 (0.02)	0.423	0.01 (0.02)	0.617
Perceived COVID-19 screen time impact	−0.03 (0.08)	0.691	**0.09 (0.04)**	**0.043**	0.06 (0.08)	0.432	0.08 (0.06)	0.194	0.05 (0.10)	0.628
Perceived time spent online and offline for social connection										
Face-to-face	**−0.11 (0.02)**	**<0.001***	−0.01 (0.01)	0.717	**−0.06 (0.02)**	**0.003**	−0.03 (0.02)	0.137	**0.10 (0.02)**	**<0.001***
Phone calls	−0.04 (0.02)	0.085	>−0.01 (0.02)	0.827	−0.03 (0.02)	0.250	−0.02 (0.02)	0.464	**0.06 (0.03)**	**0.049**
Texting	**−0.05 (0.02)**	**0.033**	>−0.01 (0.02)	0.830	−0.02 (0.02)	0.187	−0.02 (0.02)	0.319	**0.08 (0.03)**	**0.002***
Private social media	**−0.06 (0.02)**	**0.007**	−0.01 (0.02)	0.768	**−0.05 (0.02)**	**0.033**	−0.04 (0.02)	0.055	**0.10 (0.03)**	**<0.001***
Public social media	−0.04 (0.02)	0.085	0.01 (0.02)	0.441	−0.02 (0.02)	0.511	−0.02 (0.02)	0.306	**0.06 (0.03)**	**0.032**

N = 323. Associations between each indicator of Digital Technology Engagement and each type of mental health symptom are tested in single level regressions, alongside covariates of age, and dummy coded gender. Raw regression coefficients (*b*), standard errors (SE), and *p*-values are reported. Significant ($p \leq 0.05$) associations are bolded. Coefficients that met FDR-corrected significance levels are asterisked.

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and offline social time and symptoms of loneliness where all indicators significantly predicted higher levels of student loneliness. Students who talked more with friends via face-to-face ($\beta = 0.22$), text messaging ($\beta = 0.18$), and private social media ($\beta = 0.23$) methods all endorsed greater levels of loneliness, which met FDR-corrected significance levels and students who perceived themselves as using more phone calls, FaceTime, and Skype ($\beta = 0.12$) and public social media ($\beta = 0.12$) to connect with friends also endorsed higher levels of loneliness, though results did not meet FDR-corrected significance levels.

Differential associations for more isolated students: Associations between digital technology engagement and mental health as moderated by COVID-19-related social isolation

Students who reported experiencing COVID-19 related social isolation tended to report more symptoms of depression ($b = 0.14$, $SE = 0.06$, $p = 0.023$; $\beta = 0.13$) and general distress ($b = 0.15$, $SE = 0.08$, $p = 0.047$; $\beta = 0.11$) though both did not meet FDR-corrected significance levels. Results from tests of interactions modeling potential differential susceptibility can be found in Table 3.

Objective time spent on technology

As seen in Table 3, there were four significant interactions between measures of objective screen time and COVID-19 related social isolation, though none of these met FDR-corrected significance levels. Specifically, probing significant interactions between COVID-19 related social isolation and weekend productivity screen time revealed that those students who had experienced COVID-19 related social isolation saw significant associations between weekend productivity screen time and less anxious arousal ($b = -0.06$, $SE = 0.02$, $p = 0.023$; $\beta = -0.10$) and less general distress ($b = -0.12$, $SE = 0.05$, $p = 0.032$; $\beta = -0.13$), whereas those who had not experienced COVID-19 related social isolation saw non-significant associations between weekend productivity screen time and anxious arousal ($b = 0.13$, $SE = 0.07$, $p = 0.052$; $\beta = 0.23$) and general distress ($b = 0.07$, $SE = 0.06$, $p = 0.259$; $\beta = 0.08$). Socially isolated students saw a significant association between weekday entertainment screen time and more anhedonic depression ($b = 0.06$, $SE = 0.03$, $p = 0.022$; $\beta = 0.19$) whereas those students who were not socially isolated amidst the pandemic saw non-significant associations between weekday entertainment screen time and less anhedonic depression ($b = -0.02$, $SE = 0.02$, $p = 0.467$; $\beta = -0.05$). Students who had not experienced COVID-19 related social isolation saw significant associations between weekend educational screen time and less loneliness ($b = -0.11$, $SE = 0.04$, $p = 0.003$; $\beta = -0.19$) whereas socially isolated students saw a non-significant association between weekend educational screen time and loneliness ($b = 0.01$, $SE = 0.04$, $p = 0.709$; $\beta = 0.02$).

Perceived time spent on technology

No significant interactions between COVID-19 perceived social isolation and perceived social media time, screen time, or COVID-19 related increases in screen time emerged (as seen in Table 3).

Perceived time spent online and offline for social connection

There were three significant interactions between perceived frequency of online social time (Table 3; phone calls, texting, and private social media) and COVID-19 related social isolation, though none of these met FDR-corrected significance levels. Among those who were experiencing COVID-19 related social isolation, those who engaged more frequently with friends via phone calls ($b = -0.07$, $SE = 0.03$, $p = 0.031$; $\beta = -0.18$), texting ($b = -0.07$, $SE = 0.03$, $p = 0.033$; $\beta = -0.18$), and private social media ($b = -0.09$, $SE = 0.03$, $p = 0.005$; $\beta = -0.24$) reported less general distress, whereas those who had not experienced COVID-19 related social isolation saw non-significant associations between phone calls ($b = 0.03$, $SE = 0.03$, $p = 0.319$; $\beta = 0.07$), texting ($b = 0.03$, $SE = 0.03$, $p = 0.332$; $\beta = 0.08$), and private social media ($b = 0.01$, $SE = 0.03$, $p = 0.652$; $\beta = 0.03$) and general distress.

Discussion

The COVID-19 pandemic saw unprecedented spikes in social isolation, mental health symptoms, and time spent on digital technologies; educators, practitioners, parents, and social scientists all worry about potential lasting consequences for young people's wellbeing. The present study sought to understand the ways in which emerging adult engagement with digital technology (across subjective and objective measurement strategies, weekdays and weekends, and social and non-social uses) is associated with mental health amidst the COVID-19 pandemic, with results suggesting few robust harms imparted by digital technology engagement but potential benefits imparted when youth are making close social connections (both online and offline).

Overall, there was little evidence of detrimental associations of observed or perceived *time spent* on digital technology with mental health. Of 65 potential direct associations, only two emerged as significant: More weekday objective educational screen time was associated with less anhedonic depression and perceived COVID-19 screen time increases were associated with more anxious arousal. It is perhaps not surprising that those emerging adults who were experiencing more anxiety also tended to perceive their screen time as having increased – whether this be because they have been primed by the media and their parents to see screen time as harmful and perhaps to blame for their mental health symptoms (Kamenetz, 2021) or because of a more objective link between pandemic-screen time increases and anxiety (though the lack of robust associations across other more objective indicators would suggest not). Given that, amidst the

TABLE 3 Differential associations for more isolated students: associations between digital technology engagement and mental health as moderated by COVID-19-related social isolation.

	Past month mental health									
	Anhedonic depression		Anxious arousal		General distress		Depressive symptoms		Loneliness symptoms	
	b (*SE*)	*p*	*b* (*SE*)	*p*	*b* (*SE*)	*p*	*b* (*SE*)	*p*	*b* (*SE*)	*p*
Objective Time Spent on Technology										
Weekday										
Creativity × Isolation	−0.02 (0.04)	0.648	<0.01 (0.04)	0.934	−0.02 (0.04)	0.585	0.01 (0.04)	0.860	0.06 (0.04)	0.155
Educational × Isolation	−0.02 (0.05)	0.733	−0.05 (0.04)	0.236	−0.02 (0.05)	0.635	0.01 (0.05)	0.896	0.08 (0.08)	0.311
Entertainment × Isolation	**0.07 (0.03)**	**0.026**	<0.01 (0.03)	0.920	0.05 (0.04)	0.139	0.06 (0.03)	0.053	−0.03 (0.04)	0.520
Productivity × Isolation	−0.10 (0.11)	0.339	−0.05 (0.06)	0.376	−0.09 (0.08)	0.268	−0.08 (0.08)	0.303	0.17 (0.13)	0.179
Social × Isolation	−0.02 (0.03)	0.322	0.03 (0.02)	0.110	0.02 (0.03)	0.524	0.03 (0.02)	0.195	−0.01 (0.03)	0.820
Weekend										
Creativity × Isolation	−0.02 (0.04)	0.640	0.01 (0.03)	0.782	> −0.01 (0.04)	0.970	0.05 (0.04)	0.148	0.03 (0.06)	0.609
Educational × Isolation	−0.05 (0.05)	0.381	−0.03 (0.03)	0.374	−0.02 (0.05)	0.703	> −0.01(0.04)	0.109	**0.12 (0.05)**	**0.019**
Entertainment × Isolation	0.05 (0.03)	0.126	−0.01 (0.03)	0.734	0.02 (0.03)	0.636	0.04 (0.03)	0.179	0.07 (0.04)	0.121
Productivity × Isolation	<0.01 (0.11)	0.996	**−0.19 (0.07)**	**0.009**	**−0.19 (0.08)**	**0.020**	−0.10 (0.08)	0.184	0.17 (0.12)	0.154
Social × Isolation	−0.03 (0.03)	0.401	0.01 (0.02)	0.560	0.02 (0.03)	0.549	0.03 (0.03)	0.266	0.05 (0.04)	0.173
Perceived Time Spent on Technology										
Screen time × Isolation	0.03 (0.03)	0.197	>−0.01 (0.02)	0.895	−0.03 (0.03)	0.323	<0.01 (0.02)	0.948	0.01 (0.03)	0.665
Social media time × Isolation	0.03 (0.03)	0.319	0.02 (0.02)	0.407	0.02 (0.03)	0.589	0.05 (0.03)	0.065	0.03 (0.04)	0.445
Perceived COVID-19 screen time impact × Isolation	0.03 (0.15)	0.861	−0.09 (0.09)	0.326	−0.03 (0.15)	0.837	0.02 (0.13)	0.876	0.16 (0.21)	0.440
Perceived time spent online and offline for social connection										
Face-to-face × Isolation	−0.04 (0.04)	0.338	>0.01 (0.03)	0.964	−0.01 (0.04)	0.833	0.01 (0.04)	0.748	−0.04 (0.05)	0.383
Phone calls × Isolation	0.01 (0.05)	0.891	−0.04 (0.03)	0.194	**−0.10 (0.05)**	**0.026**	−0.05 (0.04)	0.194	0.05 (0.06)	0.363
Texting × Isolation	<0.01 (0.04)	1.000	−0.03 (0.03)	0.351	**−0.10 (0.05)**	**0.031**	−0.03 (0.04)	0.489	0.09 (0.06)	0.116
Private social media × Isolation	−0.03 (0.05)	0.549	−0.02 (0.03)	0.505	**−0.11 (0.05)**	**0.020**	−0.01 (0.04)	0.781	0.07 (0.05)	0.207
Public social media × Isolation	−0.04 (0.05)	0.416	>0.01 (0.04)	0.999	−0.08 (0.05)	0.103	>0.01 (0.04)	0.999	0.07 (0.05)	0.176

N = 323. Associations between each indicator of Digital Technology Engagement, COVID-19 related social isolation, and their interaction with each type of mental health symptom are tested in single level regressions, alongside covariates of age and dummy coded gender. Raw regression coefficients (*b*), standard errors (SE), and *p*-values for interaction terms only are reported here, with simple slopes for significant interactions reported in the Results section. Significant ($p \leq 0.05$) associations are bolded. No interaction terms met FDR-corrected significance levels.

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pandemic in Fall 2020, much of college education was occurring on screens, it may be that the observed association between objectively-recorded education-related screen time and anhedonic depression is reflective of well-established links between the amotivation characteristic of anhedonia and low academic engagement (Fletcher et al., 2022); that is, those students who were experiencing anhedonia were probably the least likely to be signing on to their courses' learning management systems to check homework or watch lecture videos. It must be noted, though, that neither of these associations stood up to corrections for multiple comparisons, suggesting that they are possibly spurious and should be interpreted only with caution.

In contrast to the largely null results around time spent on technology (whether assessed objectively versus subjectively on weekday or weekends), we saw slightly more robust findings around the perceived amount of time spent connecting socially with friends online (and face-to-face), where the more socially connected students tended to report less anhedonic depression and general distress (perhaps indicative of a protective association between online and offline social connection and better mental health) but more loneliness over the past month (though again, not all associations stood up to corrections for multiple comparisons). On the one hand, it seems somewhat counterintuitive that we would see different directions of association for these three indicators of mental health. However, perhaps not; it very well may be that higher levels of social connection cause emerging adults to feel less down and distressed (or, conversely, that those students who are the least down and distressed are also feeling the most amenable to fostering social connections with their peers). Also, those students who are experiencing the highest levels of loneliness (a very social form of internalizing symptom) are the most motivated to reach out to their peers for social connection. It is also notable that we seem to see more robust associations with indicators of one-on-one communication with a closer social network (i.e., face-to-face, text messaging, and private social media) relative to more public forms of social media connections (i.e., public social media). This underscores the idea that it might matter less whether young people are making their social connections in online or offline spaces, and matter more whether these social connections are meaningful and authentic (likely easier in private channels of communication).

In addition to the direct associations with social connections above, there was also some (limited) evidence for differential susceptibility for those who were experiencing the most COVID-19 related social isolation. Seven significant interactions revealed one significant "poor get poorer" interaction (socially isolated students saw an association between weekday objective entertainment screen time with more anhedonic depression), one "rich get richer" interaction (non-socially-isolated students saw an association between weekend educational screen time with less loneliness), and five "poor get richer" interactions (socially isolated students saw associations between more weekend objective productivity screen time and less anxious arousal and general distress alongside stronger associations between more perceived frequency of social connection with friends via phone/video call, text message, and private social media with less general distress). It is somewhat difficult to know what to make of this mixed bag of interactions, especially given that none of these seven interactions (of 90 possible) maintained statistical significance once multiple comparisons were accounted for and must thus be interpreted cautiously and in light of the fact that they may be unlikely to replicate.

Further, the significant associations observed here across all models were small by standard metrics (Bowman, 2012), accounting for a relatively small proportion of the overall variance in mental health symptoms. Thus, we must conclude that overall the present study yields little support for quantity of digital technology engagement as a risk factor for mental health, but some (limited) evidence for potential protections conferred by online and offline social connections against mental health symptoms, particularly for those who were feeling socially isolated by the COVID-19 pandemic. The COVID-19 pandemic is likely to have lasting impacts on youth's mental health, and current research has started to uncover ways that youth may have difficulties adjusting to school, work, and social activities. Though the current study collected data in the Fall of 2020 amidst the height of the pandemic, it is likely that these experiences of depression, anxiety, and loneliness persist beyond the pandemic, and that the processes here will continue to be of importance. It is thus important that future researchers consider ways that social connection may be beneficial to youth mental health outside of the COVID-19 pandemic and explore different ways (beyond platform usage) that youth are able to connect with their peers online.

Limitations

These findings must be interpreted in light of several specific study limitations,. First, as this study was our first foray into piloting the use of the Apple Screen Time app to track objective time spent on the students' iPhone, some informative lessons were learned here. Notably, we excluded Android users from the present analysis, as the categories of Screen Time tracking on that platform differ from iOS. While Android users made up a small proportion of the current sample (11.05%), future research should consider cross-platform harmonization of screen time measures for a more representative sample that does not rely solely on iPhone using participants. Further, we became aware after data collection that Apple offers an option to "Share across devices" for screen time data (off by default), which counts time accrued on all devices (e.g., iPhone, iPad, and Mac computers) toward the tracked screen time available in the app. Thus, we cannot be certain here that all students here are being scored on the same metric/number of devices (i.e., some students may have higher objective screen time values because they spend lots of time on their MacBook whereas others may be spending lots of time on an iPhone specifically). Future research seeking to employ

objective screen time should consider querying whether this setting turned on, and if so, what other devices the student has linked to their Apple ID that would be tracked and/or using recently developed protocols for uploading screen time screenshots that capture this setting (Sewall et al., 2022).

Second, as with all cross-sectional research, it is important to remember that the present study cannot be used for causal inference and does not tell us definitively what the drivers of the observed associations are. This concern is somewhat disputable, as few significant associations emerged to interpret (and those that were significant were fairly small), though those that did could be illustrating processes in which technology engagement drives mental health, in which mental health drives degree and type of engagement with technology, or indeed in which third variables (e.g., predispositions) drive both. It is imperative that future research employ longitudinal and experimental designs to clarify potential causal associations.

Conclusion

The present study offers further support for the growing consensus that quantity of engagement with digital technology is not universally or robustly harmful, and that our quest to prevent young adult mental health problems would be best served by focusing on the specific ways in which young people use digital technologies to meet their social needs. The importance of social connection was especially true amidst the social isolation of the COVID-19 pandemic, but certainly extends beyond the pandemic, especially in the adolescent and emerging adult periods when social connections are so developmentally salient (Barry et al., 2016). This study is strengthened by a transparent approach to reporting findings across different possible operationalizations of digital technology engagement and mental health and by data collection in real-time amidst the COVID-19 pandemic. This study suggests few consistent mental health risks imparted by time spent online (regardless of measurement strategy, including a somewhat novel self-report strategy using Apple's Screen Time app) and rather highlight some potential mental health benefits of connecting socially with friends online and offline. Nonetheless, we believe that it is important that researchers commit to carefully considering the impact of using subjective measures of digital technology engagement and to consider moving to objective measurement. This could take the form of objective measures of *quantity* of screen time (ideally separately for different types of uses) like device logs, usage screenshots, or the method employed here, or innovative methods to better understand the objective content of *what youth are doing online* like the Effortless Assessment of Risk States program (EARS; Lind et al., 2018) or the methods employed in the Human Screenome Project (Reeves et al., 2020). We will be best positioned to understand the role of digital technologies in mental health if we have a more accurate and rich understanding of what types of activities (e.g., social comparison, social connection, cyberbullying, information seeking, passive scrolling) youth are engaging in online.

Importantly, results suggest that the loneliest students are also the more likely to seek out online social connections. Those invested in the mental health of emerging adults should carefully consider the ways in which virtual tools may help foster social connections in this important developmental period, especially during crises during which face-to-face social connections are undermined (as was/is the case in the ongoing COVID-19 pandemic). Social scientists should also attend further to the importance of moving beyond crude measures of screen *time* to instead understand *how* youth are using digital technologies.

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 North Carolina at Greensboro Institutional Review Board [#21-0139]. The patients/participants provided their written informed consent to participate in this study.

Author contributions

GC, MB, and MJ contributed to conception and design of the study. MB organized the database. GC performed the statistical analyses and wrote the first draft of the manuscript. MB and MJ reviewed and edited the manuscript. All authors have substantially contributed to the manuscript, approved this submission, and agreed to be responsible for the scientific accuracy and integrity of this work.

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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EDITED BY
Leon Sterling,
Swinburne University of Technology, Australia

REVIEWED BY
Jamin J. Day,
The University of Newcastle, Australia
Lauri Lahti,
Aalto University, Finland

*CORRESPONDENCE
Teodor Zidaru
✉ t.m.zidaru-barbulescu@lse.ac.uk

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Artificial intelligence technologies and compassion in healthcare: A systematic scoping review

Elizabeth Morrow[1], Teodor Zidaru[2]*, Fiona Ross[3], Cindy Mason[4], Kunal D. Patel[5], Melissa Ream[6] and Rich Stockley[7]

[1]Research Support Northern Ireland, Downpatrick, United Kingdom, [2]Department of Anthropology, London School of Economics and Political Sciences, London, United Kingdom, [3]Faculty of Health, Science, Social Care and Education, Kingston University London, London, United Kingdom, [4]Artificial Intelligence Researcher (Independent), Palo Alto, CA, United States, [5]Iheed, Dublin, Ireland, [6]Kent Surrey Sussex Academic Health Science Network (AHSN) and the National AHSN Network Artificial Intelligence (AI) Initiative, Surrey, United Kingdom, [7]Head of Research and Engagement, Surrey Heartlands Health and Care Partnership, Surrey, United Kingdom

Background: Advances in artificial intelligence (AI) technologies, together with the availability of big data in society, creates uncertainties about how these developments will affect healthcare systems worldwide. Compassion is essential for high-quality healthcare and research shows how prosocial caring behaviors benefit human health and societies. However, the possible association between AI technologies and compassion is under conceptualized and underexplored.

Objectives: The aim of this scoping review is to provide a comprehensive depth and a balanced perspective of the emerging topic of AI technologies and compassion, to inform future research and practice. The review questions were: How is compassion discussed in relation to AI technologies in healthcare? How are AI technologies being used to enhance compassion in healthcare? What are the gaps in current knowledge and unexplored potential? What are the key areas where AI technologies could support compassion in healthcare?

Materials and methods: A systematic scoping review following five steps of Joanna Briggs Institute methodology. Presentation of the scoping review conforms with PRISMA-ScR (Preferred Reporting Items for Systematic reviews and Meta-Analyses extension for Scoping Reviews). Eligibility criteria were defined according to 3 concept constructs (AI technologies, compassion, healthcare) developed from the literature and informed by medical subject headings (MeSH) and key words for the electronic searches. Sources of evidence were Web of Science and PubMed databases, articles published in English language 2011–2022. Articles were screened by title/abstract using inclusion/exclusion criteria. Data extracted (author, date of publication, type of article, aim/context of healthcare, key relevant findings, country) was

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charted using data tables. Thematic analysis used an inductive-deductive approach to generate code categories from the review questions and the data. A multidisciplinary team assessed themes for resonance and relevance to research and practice.

Results: Searches identified 3,124 articles. A total of 197 were included after screening. The number of articles has increased over 10 years (2011, *n* = 1 to 2021, *n* = 47 and from Jan–Aug 2022 *n* = 35 articles). Overarching themes related to the review questions were: (1) *Developments and debates* (7 themes) Concerns about AI ethics, healthcare jobs, and loss of empathy; Human-centered design of AI technologies for healthcare; Optimistic speculation AI technologies will address care gaps; Interrogation of what it means to be human and to care; Recognition of future potential for patient monitoring, virtual proximity, and access to healthcare; Calls for curricula development and healthcare professional education; Implementation of AI applications to enhance health and wellbeing of the healthcare workforce. (2) *How AI technologies enhance compassion* (10 themes) Empathetic awareness; Empathetic response and relational behavior; Communication skills; Health coaching; Therapeutic interventions; Moral development learning; Clinical knowledge and clinical assessment; Healthcare quality assessment; Therapeutic bond and therapeutic alliance; Providing health information and advice. (3) *Gaps in knowledge* (4 themes) Educational effectiveness of AI-assisted learning; Patient diversity and AI technologies; Implementation of AI technologies in education and practice settings; Safety and clinical effectiveness of AI technologies. (4) *Key areas for development* (3 themes) Enriching education, learning and clinical practice; Extending healing spaces; Enhancing healing relationships.

Conclusion: There is an association between AI technologies and compassion in healthcare and interest in this association has grown internationally over the last decade. In a range of healthcare contexts, AI technologies are being used to enhance empathetic awareness; empathetic response and relational behavior; communication skills; health coaching; therapeutic interventions; moral development learning; clinical knowledge and clinical assessment; healthcare quality assessment; therapeutic bond and therapeutic alliance; and to provide health information and advice. The findings inform a reconceptualization of compassion as a *human-AI system of intelligent caring* comprising six elements: (1) Awareness of suffering (e.g., pain, distress, risk, disadvantage); (2) Understanding the suffering (significance, context, rights, responsibilities etc.); (3) Connecting with the suffering (e.g., verbal, physical, signs and symbols); (4) Making a judgment about the suffering (the need to act); (5) Responding with an intention to alleviate the suffering; (6) Attention to the effect and outcomes of the response. These elements can operate at an individual (human or machine) and collective systems level (healthcare organizations or systems) as a cyclical system to alleviate different types of suffering. New and novel approaches to human-AI intelligent caring could enrich education, learning, and clinical practice; extend healing spaces; and enhance healing relationships.

Implications: In a complex adaptive system such as healthcare, human-AI intelligent caring will need to be implemented, not as an ideology, but through strategic choices, incentives, regulation, professional education, and training, as well as through joined up thinking about human-AI intelligent caring.

Research funders can encourage research and development into the topic of AI technologies and compassion as a system of human-AI intelligent caring. Educators, technologists, and health professionals can inform themselves about the system of human-AI intelligent caring.

KEYWORDS

artificial intelligence (AI), compassion, compassionate healthcare, empathy, healthcare technology

Highlights

- Artificial intelligence (AI) refers to computer systems that are designed to think or act like humans (human approach) and systems that think or act rationally (rational approach). However, current thinking about AI falls short of understanding the underlying motivational systems of thinking and acting like a human (e.g., compassion) or the influence of such motivational systems on complex societal systems (e.g., healthcare).
- Exploration of the associations between AI technologies and compassion have been hindered by two widely held assumptions (1) that compassion is a felt emotion in the body produced through relationships and social dynamics, and (2) that technologies are objective and incapable of compassion (again an assumption based on a view that compassion only involves felt emotion). Although it is debated whether AI can feel or express genuine empathy, compassion is different because it is a system.
- The literature shows that AI technologies can be (a) individually programmed (i.e., "build compassion in") to mimic elements of human compassion (e.g., emotion detection, affective response, empathetic display, socio-cultural intelligence) to various degrees of authenticity and success, and (b) be used collectively within a system of healthcare to enhance compassion (e.g., increasing empathetic awareness, assessing needs in high-risk patient groups, understanding the person), (i.e., "use it for compassion").
- Compassion can be conceptualized as a *human-AI system of intelligent caring* comprising six elements: (1) Awareness of suffering (e.g., pain, distress, risk, disadvantage); (2) Understanding the suffering (significance, context, rights, responsibilities etc.); (3) Connecting with the suffering (e.g., verbal, physical, signs and symbols); (4) Making a judgment about the suffering (the need to act); (5) Responding with an intention to alleviate the suffering; (6) Attention to the effect and outcomes of the response. Future research into these elements could develop new and novel approaches to human-AI intelligent caring.

1. Introduction

Artificial intelligence (AI) refers to computer systems that are designed to think or act like humans (human approach) and systems that think or act rationally (rational approach) (Russell and Novig, 2020). This article uses a systematic scoping review of the literature to explore the possible association between AI technologies and compassion in healthcare. This topic relates to current debates about the way AI might be perceived or imagined to be caring (De Togni et al., 2021) or compassionate (Day et al., 2021).

Exploring the possible association between AI and compassion is important because AI mediates every area of healthcare systems (e.g., complex systems involving purchasers, providers, payers, patients, and so on) by powering search engines, analysing data and making recommendations (Bajwa et al., 2021), as well as through clinical and health-related applications (Davenport and Kalakota, 2019). AI can be incredibly powerful for processing (e.g., using pattern recognition or predictive capabilities) "big data," which refers to the masses of data that are increasingly readily available in society through digital devices (Topol, 2019). Machine learning is the most common form of AI and largely relies on supervised learning, when computers are trained with labels decided by humans. Deep learning and adversarial learning involve training on unlabeled data to reveal underlying patterns (e.g., algorithms are used to find clusters or variances in data) (see[1]). However, current thinking about AI falls short of understanding the underlying motivational systems of thinking and acting like a human (e.g., compassion) or the influence of such motivational systems on complex societal systems (e.g., healthcare).

Yet current research shows that AI technologies (i.e., AI-driven machines, devices, programs, or applications) influence not only how humans think and act but how healthcare professionals work and learn (Bin Kamarudin and Zary, 2019) ("healthcare professionals" is used here to mean the wide range of trained professionals that deliver clinical treatments and care e.g., medical, surgical, nursing, professions allied to

1 https://www.deeplearning.ai/

medicine, mental health professionals, and so on, rather than the broader health professions, general managers, administrative staff etc.). For example, by informing more accurate imaging and diagnosis (Nichols et al., 2019), improving the efficiency of clinical screening (Grzybowski et al., 2020), enabling personalized medicine (Schork, 2019), and precision medicine that is tailored to individual patient needs (Mesko, 2017; Chang, 2020). Within healthcare organizations, AI may support improved productivity, workload, performance, teamwork, and satisfaction (Hazarika, 2020; Morley et al., 2020). Patients will increasingly experience new e-health (electronic health) applications in clinical settings (Lupton, 2017), in their own homes and mhealth (mobile health) applications in their lives (Torous et al., 2018). So, to explore how AI technologies might support compassion in healthcare systems it is important to look more deeply at what compassion is.

Compassion has been described as a sensitivity to suffering in self and others, with a commitment to try and alleviate and prevent it (Gilbert, 2014). It is perceived to be an evolutionary survival feature of a social species, which promotes helpful caring behaviors in an interconnected field of social relations, steered by ethical values and social norms (Goetz et al., 2010; Gilbert, 2019). Compassionate behavior is modeled and learnt through human interactions, such as parenting and teaching (Goetz et al., 2010). Compassion research demonstrates how the psychology of compassion in the mind (experiencing or witnessing helpful interactions) (Walter et al., 2015) affects the body, improves human health (Kim et al., 2009), and benefits societies (Seppälä et al., 2017). Yet, compassion is under conceptualized and underexplored in relation to AI technologies (Bloom, 2016; Kerasidou, 2020) or the question of how AI technologies might be used to generate or enhance compassion (Day et al., 2021). Exploration of the associations between AI technologies and compassion have been hindered by two widely held assumptions (1) that compassion is a felt emotion in the body produced through relationships and social dynamics and (2) that technologies are objective and incapable of compassion (White and Katsuno, 2019) (again an assumption based on a view that compassion only involves felt emotion). Although it is debated whether AI can feel or express genuine empathy (Montemayor et al., 2021), compassion is different because it is a motivational caring system (Gilbert, 2019).

In healthcare contexts there is considerable interest in compassion for ethical and clinical reasons (Fotaki, 2015; Papadopoulos and Ali, 2016). Compassion is described as a "medical virtue" (De Bakey, 2018), a "virtuous response" (Sinclair et al., 2016a,b) or "intelligent kindness" (Gallagher and Wainwright, 2005). Compassion is an expectation of recruitment to healthcare jobs (Straughair, 2019); a component of ethical professional practice (Flores and Brown, 2018); an indicator of healthcare quality (Sinclair et al., 2017; Durkin et al., 2018; Clavelle et al., 2019; Thomas and Hazif-Thomas, 2020; Baguley et al., 2022); and a dynamic interactional experience that includes motivation, capacity, and connection (Uygur et al., 2019). Compassionate caregiving has been described as involving meaningful actions to alleviate suffering and meet individual needs and prevent further suffering (Durkin et al., 2021). Compassionate behaviors (Straughair, 2019) are taught through pedagogy (Hendry, 2019), learning objectives (Lown, 2016; Sinclair et al., 2021; Wang et al., 2022) assessment (Lown et al., 2016), and skills sets such as reflective listening (Braillon and Taiebi, 2020; Su et al., 2021). Healthcare research has examined compassion from the perspective of: the predictors of compassion in healthcare professionals (Fernando and Consedine, 2014; Bleiker et al., 2020; Pavlova et al., 2022); how care environment and organizational culture affect compassion (Casagrande, 2016; Ali and Terry, 2017; Dev et al., 2019; Tehranineshat et al., 2019; Wiljer et al., 2019; Ali et al., 2022); compassion-maintaining strategies and interventions (Blomberg et al., 2016; Terry et al., 2017; Flores and Brown, 2018; Baguley et al., 2020; Hopkins et al., 2021; Malenfant et al., 2022); compassionate leadership (Dewar and Cook, 2014; de Zulueta, 2015; Lown et al., 2019; West et al., 2020); and regulation of compassionate caregiving (Harris et al., 2019; Pedersen and Roelsgaard Obling, 2019). Culturally and critically informed perspectives of compassion highlight that different societies, professional groups, cultures, and generations hold different expectations and views about compassion (Koopmann-Holm and Tsai, 2017; Sundus et al., 2020) which change over time (Salvador Zaragozá et al., 2021). Compassion has been described as a lens for critically considering the cultural and social significance of AI technologies and the different ways that such technologies may serve or disserve the societies that created them (White and Katsuno, 2019) including how technologies affect their users (Day et al., 2021).

In recent years some AI technologists and researchers have become interested in how AI technologies might demonstrate caring or be caring (De Togni et al., 2021). Artificial empathy refers to the coding of empathy into machines (Dial, 2018) whereby emotion recognition and display technologies are designed to sense and/or show a sense of empathy in their users e.g., giving life-like virtual agents the capabilities to mimic user's facial expressions. However, technologies that appear to be empathetic may not necessarily be genuine or authentic empathy (Montemayor et al., 2021). A machine capable of artificial compassion requires more than emotion recognition and expression (Mason, 2015). Artificial compassion refers to the steps that technologists may take to intentionally design adaptive responsiveness into technologies (Critchley, 2015). For example, building cognitive architecture (a control loop that the computer runs through) that Sense-{Think + Feel}-React (Mason, 2015, 2021, 2023). In this type of computing the ability to "think" and "feel" are made possible by connecting to external reference points such as information in the cloud, or other agents, to develop a form of socio-cultural intelligence (Mason, 2021). Not all technologies need these

types of "in-built" compassion in their programming but these developments in AI systems will influence societal systems.

This article draws on different fields of systems thinking (Dori and Sillitto, 2017) to explore the associations between the types of systems involved. That is, AI technologies as computational systems (e.g., machine learning, deep-learning, algorithms, network systems etc.); compassion as a motivational caring system (Motivational Systems Theory) (Ford, 1992); and healthcare systems as complex adaptive systems (Complex Adaptive Systems Theory) (Lansing, 2003; Levin, 2003). Motivation is thought to be at the heart of many of society's and healthcare's most pervasive and enduring problems (Ford, 1992) (e.g., the "care gap"). These perspectives enabled this review to explore issues about the way technologies are imagined and used, and their capabilities to alleviate suffering through compassion.

1.1. Rationale

Advances in AI technologies and research on compassion have seen significant development and progress in recent years. However, understandings about possible associations between AI technologies and compassion are emergent and under conceptualized. It is unclear what type of AI technologies can be designed and used to enhance compassion in healthcare.

Understanding any associations between AI technologies and compassion is important in a western healthcare context that is characterized by numerous politicized issues about supply-demand-challenges in healthcare associated with a clinically complex aging population (Tiersen et al., 2021), historical under resourcing in some health services, and the COVID-19 crisis (Pagliari, 2021). These challenges have been described as a growing "care gap" (Davendralingam et al., 2017). There is also an apparent deficit or lack of compassion in healthcare systems: notions of the "compassion gap" (Trzeciak et al., 2017), or "crisis in caring" with suggestions there is "empathy erosion" or an "empathy deficit" (Stenhouse et al., 2016). The Francis Report (Mid Staffordshire NHS Foundation Trust Public Inquiry, 2013) revealed sub-standard patient care and increased mortality rates in UK hospitals to show the devastating effects of practicing medicine without compassion (Gray and Cox, 2015). Consequently, multiple "compassion cultivation" programs and initiatives such as empathy training have been implemented in health services and staff training (Davendralingam et al., 2017). Other related issues include "compassion fatigue" (Sheppard, 2015; Figley and Regan Figley, 2017), staff resilience and staff burnout (Stevenson et al., 2022), and the "pure hard slog" of caregiving roles (Bogossian et al., 2014). Issues about the human cost of emotional labor (Larson and Yao, 2005) are reflected in "compassionomics": The study of the effects of compassionate healthcare for patients, healthcare systems, payers, and providers (Trzeciak et al., 2017). This context also includes issues about the prevalence of workplace discrimination and violence in healthcare (Greinacher et al., 2022), intention to leave (Greinacher et al., 2022), COVID-19 related "compassion collapse" (Hagman et al., 2022), as well as staff experiences of "compassion satisfaction" (enjoyment, reward, and passion for work) (Okoli et al., 2020; Baqeas et al., 2021; Qu et al., 2022; Unjai et al., 2022). Other research has investigated "compassion inequalities," which refers to differentials in patient treatment and care associated with stigmatized health conditions such as opioid use disorder (Singh et al., 2021). These issues set an important but complex context for exploring how AI technologies might be used to address some of the real-world "caring problems" in healthcare systems.

Current conceptualizations of compassion are limited by the fact that they do not consider the possibility of AI technologies as tools for compassion (except for artificial compassion, Mason, 2021, 2023). Compassion science mainly focuses on the bodily (psychological and neurobiological) and behavioral elements of compassion (Kim et al., 2020; Goldberg, 2020) and the effects of oxytocin in the body (Brown and Brown, 2015; Palgi et al., 2016; Seppälä et al., 2017). There is growing evidence about self-compassion and compassionate touch interventions (Bond, 2002; Field, 2014; Serpa et al., 2021), self-care interventions (Ehret et al., 2015; Friis et al., 2016; Brown et al., 2020), professionals' self-care and self-compassion and compassion for others (Mills et al., 2017); and resilience in caring roles (Bleazard, 2020; Baqeas et al., 2021). Compassion is often used interchangeably with the notion of empathy (Håkansson Eklund and Summer Meranius, 2021); previously defined as a person's ability to sense another's thoughts, feelings, and experiences, to share the other's emotional experience, and to react to the observed experiences of another person (Wieseke et al., 2012). However, compassion is different to empathy. Compassion refers to not only a sensitivity to suffering, but the commitment to try to alleviate and prevent it, i.e., a caring motivational system (Gilbert, 2019).

Understanding any potential of AI technologies to enhance compassion could help to respond to many different concerns about modern technologies in healthcare. Issues that include the safe and ethical use of information and communication technologies as clinical devices (Lupton, 2017), "data entry burden"(Dragano and Lunau, 2020), and "digital tick-boxing" associated with electronic health records (Collier, 2017); information overload and "doctor as machine" (Padmanabhan, 2020); screen fatigue associated with telemedicine and device use (Alameddine et al., 2019); "digital distraction," frequent prompts and interruptions to care that affect service safety and quality; "technostress" (La Torre et al., 2020) when technologies don't meet expectations creating negative feelings or behaviors; "disinhibition effect" (Terry and Cain, 2016) associated with online settings that can include "cyberbullying" (Hutson et al., 2018); "digital exclusion" and "digital inequalities" (Crotty and Somai, 2022); maintaining human connection with

mediated communication (Nieto et al., 2021); as well as concerns about the safe, ethical and fair uses of AI technologies (Buolamwini, 2017; Figueroa et al., 2021; Martinez-Martin et al., 2021; Oszutowska-Mazurek et al., 2021; Suresh and Guttag, 2021; Tschandl, 2021; Schmidt et al., 2022).

1.2. Objectives

The objective of this scoping review was to provide a comprehensive depth and a balanced perspective of the emerging topic of AI technologies and compassion to inform future research and practice.

1.3. Approach

The approach was to undertake a scoping review of the topic using a recognized framework and process. We used the approach originally proposed by Arksey and O'Malley (2005), further enhanced by the work of Levac et al. (2010) and consolidated in the Joanna Brigs Institute (JBI) approach to the conduct of scoping reviews (Peters et al., 2020). Presentation of the scoping review conforms with PRISMA-ScR (Preferred Reporting Items for Systematic reviews and Meta-Analyses extension for Scoping Reviews) guidelines and 20 essential item checklist (Tricco et al., 2018) from the EQUATOR (Enhancing the QUAlity and Transparency Of health Research) Network.

Scoping reviews are useful for examining emerging evidence when it is still unclear what other, more specific questions can be posed for evidence syntheses and valuably addressed (Mays et al., 2001). Unlike a systematic review, scoping reviews do not tend to produce and report results that have been synthesized from multiple evidence sources following a formal process of methodological appraisal to judge the quality of the evidence (Peters et al., 2020). Rather, scoping reviews follow a systematic approach to map evidence on a topic and identify main concepts, theories, sources, and knowledge gaps (Tricco et al., 2018).

Five main stages of the review process (Arksey and O'Malley, 2005) were:

(1) identifying the research question.
(2) identifying relevant studies.
(3) study selection.
(4) charting the data.
(5) collating, summarizing, and reporting the results.

Each stage was informed by the team's multidisciplinary expertise and understanding from fields of nursing, medicine, anthropology, health service research, AI strategy, and AI technology design. Our working methods were to use online meetings for discussions (*via* Microsoft Teams) supported by sharing files, articles, and comments (using Miro whiteboard and file share software).

Four review questions were developed to reflect the aims:

1. How is compassion discussed in relation to AI technologies in healthcare? For example, different schools of thought, controversies, or perspectives.
2. How are AI technologies being used to enhance compassion in healthcare? For example, professional practice, education and learning, clinical care, or health care delivery or outcomes.
3. What are the gaps in current knowledge and unexplored potential? For example, are there uncertainties, problematic concepts, or a lack of empirical research.
4. What are the key areas where AI technologies could support compassion in healthcare? For example, suggestions or claims for how AI technologies may support compassion in healthcare in the future.

1.4. Definitions and scope

To explore possible associations between AI technologies and compassion in healthcare a broad scope of the review was defined according to three concept constructs, explained below.

1.4.1. AI technologies construct

A comprehensive list of key terms for the searches was generated by drawing on existing definitions of AI (Russell and Novig, 2020), subject indexing for artificial intelligence (National Library of Medicine), knowledge of the team (CM and MR), search terms used in a previous review of AI technologies in mental health (Zidaru et al., 2021) and digital health interventions (Boucher et al., 2021; **Table 1**). The terms did not include issues or factors relating to digital health (Lupton, 2017), patient consent, data sharing, electronic health records see (de Zulueta, 2021), remote healthcare delivery, internet-based modes of health information delivery, digital health platforms, web-based health interventions, online health clinics, virtual visits/care or telemedicine, or telehealth.

Table 1 shows the key search terms that were developed for each construct and used in the electronic searches.

1.4.2. Compassion construct

As the aim of this review was to focus on the concept of "compassion" in relation to AI technologies the compassion construct for the searches used key terms that are most associated with compassion in the literature (these are "compassion" and "empathy"). Medical subject classification terms were not available for the term "compassion" (MeSH index compassion under Empathy), so key terms were identified

from the literature on compassion (previously described in Section "1.1 Rationale"). We also decided to include terms for "self-compassion" and "compassion fatigue" to explore any association between AI technologies and these perspectives of compassion which are important in healthcare. It was also important to develop a working definition of compassion to support the screening and thematic analysis stages of the review, by drawing on existing literature on compassion. Although diverse perspectives and understandings of compassion exist, there is a degree of commonality around the notion of compassion as a prosocial/caring motivational system (Seppälä et al., 2017; Leffel et al., 2018; Gilbert, 2019). Expert consensus is that compassion has 5 component elements (Strauss et al., 2016): (1) recognizing suffering, (2) understanding the universality of suffering in human experience, (3) emotionally connecting with the person in distress, (4) tolerating uncomfortable feelings so that we are able to help, and (5) being motivated to act or acting to help/alleviate suffering (Gu et al., 2017). The present review drew on these understandings to create a working definition of compassion as involving:

(1) Awareness of suffering (e.g., pain, distress, risk, disadvantage).
(2) Understanding the suffering (significance, context, rights, responsibilities etc.).
(3) Connecting with the suffering (e.g., verbal, physical, signs and symbols).
(4) Making a judgment about the suffering (the need to act).
(5) Engaging in a behavior with the intention to alleviate the suffering.

Within this working definition, "suffering" is used to include notions of pain, distress, risk, and disadvantage in healthcare contexts (e.g., physical, or mental pain), as well as more broadly to include suffering associated with risks to health, hardship, social disadvantage (social determinants of health) (Braveman and Gottlieb, 2014), barriers to healthcare (Powell et al., 2016), and health inequalities (Scambler, 2012). This definition acknowledges that health and suffering extend beyond the provision of clinical treatment and clinical care, e.g., through actions to protect human rights, minimize risk to human lives, or promote health equality, for example.

TABLE 1 Key search terms.

AI technologies construct	Compassion construct	Healthcare construct
Affective computing	Compassion	Health care
Artificial intelligence	Empathy	Health-care
Automation	Self-compassion	Healthcare
Bioinformatics	Compassion fatigue	
Chatbot		
Computer-assisted		
Data mining		
Decision support systems		
Deep learning		
Digital health		
eHealth/e-health		
electronic health		
Health app		
Human machine systems		
Information systems		
Machine learning		
Medical informatics		
mHealth		
Neural networks, computer		
Natural language processing		
Robotics		
Smartphone		
Sentiment analysis		
Virtual reality		
Wearable		

1.4.3. Healthcare construct

Healthcare was defined as a complex adaptive system: a complex dynamic network of interactions that might not always be predictable or perceivable to those within it (Cillers, 1998). It is adaptive, in that, the individual and collective behavior can alter and self-organize corresponding to internal or external micro-events or combined events (Lansing, 2003). Thus, the approach to the searches was to use broad key word terms ("health care," "healthcare," "health-care") as a strategy to include articles relating to any groups of health professionals, different settings/fields (e.g., primary, acute, intermediate care, care homes, educational settings), and all groups of patients, carers. Different forms of the term "healthcare" are used in the literature and internationally, so variations of the term (i.e. single word, phrase, hyphenated) were used to ensure the searches could retrieve all relevant articles.

The AI technologies construct is defined in more specific terms, compared to the more general terms used to define the compassion and healthcare constructs. This is because the concept of compassion is itself complex, in that multiple understandings, perspectives and definitions of this term exist. Thus, in this review we needed to focus (specificity) on the concept of "compassion" to perform a meaningful exploration of how this concept is understood and used in relation to AI technologies. It was appropriate to use a general healthcare construct, a very broad definition, to set a wide context for the searches. Thus, the construct covers healthcare systems, health

service organizations, as well as treatment and care provided by healthcare professionals.

2. Materials and methods

In accordance with PRISMA-ScR guidelines on the presentation of scoping reviews the methods explain the eligibility criteria, information sources, search strategy and selection of sources of evidence (inclusion/exclusion criteria), key search terms, data charting process, data items, critical appraisal, synthesis of results, reliability, and rigor. A review protocol was not developed or published for this scoping review, which follows JBI methodology (Peters et al., 2020).

2.1. Eligibility criteria (inclusions/exclusions)

The review is inclusive of all literature published in English language (articles written in other languages were included if published translations were available). Owing to the newness of the topic, we limited years considered to publication in the last 10 years (2011–2022).

Inclusion/exclusions were:

- Articles published in English between 2011 and the date of the searches (August 2022) were included.
- Included articles were research articles (using any type of study designs or research methods), evaluations or design studies, discussion/commentary, case studies, conference/symposia. Comments on articles were excluded.
- Publication status included articlesx published early online or online only. No unpublished articles were included.
- Included articles described or closely relate to the design, implementation, use, views, or perception of AI technologies (as defined above). Articles relating to "non-AI" technologies (e.g., electronic health records, information communication technologies, social media, online simulation training) were excluded.
- Included articles related to compassion (according to the key search terms above). Other related concepts and terms (dignity, sympathy, kindness, altruism, solidarity) were not included.
- Included articles related to healthcare contexts (any healthcare settings, health professional groups, patient or client groups, students in training), any type of healthcare interventions or practices including self-compassion. Articles outside of healthcare contexts were excluded (i.e., animal health, farming, engineering, architecture, meteorology).

2.2. Search process

Preliminary searches were undertaken (using Google search) in September-December 2021 to inform the review topic and questions. The final searches were conducted in August 2022. Information sources were (1) Web of Science (Science Citation Index, Social Sciences Citation Index, Arts and Humanities Citation Index, Conference Proceedings Citation Index, Book Citation Index, Emerging Sources Citation Index, covering over 12,000 high impact journals) (2) PubMed (covering biomedical literature from MEDLINE, life science journals, and books). These sources were chosen because they index extensive health and healthcare research journals as well as computing, data science, information technology, and design sciences. No other sources were used as the low specificity of the searches would have rendered an unfeasible number of returns for screening (Peters et al., 2020). The searches were performed by two experienced researchers (EM and TZ).

Table 2 presents summary information about the electronic searches and results for Web of Science and PubMed databases (**Table 2**). The table sets out how the constructs were searched using OR and combined using AND functions. The much larger number of articles returned by Web of Science for the AI technologies construct reflects the scope of this database beyond medicine and healthcare. The compassion construct and the healthcare construct retrieved similar numbers of articles for both databases.

2.3. Screening

A total of 3,124 articles were identified (Web of Science 1,312 articles, PubMed 1,812 articles). The screening process was to systematically assess eligibility of each article by reading the title and abstract of all returned articles and applying inclusion/exclusion criteria. If articles were considered eligible for inclusion the full article was accessed online. A record of the reasons for exclusion of articles was maintained to support rigor and reliability. **Figure 1** illustrates the screening process and information about the article type of the 197 included articles.

2.4. Data charting

Data from included articles were extracted to bespoke data tables (using Microsoft Word) designed to hold data about the article and content items relating to the four review questions. Tables were piloted with 10 articles; small adjustments to headings and formatting were made. Categories of data that were extracted were (1) Reference: Author/Date of publication (and citation) (2) Type of article (Categories I–VI, see below) (3) Aim/Context (e.g., healthcare issue/setting

TABLE 2 Search results.

AI technologies construct	Compassion construct	Healthcare construct	Number of articles (search returns)
AND	AND	AND	
Affective computing OR Artificial intelligence OR Automation OR Bioinformatics OR Chatbot OR Computer-assisted OR Data mining OR Decision support systems OR Deep learning OR Digital health OR eHealth/e-health OR electronic health OR Health app OR Human machine systems OR Information systems OR Machine learning Medical informatics OR mHealth OR Neural networks, Computer OR Natural language processing OR Robotics OR Smartphone OR Sentiment analysis OR Virtual reality OR Wearable	Compassion OR Empathy OR Self-compassion OR Compassion fatigue	Health care OR Health-care OR Healthcare	3,124
Web of science database (2022-08-24)			
6,912,998	50,252	2,108,971	1,312
PubMed database (2022-08-25)			
2,271,897	45,967	2,619,101	1,812

etc.) (4) Key relevant findings (5) Country (based on first author). Data charting was done by one experienced qualitative researcher (EM). No other processes were used to obtain or confirm data from investigators/authors. Key findings/points from articles were identified from abstracts and/or full texts where relevant to the review questions. As this was a scoping review not a systematic review of research evidence, selection of key information did not give weighting to research articles or aim to combine value outcomes from research studies. Information about research methods and participants was captured when relevant to contextualize key findings. For design studies information about specific AI technologies was captured where available.

2.5. Analysis

The analysis of included articles used a basic assessment of quality using article type. During charting of the data article type was coded (Article Type: I-Systematic review, II-Research studies and study protocol, III-Review of literature/policy/practice, IV-Discussion chapters/report/opinion piece, V-Conference paper/workshop/symposia, and VI-Design study and service improvement) to gain an overview of the data not to make judgments about research quality or to combine evidence of outcomes. Thematic analysis used an inductive-deductive approach (Mays et al., 2001) to generate categories from the review questions and the data itself. The thematic analysis began with "familiarization" to build up an understanding of the nature and content of included articles, "identification" of emerging themes during the process of data extraction, and "synthesizing" key findings or issues. A multidisciplinary team assessed 52 emerging themes for resonance and relevance to research and practice, which were refined into 24 themes.

2.6. Reliability and rigor

A multidisciplinary team ensured that the topic and focus of the review had resonance with the challenges and problems in their areas of practice. The review used an established review process (Arksey and O'Malley, 2005). Reliability of the search process was supported by using defined search terms and using two robust sources of data for a comprehensive search of published literature (Peters et al., 2020). Rigor of screening was supported by using defined inclusion/exclusion criteria, consistency of screening decisions, and maintaining a record of the reasons for exclusion (detail in **Figure 1**). A record of duplicates within sources and between data sources was maintained. Rigor in the identification of themes (Mays et al., 2001) was supported by team discussions and reflections on resonance and meaning of emerging themes and relevance to the review questions. For transparency information about all included articles is provided (**Supplementary Appendix 1**).

3. Results

3.1. Overview of the included literature

3.1.1. Included articles

The searches identified 3,124 potentially relevant articles. All were assessed for eligibility based on titles/abstracts. A total of 197 relevant articles were included (literature tables in **Supplementary Appendix 1**). Total included articles = 197 (6.3% of 3,124 screened).

3.1.2. Year of publication

The number of articles increased steadily over 10 years: 2011 (n = 1), 2012 (n = 1), 2013 (n = 3), 2014 (n = 2), 2015 (n = 4),

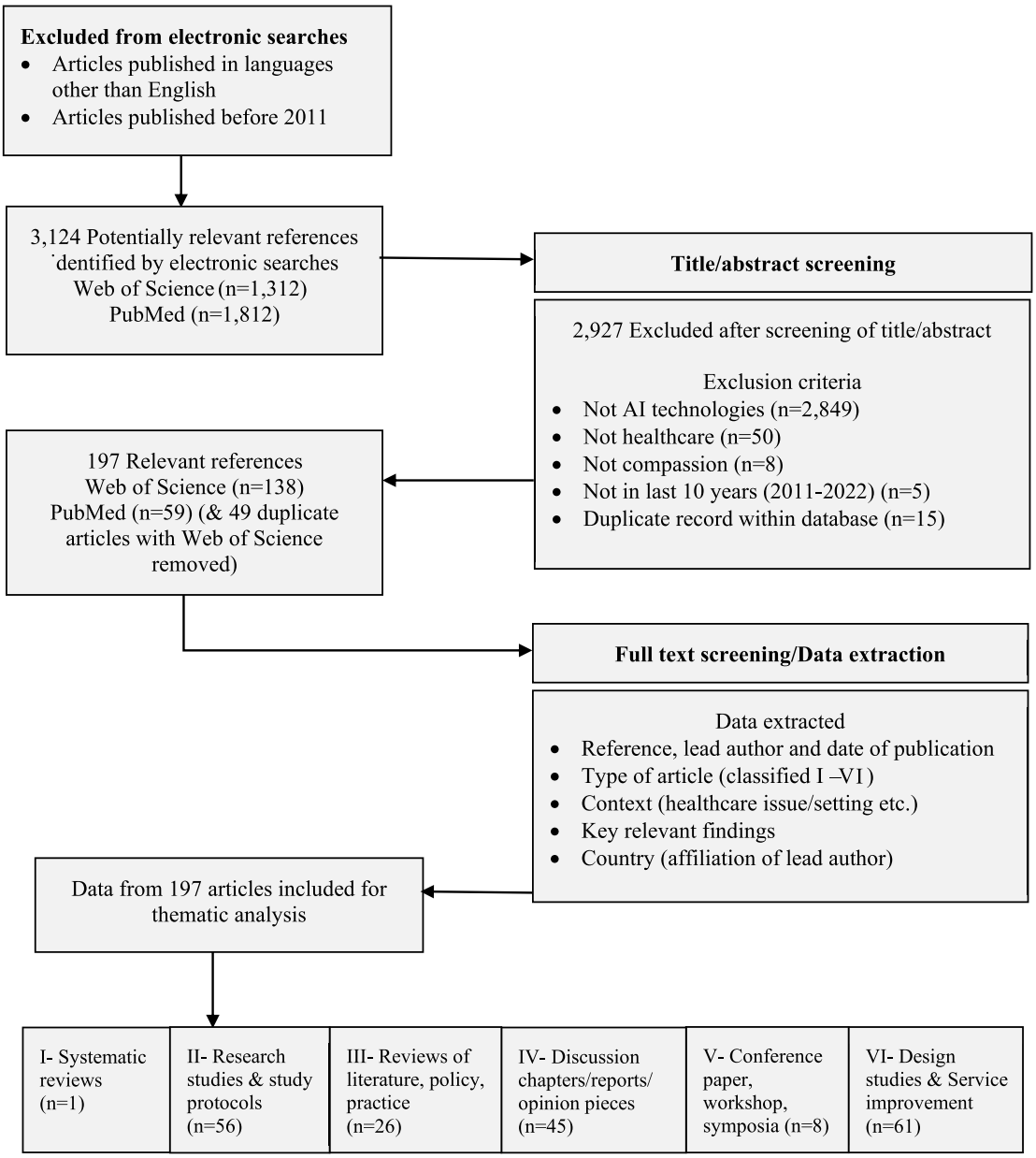

FIGURE 1
Inclusion flow diagram.

2016 (n = 6), 2017 (n = 15), 2018 (n = 15), 2019 (n = 34), 2020 (n = 32), and 2021 (n = 47). From Jan-Aug 2022 (n = 35 articles).

3.1.3. Article types

Approximately a third of the articles were categorized as VI-Design studies (30.9%, n = 61) (concept development, proof of concept, design evaluation, and service improvement). Nearly a third of the articles were II-Research study (n = 56, 28.4%) (including experimental/intervention studies, qualitative research, survey research, mixed methods, exploratory, pilot, and feasibility studies). Other categories were IV-Discussion (chapter, commentary, perspective, and opinion piece) (n = 45, 22.3%), III-Reviews (integrative review, narrative review, literature review, and scoping reviews) (n = 26), V-Conference (paper, symposia, workshop) (n = 8), I-Systematic review (n = 1).

3.1.4. Article country (first author)

A third of the articles were from United States = 65 articles (32.9%), with United Kingdom = 24 articles (12.1%), Canada = 17 articles (8.4%), Netherlands = 10 articles (4.9%), Australia = 10 articles (4.9%), New Zealand = 10 articles (4.9%), Germany = 6 articles, Japan = 6 articles, Italy = 5 articles, and

Taiwan = 4 articles. Articles from other countries (40, 19.9%) were: 3 articles each from France, India, Republic of Ireland, Spain, Sweden, Switzerland, 2 articles each from Bangladesh, Korea, Norway, Pakistan, Philippines, Singapore, 1 article each from Belgium, China, Denmark, Finland, Greece, Lebanon, Malaysia, Qatar, Republic of Korea, Romania.

3.1.5. Research articles

The review identified one systematic review (Bevilacqua et al., 2020) on personal health coaching. Of the 56 articles that were classified as II-Research study, more than two-thirds were studies using an intervention or experimental methods (n = 42, 73.6%) including one randomized controlled trial (RCT) in an educational setting (Johanson et al., 2019). 11 were qualitative studies (interviews, survey research, focus groups, consensus building approaches, ethnography). Other methods were mixed methods (1), feasibility study (1), pilot study (1).

3.1.6. Frequency of key words

Articles most frequently mentioned the term "empathy" (113 articles). Nearly a quarter of the articles used the term "compassion" in their title or abstract (41 articles). Few articles used the term "self-compassion" (10 articles) or "compassion fatigue" (2 articles).

3.1.7. Themes in the data

There are four overarching themes relating to the review questions and 24 themes, as illustrated by **Table 3**.

TABLE 3 Overview of themes in the literature.

1. Developments and debates (7 themes)
• Concerns about AI ethics, healthcare jobs, and loss of empathy (25 articles)
• Human-centered design of AI technologies for healthcare (16 articles)
• Optimistic speculation AI technologies will address care gaps (12 articles)
• Interrogation of what it means to be human and to care (11 articles)
• Recognition of future potential for patient monitoring, virtual proximity, and access to healthcare (10 articles)
• Calls for curricula development and healthcare professional education (5 articles)
• Implementation of AI applications to enhance health and wellbeing of the healthcare workforce (2 articles)
2. How AI technologies enhance compassion (10 themes)
• Empathetic awareness (15 articles)
• Empathetic response and relational behaviour (12 articles)
• Communication skills (12 articles)
• Health coaching (11 articles)
• Therapeutic interventions (8 articles)
• Moral development learning (8 articles)
• Clinical knowledge and clinical assessment (7 articles)
• Healthcare quality assessment (6 articles)
• Therapeutic bond and therapeutic alliance (5 articles)
• Providing health information and advice (3 article)
3. Gaps in knowledge (4 themes)
• Educational effectiveness of AI-assisted learning (11 articles)
• Patient diversity and AI technologies (10 articles)
• Implementation of AI technologies in education and practice settings (8 articles)
• Safety and clinical effectiveness of AI technologies (4 articles)
4. Key areas for development (3 themes)
• Enriching education, learning, and clinical practice (10 articles)
• Extending healing spaces (9 articles)
• Enhancing healing relationships (7 articles)

3.2. Developments and debates

3.2.1. Concerns about AI ethics, healthcare jobs, and loss of empathy (25 articles)

This was the strongest theme of the literature and conveyed manifold concerns about AI ethics and regulation (Zelmer et al., 2018; Abdullah et al., 2021); ethical design and use of AI technologies in healthcare contexts (Sikstrom et al., 2022); concerns about data privacy, data biases and data collection (Harris, 2021; Ostherr, 2022); as well as concerns about trust, care quality, and liability (Davenport and Kalakota, 2019; Sanal et al., 2019). There is a strong anticipation perspective relating to concerns about role replacement (Johnston, 2018; Blease et al., 2019; Bridge and Bridge, 2019; Powell, 2019; Blease et al., 2020; Doraiswamy et al., 2020; Alrassi et al., 2021) and which parts of healthcare practice, can and should be entrusted to AI technologies (Loftus et al., 2020; Nadin, 2020). Concerns about role replacement discuss the enduring role of critical human attributes for safe and effective healthcare (Joda et al., 2020; Irfan, 2021). Speculation about the replacement of nurses with robot nurses has led to theoretical development on the interrelationship of technological competency as caring and acknowledgment that AI technologies are already fundamental to the delivery of high-quality healthcare (Locsin, 2017; Buchanan et al., 2020). Research on patient's views about future uses of AI technologies echoes professional's concerns regarding trust, communication, regulation, liability risks, cyber-security, accuracy, and loss of human empathy toward patients (Slomian et al., 2017; Esmaeilzadeh et al., 2021; Raja et al., 2021; Zhang et al., 2021; Visram et al., 2022).

3.2.2. Human centered design of AI technologies for healthcare (16 articles)

The second strongest theme of this literature reflects broader debates about design ethics and using human-centered design approaches (HCD) to generate empathetic technological responses to health needs (Portz et al., 2020). In HCD processes designers are felt to gain empathetic understanding by working

closely with end users, such as stroke patients to co-design AI technologies to support health and recovery (Willems et al., 2021). User-centered participatory design methods (e.g., interviews, workshops, trials of prototypes) narrow the gap between designers and users by supporting inclusion and engagement in the design process (Hou et al., 2020; Tiersen et al., 2021). For example, user-centered research with 15 people after stroke, led to the idea and creation of a character Stappy for a meaningful interface to support empathy in the use of a sensor-feedback system that enables stroke patients to walk (Jie et al., 2020). Research using co-design methods with young people with type 1 diabetes exposed a radically different view of technology than either their parents or practitioners, illustrating the need to involve target end-users in design (Pulman et al., 2013). This literature suggests HCD supports compassion in healthcare by creating methods and opportunities for inclusion in the design of technologies that address real and significant needs in people's lives (McCarthy et al., 2020; Majid et al., 2021) as well as promoting trust that empathy will be preserved and acceptance of new AI technologies in a healthcare space (Zhang et al., 2021). HCD to develop an electronic crutch for paralyzed people has been described as a humanitarian project designed with empathy for patients in mind (Sarkar et al., 2020). HCD informs humanitarian applications of AI technologies (Fernandez-Luque and Imran, 2018); the design of "positive technology" to generate motivation and engagement (Riva et al., 2016); and "transformative technologies" to facilitate positive, enduring transformation of the self-world for the benefit of health and wellbeing (Riva et al., 2016). HCD embeds compassion within AI technology design by recognizing and engaging with human suffering, now or in the future (i.e., maintaining health) (Fritzsche et al., 2021), activities to co-design technological solutions that have utility and value for users (Mirkovic et al., 2018; Raman and McClelland, 2019); and ethical attention to when technology might not be a suitable solution (Pulman et al., 2013).

3.2.3. Optimistic speculation AI technologies will address care gaps (12 articles)

There is hope in this literature, that AI technologies can preserve the "spirit" of welfare state and the principles of risks-sharing and equal access to care for all (Weil-Dubuc, 2019). Literature on social robots argues for the potential social utility of robots as treatment providers, custodial caregivers, social assistants, and home companions (Pedersen et al., 2018). Health professionals are hopeful that e-mental health technologies may offer a solution to the growing problem of unmet mental health needs, provided that human centered principles are maintained (Strudwick et al., 2020). VR technology and research on implicit bias are perceived to be tools to address bias, prejudice, cultural insensitivity, eroding levels of empathy, and social disparities of health (Jones-Schenk, 2016). In these discussions there is a collective aspiration for AI to reflect human wisdom in the provision of more compassionate (Lee et al., 2021; Ali et al., 2022) and "compassionomic" solutions to healthcare (i.e., safe and cost effective) (Trzeciak et al., 2017). Other expressions of optimism relate to the hope of improvements in service efficiency and quality (Blease et al., 2019; Kemp et al., 2020); entrepreneurial opportunities (Shepherd and Majchrzak, 2022); and the design of AI technologies that can encourage collective good and increase prosocial behavior (Day et al., 2021).

3.2.4. Interrogation of what it means to be human and to care (11 articles)

Discussion of the complexity of interwoven "gossamer threads" of disparate, conflicting information about technologies in society raises questions about human development and empathetic response (Bjorklund, 2016). Research on transhumanism and posthumanism has explored the idea of self, soul, and human consciousness and what makes humans human (Fleury-Perkins and Paris, 2019; Ajeesh and Rukmini, 2022). Suggestions that AI and humans can create harmonious bios built on bioethical human properties, attitudes, and virtues (Sass, 2014), have been expressed creatively in medical arts with particular emphasis on preserving, or indeed enhancing, "3Cs" of communication, compassion, and competence (Yaghy et al., 2019). Research into VR simulation-based training suggests such technologies are valuable for cultivating humanization competencies (Jiménez-Rodríguez et al., 2021) and assessing professional moral actions (Francis et al., 2018). Authors have argued that techno-commercial motives are discordant with professional-relational foundation for care (Andersson et al., 2017); that AI technologies could fundamentally alter the way in which empathy, compassion and trust are currently regarded and practiced in healthcare (Kerasidou, 2020); and that failing to understand difficult to quantify human inputs into AI-based therapeutic decision-making processes could lead to important errors in clinical practice (Brandt et al., 2018; Kerr and Klonoff, 2019).

3.2.5. Recognition of future potential for patient monitoring, virtual proximity, and access to healthcare (10 articles)

Studies of healthcare professionals show they value the capabilities of AI technologies for remote monitoring of patient's physical and mental health status, and the advantages of virtual proximity for maintaining compassionate connection (Montayre, 2018; Walker et al., 2020). Although technologies are being developed for remote monitoring of older people in their own homes (Yokoo et al., 2020), little is known about clinical effectiveness or patient outcomes (Bouabida et al., 2021). Virtual proximity is also recognized as a benefit of interventions for mental health that use ecological momentary interventions (EMIS), a specific type of mobile health that enables patients to access interventions in each moment and context of daily life called a "therapist in your pocket approach"

(Schick et al., 2021) such as encourage physical activity in blue-green spaces (HEART by BioAsssist) (Gallos et al., 2022). Automated topic modeling is recognized as being useful for personalized digital self-compassion interventions and overcoming barriers to traditional care (van der Lubbe et al., 2022). eHealth coaching for older people's self-management may have benefits for addressing unmet need in mental health services (Bevilacqua et al., 2020). There is optimistic debate concerning the potential to increase access to health information and advice using widely available conversational agents (such as Apple Siri, Google Assistant, Amazon Alexa, and Microsoft Cortana) if the safety and effectiveness of these systems can be improved (Kocaballi et al., 2020a). Embodied conversational agents (ECA) (i.e., a lifelike virtual human) could have potential for engaging and motivating users for health-related learning and behavioral change (Scholten et al., 2017).

3.2.6. Calls for curricula development and healthcare professional education (5 articles)

There is a sense of urgency in this literature to teach health professionals essential digital skills and overhaul curricula (Konstantinidis et al., 2022) as well as to introduce AI technologies in educational environments in safe and effective ways that address risks and responsibilities (Combs and Combs, 2019). Such as the opportunities and implications of using standardized virtual patients (VPs) (Gavarkovs, 2019), patient clinical scenarios (Yang et al., 2022), and digital simulations (Patel et al., 2020).

3.2.7. Implementation of AI applications to enhance health and wellbeing of the healthcare workforce (2 articles)

Few studies have investigated the use of AI technologies for healthcare provider wellbeing but there does seem to be a link with compassion for staff and patients. Examples are music virtual reality for healthcare workers (Hayakawa et al., 2022) and The Provider Resilience app for mental health care providers (Wood et al., 2017).

3.3. How AI technologies enhance compassion

This section of the results presents themes relating to applications and uses of AI technologies to enhance compassion in healthcare, as reported in the literature. Ten themes are presented in order of their strength in the literature (number of articles mentioning the issues not number of technologies).

Table 4 maps the themes in this section to the working definition of compassion (the 5 elements defined in Section "1.4 Definitions and scope"). Organizing the themes in this way, **Table 4** highlights the different ways that AI technologies are associated with compassion in healthcare. No articles or studies were found in this literature which map onto the compassion element, "(4) Making a judgment about the suffering (the need to act)." It is unclear why, but this lack of discussion could reflect assumptions about clinical judgment (i.e., perceived to be an objective assessment) and compassion (i.e., perceived to be a felt emotion) in healthcare. As a result of the findings in this section, and the mapping work, the wording of element five has been altered from the working definition (Engaging in a behavior with the intention to alleviate the suffering) to "Responding with an intention to alleviate the suffering." This change marks a move away from only perceiving compassion in terms of a human behavioral response to suffering toward a broader understanding of compassion as a system as well as the possibility of an AI or human response that is not behavioral i.e., not only visible acts of caring but also digital empathetic responses, provision of health information, advice or coaching by AI technologies. An additional sixth element of the compassion construct emerged from this analysis of the literature ("Attention to the effect and outcomes of the response," illustrated by the final row in **Table 4**). The implications of this additional element for the reconceptualization of compassion are discussed later (Section "3.3 Reconceptualizing compassion as a human-AI system of intelligent caring").

3.3.1. Empathetic awareness (15 articles)

In this literature compassion and AI technologies are most strongly associated with generating empathetic awareness in humans and robots. There is good evidence that immersive VR experiences that simulate patient experiences of illness can help healthcare professionals to understand what it is like to have a specific disease or health need (Brydon et al., 2021; Demarinis, 2022), which may translate into empathetic response or relational behaviors. For example, nursing students who virtually experienced the conditions of perioperative patients through VR blended learning showed increased levels of empathy, positive attitudes toward patient safety treatment, confidence in nursing care, and improved clinical skill performance (Kim and Chun, 2022). Multiple evaluation studies into the effects of immersive simulation for dementia suggest that an VR experience can simulate a range of aspects of dementia so that students can develop empathetic understanding (Ball et al., 2015; Slater et al., 2019; Hirt and Beer, 2020; Sung et al., 2022). However, research in the US indicates that both VR and physical delivery formats of a dementia tour can be effective, but university students on healthcare courses (n = 41) reported poorer attitudes about living with advanced dementia and feeling less prepared for caregiving in both approaches (Torrence et al., 2022). Interesting research in Romania (Groza et al., 2017) and Germany (Schmidt et al., 2022) into the use of age simulation suits shows that "instant ageing" can generate more negative expectations regarding older age and reenforced stereotypes. Tele-empathy is a promising emerging field where clinicians and carers can get a sense of what the patient is experiencing physically, such as tremors in

TABLE 4 Artificial intelligence (AI) technologies mapped to compassion in healthcare.

Compassion	Healthcare	AI technologies (applications and studies reported in the literature)
(1) Awareness of suffering (e.g., pain, distress, risk, disadvantage)	Empathetic awareness (15 articles)	← Immersive VR experiential learning for healthcare professionals e.g., experiencing old age, disabilities (Brydon et al., 2021; Demarinis, 2022; Kim and Chun, 2022) ← Empathy training VR technologies for specific conditions (e.g., dementia, Parkinson's disease) (Ball et al., 2015; Slater et al., 2019; Hirt and Beer, 2020; Sung et al., 2022; Torrence et al., 2022) ← Old age simulation suits for education, research, or technology design (Groza et al., 2017; Schmidt et al., 2022) ← Tele-empathy (Palanica et al., 2019) ← Serious games (Sterkenburg and Vacaru, 2018), perspective switch (Buijs-Spanjers et al., 2019; Ma et al., 2021) ← Robot attentional behaviours (Tanioka, 2019; Tanioka et al., 2019; Tanioka et al., 2021)
	Moral development learning (8 articles)	← VR simulations for moral development learning (Wartman, 2019; Wartman and Combs, 2019) e.g., cultural competencies and anti-discriminatory communication practices (Roswell et al., 2020); promoting understanding of social determinants of health (Gillespie et al., 2021; Brammer et al., 2022) ← Safe investigation of medical decisions/care ethics using VR scenarios (Francis et al., 2018) ← Game-based VR immersions or VR simulations with virtual patients to teach social determinates of health (Amini et al., 2021; Hershberger et al., 2022)
(2) Understanding the suffering (significance, context, rights, responsibilities etc.)	Clinical knowledge and clinical assessment (7 articles)	← Immersive VR training on symptoms of disease (Jones et al., 2021) e.g., vignettes for Parkinson's disease (Hess et al., 2022), VR training for testicular disease (Jacobs and Maidwell-Smith, 2022; Saab et al., 2022) ← Learning about anatomy and physiology of disease awareness using digital anatomy (Osis, 2021) ← Automated student skills assessment in pain assessment skills development (Moosaei et al., 2017) ← Automated patient health status and mood assessment (Yokoo et al., 2020) ← Automated assessment of Parkinson's disease (Sabo et al., 2022)
(3) Connecting with the suffering (e.g., verbal, physical, signs, and symbols)	← Communication skills (12 articles)	← Communication skills training using virtual humans (Wu et al., 2017; Guetterman et al., 2019), VR patients (Guetterman et al., 2017; Yao et al., 2020) ← Simulated language translator/translation apps (Herrmann-Werner et al., 2021) ← Virtual worlds (VW) for communication and teamworking skills development (Mitchell et al., 2011; Wu et al., 2019) ← VR environments for communication skills and research (Sanders et al., 2021) ← Robot facial expression research (Broadbent et al., 2018; Milcent et al., 2021; Kovalchuk et al., 2022), human engagement and attention in research contexts (Johanson et al., 2019)
	Therapeutic bond and therapeutic alliance (5 articles)	← Digital therapeutic bond research in conversational agents (Darcy et al., 2021) ← Automated VR exposure therapies (VRETs) for patient adherence and efficacy of self-guided treatments (Brandt et al., 2018; Miloff et al., 2020) ← Digital therapeutic alliance research (Tong et al., 2022) ← Using apps to promote access and adherence to treatment for people who experience stigma (beneficent dehumanization of care) (Palmer and Schwan, 2022)
(4) Making a judgement about the suffering (the need to act)	-	-
(5) Responding with an intention to alleviate the suffering	Empathetic response and relational behaviour (12 articles)	← Robot/artificial emotional response behaviours (artificial empathy) (Kennedy et al., 2012; Pepito et al., 2020; Kerruish, 2021; Montemayor et al., 2021) ← Empathetic chatbots (Amini et al., 2013; Liu and Sundar, 2018; Daher et al., 2020) ← Empathetic medical conversations (Yun et al., 2021) digital voice (James et al., 2021) ← Empathetic service robots (Kipnis et al., 2022) ← Therapeutic zoomorphic robots (Kerruish, 2021)

(Continued)

TABLE 4 (Continued)

Compassion	Healthcare	AI technologies (applications and studies reported in the literature)
	Providing health information and advice (3 articles)	← Conversational agents for health needs, safety or lifestyle information and advice (Kocaballi et al., 2020a) ← Web app that provides cancer disease related information to patients (Papadakos et al., 2017) ← AI-generated diagnosis information for radiology patients (Zhang et al., 2021)
	Health coaching (11 articles)	← Virtual health coaches (Kennedy et al., 2012; Bevilacqua et al., 2020), smoking cessation (He et al., 2022), weight-loss (Stein and Brooks, 2017), self-management of depression (Inkster et al., 2018), and chronic disease self-management (Hernandez, 2019) ← Therapeutic chatbots for mental health (Lee et al., 2019; Valtolina and Hu, 2021) ← Digital self-compassion interventions using established therapeutic methods (Stenberg et al., 2015; Rodgers et al., 2018; Boggiss et al., 2022)
	Therapeutic interventions (8 articles)	← Dolls and robot therapies (Márquez Sánchez et al., 2020) ← Assistive robots for daily-care activities (Law et al., 2019) ← VR technologies for mental health support or development of patient's empathetic awareness (Baghaei et al., 2019) ← Avatar-based VR therapy for empathetic understanding (van Rijn et al., 2017) ← Intelligent assistant for psychiatric counseling (Oh et al., 2017) ← Social cognition training for autism spectrum disorder (van Pelt et al., 2022) ← Immersive VR self-compassion training for self-criticism (Falconer et al., 2014) ← VR intervention for cancer patients incorporating relaxation and compassionate mind training (O'Gara et al., 2022)
(6) Attention to the effect and outcomes of the response	Healthcare quality assessment (6 articles)	← Automated healthcare quality assessment e.g., sentiment analysis of patient feedback from diverse groups of service users (Doing-Harris et al., 2017; Rahim et al., 2021) ← Automated analysis of patient and family feedback captured by interactive patient care technology in hospitals (Clavelle et al., 2019) ← Automated analysis of online health communities to inform policy for patient self-care (Panzarasa et al., 2020) ← Automated evaluation of psychotherapy services linked to training, supervision, and quality assurance (Flemotomos et al., 2022; Xiao et al., 2015).

Parkinson's disease (Palanica et al., 2019). Research on serious games for medical education (The Delirium Experience) shows certain game features, being able to "switch perspective," can enhance medical student empathy if they play the game from the patient or nurse perspective (Buijs-Spanjers et al., 2019; Ma et al., 2021). Experiments in the Netherlands on a serious game for care workers for people with disabilities (The world of EMPA) showed participation did not enhance empathy for disabled people but it did decrease personal distress in care workers (Sterkenburg and Vacaru, 2018). In robotics, experiments in Japan (Pepper robot) (Tanioka, 2019; Tanioka et al., 2019; Tanioka et al., 2021) identify the need to develop "listening" and "gaze" together with the fidelity of responses, to mimic empathetic awareness.

3.3.2. Empathetic response and relational behavior (12 articles)

In theory, AI technologies cannot feel or express genuine empathy, hence the term empathy* has been suggested as a term to differentiate real empathy from artificial empathy (Montemayor et al., 2021). Nonetheless, empathy display and relational behavior are significant research themes in dialog systems development and robotics (Kennedy et al., 2012; Liu and Sundar, 2018; Pepito et al., 2020; Kerruish, 2021). Studies with patients have shown that most people prefer medical assistant chatbots that mimic empathy (Amini et al., 2013; Liu and Sundar, 2018; Daher et al., 2020), this is particularly true for users who are initially skeptical about machines possessing social cognitive capabilities. However, research in Korea (Yun et al., 2021) shows there is a discrepancy between expressed behavioral intentions toward medical AI and implicit attitudes (detected in brain scans) which shows people respond differently to the same conversation if it is delivered by a human doctor or medical AI. Other research has modeled an empathetic voice for healthcare robots, to show that people prefer robots that have an empathetic voice (James et al., 2021). A study of service robots for people with disabilities showed that they perceive robots as being able to stimulate and regulate emotions

by mimicking cognitive and behavioral empathy, but unable to express affective and moral empathy, which they felt was essential for the feeling of "being cared for" (Kipnis et al., 2022). Analysis of human empathy toward a therapeutic zoomorphic robot (Paro) and a health care support robot (Care-O-Bot) draws attention to how the cultivation of user empathy toward robots influences patient sociality and relational interactions between human care providers (Kerruish, 2021).

3.3.3. Communication skills (12 articles)

Artificial intelligence (AI) technologies are associated with compassion through helping to improve health professional's verbal and non-verbal communication skills (Wu et al., 2017; Guetterman et al., 2019), for example breaking bad news to a virtual human program (Guetterman et al., 2017), and communicating with suicidal virtual patients (Yao et al., 2020). Students that engaged in a 90-min simulation with a standardized patient (SP) and a language translation app (LTA iTranslate Converse) rated the teaching unit as being excellent but wanted practical training with an SP plus a simulated human translator first on how to maintain empathy in patient-physician communication mediated by LTA (Herrmann-Werner et al., 2021). Online virtual worlds (VW) (such as Second Life, Altspace, Rec Room, Google Earth VR) are rapidly becoming part of everyday life for children and adults (in 2020 Roblox had 150 million active users), and VWs have been used to improve patient-centered communication skills and student teamworking (Mitchell et al., 2011; Wu et al., 2019). A scoping review of virtual environments (VE) for clinical communication skills (Sanders et al., 2021) suggests multiple uses for enhancing clinician's communication and empathy skills, as well as utility for communication research purposes. Evidence on effective doctor-patient communication has been applied as principles to robot-patient communication (Broadbent et al., 2018) and empathy display/facial expression (Milcent et al., 2021; Kovalchuk et al., 2022), to increase human engagement and attention in research contexts (Johanson et al., 2019).

3.3.4. Health coaching (11 articles)

There is a strong association between AI technologies (i.e., virtual coaches and health promoting chatbots) and compassion in health coaching to encourage and motivate positive health-related behavior change such as physical exercise (Kennedy et al., 2012; Bevilacqua et al., 2020), smoking cessation (He et al., 2022), weight-loss (Stein and Brooks, 2017), self-management of depression (Inkster et al., 2018), and chronic disease self-management (Hernandez, 2019). An interesting experiment with a self-compassion chatbot (Vincent) (Lee et al., 2019) revealed participation in self-compassion exercises enhanced self-compassion, particularly when participants were asked to care for the chatbot itself (versus the chatbot caring for them). In Italy a chatbot designed for older adults (Charlie) (Valtolina and Hu, 2021) can alert users to health commitments and medicines, connect remotely with doctors, family, entertain and assist elders using motivational strategies based on gamification, active notifications, and promotion of self-compassion and preventive mental healthcare. Virtual health coaches can improve self-compassion by incorporating established therapeutic methods to remodel thoughts, change behaviors and enhance relationships with self and others (Stenberg et al., 2015; Rodgers et al., 2018; Boggiss et al., 2022).

3.3.5. Therapeutic interventions (8 articles)

The literature suggests an association between AI technologies and compassion occurs through therapeutic interventions. Interesting examples are dolls and robot therapies for Alzheimer's Disease, autism spectrum disorder, stress, or depression which can evoke different verbal, motor, and emotional reactions in patients (Márquez Sánchez et al., 2020): assistive robots for daily-care activities, health-promoting behaviors, and companionship (Law et al., 2019); VR perspective-switching to treat young people with mental health problems by switching perspective (Baghaei et al., 2019); avatar-based VR therapy to develop empathetic understanding in a therapeutic community prison in the UK (van Rijn et al., 2017); and use of an intelligent assistant for psychiatric counseling (Oh et al., 2017). In one study social cognition training for adults with autism spectrum disorder (ASD) was perceived to be useful but lacking ecological validity (authenticity to real world triggers and situations) (van Pelt et al., 2022). Immersive VR therapy has exploited the known effects of identification with a virtual body to overcome self-criticism in healthy women (Falconer et al., 2014). Another study (The SafeSpace study) co-designed and tested a VR intervention for cancer patients that incorporates relaxation and compassionate mind training to enhance feelings of wellbeing (O'Gara et al., 2022).

3.3.6. Moral development learning (8 articles)

Artificial intelligence (AI) technologies (VR applications) can support compassion through moral development learning in accordance with ethical standards (Wartman, 2019; Wartman and Combs, 2019). For example, by enhancing participant's cultural competencies and anti-discriminatory communication practices (Roswell et al., 2020); promoting understanding of social determinants of health (social, physical, and economic conditions that impact upon health) (Gillespie et al., 2021; Brammer et al., 2022); and facilitating the safe investigation of simulated moral actions in aversive moral dilemmas (Francis et al., 2018). Interactive game-based VR immersions and VR simulations have been shown to heighten health professional's awareness and cultural sensitivity to health equity issues (Amini et al., 2021; Hershberger et al., 2022).

3.3.7. Clinical knowledge and clinical assessment (7 articles)

The literature suggests that AI technologies can support compassion by helping health professionals to understand and respond to human suffering. Specific examples include immersive VR training on psychological symptoms of dementia (Jones et al., 2021); VR training using vignettes for Parkinson's disease (Hess et al., 2022), and VR training for testicular disease (Saab et al., 2022). However, benefits of student engagement and perceived learning associated with immersive learning may not translate into better exam scores or clinical skills (Jacobs and Maidwell-Smith, 2022) without sufficient preparation or teaching support (Saab et al., 2022). Another emerging field is digital anatomy, which uses digital replicas of historic specimens to foster understanding and empathy through discussion of ethics, bias, and social aspects of health and disease (Osis, 2021). Student's understanding of pain can be assessed by using facially expressive robotic patient simulators (Moosaei et al., 2017). AI technologies are also being developed to support clinical assessment. Examples include trials in Japan to develop automated health and mood assessment systems (motion sensors and human emotion detection connected *via* the internet of things) to assess older adults in home settings (Yokoo et al., 2020); and technology development in Canada (automated video capture and spatial-temporal analysis) to accurately predict clinical scores of parkinsonism (Sabo et al., 2022).

3.3.8. Healthcare quality assessment (6 articles)

In the literature AI technologies are associated with compassion through automated healthcare quality assessment. Specific examples are the use of natural language processing and patient's online social media comments to capture service feedback information from diverse groups of service users (Doing-Harris et al., 2017; Rahim et al., 2021); automated analysis of patient and family feedback captured by interactive patient care technology in hospitals (Clavelle et al., 2019); a large-scale network study of online health communities to inform future policy interventions for patients' self-care (Panzarasa et al., 2020). At the clinical level, automated evaluation of psychotherapy skills using speech and language technologies can augment experts' capabilities in training, supervision, and quality assurance of services (Xiao et al., 2015; Flemotomos et al., 2022).

3.3.9. Therapeutic bond and therapeutic alliance (5 articles)

Artificial intelligence (AI) technologies are associated with compassion through extending or enhancing human and digital therapeutic bond and therapeutic alignment (Lindner, 2021). For example, a study of a cognitive behavioral therapy conversational agent (Woebot) demonstrated therapeutic bond scores that are comparable to traditional therapy within 5 days of initial app use (Darcy et al., 2021). Automated VR exposure therapies can improve adherence and efficacy of self-guided treatments (Miloff et al., 2020) and address challenges of asynchronous feedback in traditional care (Brandt et al., 2018). Learning from persuasive/positive technology and human-app attachment can potentially help to foster a sense of empathy, build tasks and goals, and develop bonds and digital therapeutic alliance (Tong et al., 2022). Medical AI carebots can overcome barriers to care and adherence to treatment for people who experience stigma (the concept of beneficent dehumanization of care) (Palmer and Schwan, 2022).

3.3.10. Providing health information and advice (3 articles)

Artificial intelligence (AI) technologies can support compassion by providing health information and advice but the evidence of effectiveness of specific technologies is underexplored. Commonly available conversational agents (e.g., voice commands on smartphones) are currently limited in their ability to pick up on conversational cues for health needs and effectively advise on health safety or lifestyle prompts (Kocaballi et al., 2020b). A web app can replicate cancer library functions but with limitations associated with explaining information and supportive care (Papadakos et al., 2017). Radiology patients perceived AI generated diagnosis information to be useful for confirming the doctor's opinions and preparing for the consultation, but patients saw AI technology as having drawbacks of cyber-security, accuracy, and lack of empathy toward patients (Zhang et al., 2021).

3.3.11. Gaps in knowledge

This section of the results presents themes relating to gaps in knowledge and underexplored potential of AI technologies as described in the literature.

3.3.12. Educational effectiveness of AI-assisted learning (11 articles)

This theme in the literature reflects an undercurrent of uncertainty about the effectiveness of specific types of AI technologies in health professional education contexts (Jones et al., 2021; Sukhera and Poleksic, 2021) as well as the possible negligible benefit (Navarrete et al., 2021) or loss of benefits associated with replacing existing educational methods with technologies [such as the benefits of involving real patients in teaching as described by Abeyaratne et al. (2020)]. The issue is not that technologies cannot generate empathy in some groups of learners, but that empathy might not translate into longer-term prosocial caring behaviors in healthcare systems (Gillespie et al., 2021; Beverly et al., 2022). For example, VR dementia training may not benefit all learners and VR may differentially assist leaners of different ages and English-speaking backgrounds, suggesting that more research is needed to understand for which variables and

for whom VR is a useful teaching tool (Jütten et al., 2018; Stargatt et al., 2021). VR provides a small snapshot of the vicissitudes of living with an illness or disability that might leave a false impression of what patients "like that" feel (Dean et al., 2020). It could be that other types of technologies, less standardized (more complex and diverse) virtual patients (Shorey et al., 2019), or digital anatomy could inform professional training and enhance student learning or empathy more effectively (Osis, 2021), but this is unknown. Learning technologies that have "point-of-view" functions may enable students to see issues from different perspectives (Levett-Jones et al., 2017) and diverse service users' experiences (Riches et al., 2022) which could benefit caring relationships.

3.3.13. Patient diversity and AI technologies (10 articles)

There are significant gaps in understanding about how patient diversity relates to AI technologies and compassion. These gaps relate to "high" and "low" users of technologies (Inkster et al., 2018); differences in acceptability of technologies e.g., service robots for healthcare (Giambattista et al., 2016), psychological evaluation (Rossi et al., 2020) or self-management technologies (Mirkovic et al., 2018); language and communication style preferences (Herrmann-Werner et al., 2021; Boggiss et al., 2022; Eagle et al., 2022). Race-concordance has emerged as an important factor in the design and use of virtual patients and virtual clinicians, but the implications for teaching and practice are unclear and underexplored (Halan et al., 2015; Krieger et al., 2021). For example, in one design study black men (n = 25) designed a Black male virtual clinician (VC) that was named Agent Leveraging Empathy for eXams (ALEX) and referred to as "brother-doctor"; participants wanted to interact with ALEX over their regular doctor (Wilson-Howard et al., 2021). While automated services could extend access to psychological support, research into digital therapeutic alliance is needed to ensure AI technologies work for diverse patient groups (Scholten et al., 2017; Grekin et al., 2019; Tong et al., 2022). The first therapeutic alliance instrument developed for use with embodied virtual therapists is the Virtual Therapist Alliance Scale (VTAS): preliminary assessments suggest that alliance toward a virtual therapist is a significant predictor of treatment outcome (Miloff et al., 2020). Patient diversity also needs to be considered in relation to equipping virtual agents with more human-centric prosocial rule breaking, which is a common beneficial feature of human ethical decision-making behavior that is difficult to mimic in AI technologies (Ramanayake et al., 2022); as well as to support patient's "social convoy" (Portz et al., 2020) (i.e., family members, friends, neighbors, formal caregiving supports) to facilitate appropriate involvement and information sharing.

3.3.14. Implementation of AI technologies in education and practice settings (8 articles)

It is currently unclear how the implementation of AI technologies might affect compassion in different contexts of healthcare (Verma et al., 2021), such as medical imaging (Bleiker et al., 2020) or intensive care (Price, 2013). Little is known about how AI technologies and compassion might relate to service efficiency or patient care (Kocaballi et al., 2020a); or public perceptions of AI capabilities (Chew and Achananuparp, 2022). Future research is needed to explore the role and implementation of VR for enhancing empathy in various real-world contexts, and the mediating role of individual differences in use of AI-driven interventions (Louie et al., 2018; Nisha et al., 2019). Implementation of AI technologies in healthcare systems requires development and implementation of new curricula and new approaches to teach students how to interact with AI technologies, learn within interactive learning environments, and manage Al systems (Srivastava and Waghmare, 2020).

3.3.15. Safety and clinical effectiveness of AI technologies (4 articles)

The effectiveness of VR based "switching perspective" technologies (encouraging a self-compassionate lens) for early intervention for mental health issues is promising but research is needed to explore safety and privacy issues in real-world contexts (Baghaei et al., 2021). Further research into general conversational agents is needed to establish guidelines for designing safe and effective response structures for different prompt types (Kocaballi et al., 2020b). The potential capabilities and risks of active assistance technologies is underexplored and there is a need to consider informatics methods and algorithms more fully for safety and ethical reasons (Kennedy et al., 2012). It is unclear how to maintain the initial benefits and permanence of behavior change produced by short-term virtual health coaching interventions (Bevilacqua et al., 2020) and this needs further research to attain lasting clinical benefits.

3.4. Key areas for development

3.4.1. Enriching education, learning, and clinical practice (10 articles)

Findings in the literature suggests there is great potential for AI technologies to enhance underexplored elements of compassion by enriching education, learning and clinical practice (Sukhera and Poleksic, 2021; Saab et al., 2022). There appears to be an "engagement factor" (Navarrete et al., 2021) associated with immersive VR environments which could be further explored for student engagement and empathy awareness as well as other elements of compassion, such as making a judgment about the suffering (the need to

act). Understanding suffering could be enhanced by using immersive technologies in combination with new types of haptic technologies (technologies that create an experience of touch by applying forces, vibrations, or motions to the user) (Ling et al., 2020) or existing tele-empathy applications (Ho et al., 2017; Palanica et al., 2018). Learning from self-compassion apps about identification with a virtual body (Falconer et al., 2014) could be integrated into immersive VR interventions to enhance clinical knowledge and clinical assessment skills in order to better understand suffering associated with the body (Plotzky et al., 2021). It could be useful to take learning from co-designed virtual health coaching apps into educational applications (Atif et al., 2022). There is potential to use VR technologies with clinical simulations and virtual patients to enhance approaches to moral development learning and ethical clinical decision making (Francis et al., 2018). Future research could explore the notion of beneficent dehumanization of care (e.g., to overcome stigma, stereotyping, negative emotions, or regret) and the implications for professional training and education (Palmer and Schwan, 2022). There is a clear need for research and education on AI technologies in relation to global humanitarian health analysis and responses (Fernandez-Luque and Imran, 2018) which could include development of virtual health tours for different groups of health professionals to teach about health issues in different countries and regions.

3.4.2. Extending healing spaces (9 articles)

Virtual and immersive spaces may have additional benefits for patients, health professionals, and students with respect to health and wellbeing outcomes that are not yet known (Gavarkovs, 2019), such as stress reduction (Michael et al., 2019). There is potential to integrate AI technologies to deliver combined physical health and wellbeing interventions for more effective mind-body interventions for patients and healthcare professionals (Rosa, 2014; Michael et al., 2019; Zheng et al., 2022). Such AI-assisted healing spaces could be devised to be individual (e.g., immersive VR) or shared virtual restorative spaces (e.g., making use of virtual worlds) drawing on known effective interventions for wellbeing. Co-therapy approaches, where community peers use avatars to share health information (Atif et al., 2022) have the potential to take clinics into communities, especially in resource-poor settings. Research on the internet of things (IoT) (Tiersen et al., 2021) opens new possibilities and challenges for seeing people's homes as clinical spaces (Kelly et al., 2020; Bouabida et al., 2021).

3.4.3. Enhancing healing relationships (7 articles)

According to the literature, AI technologies could support compassion by enhancing healing relationships. For example, by exploring and developing bonds between humans and technologies could boost engagement and efficacy of digital therapeutics (Darcy et al., 2021). It could be useful to explore further how therapeutic relationships are affected by virtual characters that exhibit certain perceived qualities such as gender (García et al., 2003) or ethnicity (Marcoux et al., 2021), to inform virtual health coach systems (Bevilacqua et al., 2020). Further research into traits and behaviors such as humor, self-disclosure, facial expressions, eye gaze, body posture, and gestures (Johanson et al., 2021) could inform effective human-robot interaction and human-human interactions in healthcare (Liu and Sundar, 2018). Cross-cultural research could inform ongoing development (in New Zealand) of an autonomous empathy system of a digital human to understand the challenges and opportunities for empathetic interactions (Loveys et al., 2022).

4. Discussion

4.1. Contribution of this review

The core contribution of this review is to demonstrate the association between AI technologies and compassion in healthcare and to elaborate on the nature and complexities of this association. Specifically, the review (1) shows the ways that AI technologies are currently being debated, developed, and used to enhance compassion in healthcare systems, so that these areas might be explored in more depth in the future (2) reconceptualizes compassion as a *human-AI system of intelligent caring* comprising six elements. These new understandings are theoretically informed, derived from an established scoping review methodology (Arksey and O'Malley, 2005; Peters et al., 2020) and a systematic process of data extraction and thematic analysis (Mays et al., 2001). A multidisciplinary team interrogated the themes and interpreted the findings for research and practice. Future development work using deliberative methods could test the validity of the findings with interdisciplinary cohorts of health professionals, educators, students, technologists, patients, and researchers, for example, to explore the themes that have been identified; and to debate priorities for future research and practice. The present review has developed and provided a set of search terms, and captured baseline data, which means the exercise could be repeated in a year or two to investigate any developments in this emerging topic area.

4.2. Limitations

As this scoping review only includes articles published in English it is biased toward westernized perspectives of healthcare and compassion. It does not consider alternative cultural understandings or ways of perceiving compassion, for example, the African philosophy of *ubuntu* or the Buddhist *maitrî* (aka mettâ). The literature and perspective firmly

focuses on compassion for people, rather than alternative understandings of compassion for sentient beings, or the environment, which are increasingly relevant to health and healthcare services. The review did not examine whether specific AI technologies, or their use in particular interventions or contexts, are effective, usable, and adoptable. It did not use statistical tests, or percent values about adoption and/or use of different kinds of technological practices or tools and satisfaction/dissatisfaction about them or any other type of outcomes. The review does not draw on learning from other fields (e.g., AI in military ethics, automated vehicle ethics, computer generated imagery or the film industry, business hybrid systems of online/offline communication, medical crowdsourcing etc.). Identified key areas for potential are biased toward present use cases in healthcare, and biases toward applications in elderly care, dementia, and finding AI-driven solutions to an aging population. Issues relating to young people, minority patient groups, people who suffer health inequalities (Scambler, 2012) or barriers to healthcare (Powell et al., 2016), are likely to be underrepresented in the results.

4.3. Reconceptualizing compassion as a human-AI system of intelligent caring

It is challenging to think of compassion as a system rather than a feeling or experience, yet a systems perspective is where the meaning and value of the concept lies: offering possibilities to align and integrate motives and motivation for intelligent caring behavior in humans, AI technologies, and healthcare systems (Lansing, 2003; Levin, 2003). Compassion, in this reconceptualization, is not about managing professional virtues or mimicking emotions (Pedersen and Roelsgaard Obling, 2019) it is about combining human and AI capabilities in an integrated system of intelligent caring.

Reconceptualizing compassion as a human-AI system of intelligent caring connects thinking about compassion at the individual human level (i.e., human psychology and behavior), with compassion as a function of AI technologies (e.g., artificial empathy, artificial compassion, HCD and technology design practices), and compassion as an essential aspect of healthcare system effectiveness and human flourishing. This conceptualization allows compassion, as it is perceived and manifest in everyday healthcare practice to connect with highly technical discourses about the use of AI technologies in healthcare systems, and human-machine boundaries (De Togni et al., 2021). It offers clear elements to explore how together humans and AI technologies might become more intelligent and caring.

As noted in the findings on how AI technologies are being used to enhance compassion in healthcare (Section "2.9 How AI technologies enhance compassion") a new sixth element of compassion emerged from the analysis of the literature (as shown in the final row of **Table 4**). That is, "(6) Attention to the effect and outcomes of the response." This new element that has been identified, corresponds with previous compassion research which suggests that experiencing or witnessing helpful human interactions is an important mechanism for developing understandings about compassion (Walter et al., 2015). This additional sixth element appears to be necessary to complete a feedback cycle, so that the person, the AI technology, or the healthcare system, is aware suffering has been alleviated or not, thereby creating future motivation (Ford, 1992). This sixth element corresponds with the importance of learning over time e.g., through training or performance feedback, learning from examples of excellence as well as learning from failings in healthcare.

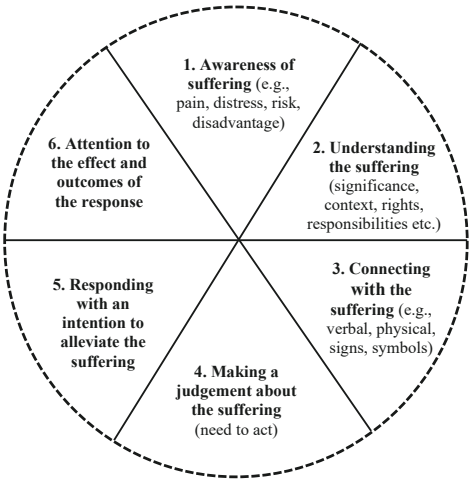

FIGURE 2
Reconceptualizing compassion.

Figure 2 draws together the elements developed from the original working definition of compassion (Section "1.4 Definitions and scope") and informed by the review findings, to illustrate how compassion may be reconceptualized as a system of at least six interrelated component elements, which may or may not interconnect in any individual, organization, or system level to form a cyclical feedback system. Although the components are numbered 1–6, they may exist in different health systems, areas of practice, or health professional's behaviors simultaneously. Alternatively, some or all elements may absent or underdeveloped. For example, a person may have very good empathetic awareness, but this may not translate into a decision to act or a response with the intention to alleviate suffering. At the macro level, it could be that a healthcare organization may generate responses with the intention to alleviate suffering, yet fail to connect with the suffering, meaning that patients are not consulted, are unaware, or do not feel involved in decisions about the type of response.

This reconceptualization has six component elements of compassion that are numbered 1–6 for clarity, but they are not necessarily sequential. Elements can be learnt and enhanced by individual humans and some AI technologies that have appropriate programming features (Mason, 2015, 2023). At a higher macro level, these elements of a compassion system can be developed by whole healthcare organizations, or across healthcare systems with strategic and supportive interventions. For example, healthcare professionals in training can learn to develop empathetic awareness but also to understand suffering in context, such as the provision of high-quality healthcare to address health inequalities and promote health equity. This reconceptualization of compassion, as a system, acknowledges the ethical challenges of artificial empathy, unease about virtual human's mimicry, deception, and moral incongruence (Montemayor et al., 2021), and asserts a way forward through the authentic empathy debate. It does this by showing that it is possible for humans and AI to collectively promote collective good (Day et al., 2021). The nature of the system, through which this is made possible, is encapsulated by the six component elements of compassion. AI technologies can contribute to each, or all, of these different elements of compassion. Thus, this understanding offers a much more significant and useful contribution of AI technologies to compassionate patient care and healthcare systems compared to concerns about replacing human empathy with digital empathy.

We suggest that when all six elements of compassion are present, functioning well, and interconnected, compassion is an intelligent caring system. Compassion involves intelligence in the sense that it is a learning system that is responsive and adjusts to new information and feedback. This is because the sixth element provides feedback (to the individual, the organization, or the system) about whether compassion has occurred, and suffering has been alleviated. For example, to tell humans when to step back with AI technologies and the circumstances when a human empathetic response is what a person wants and needs to lessen their suffering (e.g., breaking bad news, end of life care, apologizing for failings in care) (Elkin, 2021).

The review shows that concerns in the literature regarding AI technologies center on the issue of whether AI technologies are fundamentally about the replication of humans (Section 3.2). The review highlights that there are a range of AI technologies in development that aim to replicate human bodies, voices, and mannerisms (e.g., affective computing, robotics, embodied virtual agents), or to imitate human relationships (digital bonds, digital therapeutic relationships etc.), or to reproduce human capabilities (e.g., job roles, skill sets, knowledge, abilities). Aiming to replicate humans and human relationships could be problematic in the longterm, not only for technical reasons or the authenticity and artificial empathy. From a sociological point of view, replication risks reformation of harmful or unfair social structures (e.g., power dynamics, status, capital, agency) (Parsons, 1982) in new forms of deceptive relationships, based on artificial emotions (Montemayor et al., 2021). However, the results on how AI technologies are being used (Section "3.3 Reconceptualizing compassion as a human-AI system of intelligent caring") show a more positive and transformative ambitions here, in the form of innovative applications and studies of AI technologies that seek to "augment," "enrich," and "enhance" human lives, not to replace them.

Current applications in education and practice are providing engaging learning experiences; supporting human-human healing relationships; as well as providing some effective interventions for health and wellbeing such as therapeutic counseling. These applications are doing this in unique and original ways that are made possible through AI e.g., immersion, VR, perspective switch, avatars, simulation suits. Rather than evaluating the extent to which a given technology has successfully replicated human capacities or designing technologies according to understandings of the human body or mind, future research might instead seek to transform rather than replicate pre-existing human or societal systems with their biases, faults, and limitations. The potential of AI technologies is not so much the simulation of human intelligence and care-giving but rather an expansion of possibilities through which to realize these human capacities.

This review has identified some clear areas to explore new and novel approaches to human-AI intelligent caring. There are opportunities for innovation (and possible commercial opportunities) to build on and develop (1) better human-AI systems for detecting suffering (e.g., pain, distress, risk, and discrimination) to fine tune AI/human empathetic awareness; (2) use of human-AI intelligence to understand suffering in context; (3) better human-AI verbal and non-verbal communication systems to connect with suffering; (4) human-AI intelligence to inform decisions about the need to act, (5) more authentic and sustainable forms of human-AI empathetic response and interventions; (6) better human-AI intelligence about the effects and outcomes of responses and whether they have alleviated suffering or need to be modified.

In terms of motivation for a human-AI intelligent caring system, it is evident from this literature that AI technologies are helping humans to develop empathetic understanding of human experiences of living with debilitating conditions (Groza et al., 2017; Palanica et al., 2018; Schmidt et al., 2022). Next steps could be to build evidence about how AI technologies might support new ways of connecting (e.g., verbal, physical, signs and symbols) with various forms of suffering (e.g., pain, distress, risk, disadvantage); enable virtual/real proximity such as safe relating (Gilbert, 2021); explore therapeutic alignment (patient preferences for human and virtual providers); or address stigma (e.g., beneficent dehumanization of care). Motivation can be found in examples of AI technologies that are alleviating human suffering; specific use cases identified by this review could be considered humanitarian or miraculous in their effects, such as helping paralyzed people to walk (Sarkar et al., 2020). However, there are more ordinary applications that are nonetheless

useful and can build compassion, such as providing the right information to patients at the right time to alleviate distress (Papadakos et al., 2017).

What these findings also highlight is that people are inspired to help each other to help themselves, through the new capabilities of AI technologies. This is evidenced by the development of numerous self-care and self-compassion technologies. There are also entrepreneurial motives (Shepherd and Majchrzak, 2022) which need to be considered in relation to a system of human-AI intelligent caring. Future research could explore the themes of healing spaces and healing relationships to boost self-compassion and self-care in patients and health professionals. There is a need to direct more attention to not only the theory of compassion, but how to use AI technologies to help close the compassion cycle: in other words, how AI technologies can be an important tool for informing and assuring healthcare quality at multiple levels, from individual practitioner, AI technologies, healthcare organizations, to whole healthcare systems–for seeing when responses have made a positive difference to people's lives or provided motivation to continue to care.

This reconceptualization of compassion aligns with calls to develop compassion as a healthcare system goal and professional development priority (Gray and Cox, 2015; Swendiman et al., 2019). It helps to connect the subjective, experiential, and practical dimensions of compassion (e.g., getting people home safely, organizing transport, "going the extra mile") with an understanding of how AI technologies might support societal forms of caring (e.g., protecting human rights, advancing health equality) through their individual design and combined effects (Day et al., 2021). A systems perspective of compassion proposes that not everyone or every AI application needs to be delivering empathetic responses in a healthcare system all the time (Bleiker et al., 2020). This is not to say that healthcare professionals should not aim to be "highly humanistic" in their practice (Swendiman et al., 2019), but rather that the system of compassion in healthcare extends beyond human interactions at the individual level. Therefore, compassion can relate not only to direct clinical treatments and patient care but to indirect actions such as the development of AI-driven organizational systems for patient feedback, the use of guidance for use of AI technologies, professional codes of practice for the use of AI technologies, and so on; to employ human health professionals and use AI technologies to best effect within an overall system of intelligent caring.

4.4. Implications

In a complex adaptive system such as healthcare, human-AI intelligent caring will need to be implemented, not as an ideology, but through strategic choices, incentives, regulation, professional education, and training, as well as through joined-up thinking about human-AI intelligent caring. *Research funders* internationally in different areas of health, education, and technology research can encourage research and development into the topic of AI technologies and compassion. Interdisciplinary empirical research is needed to explore issues about the educational effectiveness of AI-assisted learning; patient diversity and AI technologies; safety and clinical effectiveness of AI technologies. Theoretically informed research should take a longterm view of how AI technologies can enhance compassion by enriching education, learning and clinical practice; extending healing spaces; and enhancing healing relationships. *Educators* in computing, design sciences, health professional education, and other fields and disciplines of science and humanities, can inform themselves about the association between AI technologies and compassion and promote an understanding of compassion as a human-AI system of intelligent caring involving six elements (see **Figure 2**). Educators can make use of modern learning technologies to enhance learning engagement, student empathetic awareness, to learn about how to respond to different types of suffering (e.g., pain, distress, risk, and disadvantage), communication skills and teamworking. *Technologists and computer scientists* should be aware that compassion is important and beneficial to human health as well as the sustainability of healthcare systems. They can consider how, in some applications it could be useful to build in artificial empathy (Dial, 2018), or artificial compassion (Mason, 2015, 2023), while in other contexts AI technologies can contribute to specific elements of compassion within healthcare/social systems (e.g., supporting sensitivity to suffering). *Health professionals* can link into interprofessional virtual communities of practice (McLoughlin et al., 2018) to learn and share knowledge of how AI technologies might support compassion in healthcare and to develop the practice of human-AI intelligent caring.

5. Conclusion

This systematic scoping review of the literature shows there is an association between AI technologies and compassion in healthcare. Interest in this association has grown internationally over the last decade, with more articles debating the topic and reporting on developments each year. In a range of healthcare contexts, AI technologies are being used to develop or enhance empathetic awareness; empathetic response and relational behavior; communication skills; health coaching; therapeutic interventions; moral development learning; clinical knowledge and clinical assessment; healthcare quality assessment; therapeutic bond and therapeutic alliance; as well as to provide health information and advice. The findings inform a reconceptualization of compassion as a *human-AI system of intelligent caring* comprising six elements. Future research and development into the association between AI technologies and compassion could enrich education, learning, and clinical practice; extend healing spaces; and enhance

healing relationships in new and novel ways, made possible by artificial intelligence.

Author contributions

EM and FR initiated the review and collaborated with CM, TZ, KP, RS, and MR to plan and develop the review focus and approach. EM and TZ undertook the searches. EM wrote the draft. All authors contributed to discussions online (Sept 2021–Jan 2022) and thereafter contributed to conceptualization, thematic analysis, interpretation of the results, and approved the submitted version and commented on the final draft.

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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.2022.971044/full#supplementary-material

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EDITED BY
Stephen Schueller,
University of California,
Irvine, United States

REVIEWED BY
Hideyuki Kanematsu,
Suzuka College,
Japan
Lisbeth Carolina Bethelmy Rincón,
Simón Bolívar University,
Venezuela

*CORRESPONDENCE
Andrea Gaggioli
✉ andrea.gaggioli@unicatt.it

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Liminal design: A conceptual framework and three-step approach for developing technology that delivers transcendence and deeper experiences

Johan Liedgren[1], Pieter M. A. Desmet[2] and Andrea Gaggioli[3,4]*

[1]Independent Researcher, Seattle, WA, United States, [2]Department of Human Centered Design, Delft University of Technology, Delft, Netherlands, [3]Research Center in Communication Psychology, Università Cattolica del Sacro Cuore, Milan, Italy, [4]IRCCS, Istituto Auxologico Italiano, Milan, Italy

As ubiquitous technology is increasingly mediating our relationships with the world and others, we argue that the sublime is struggling to find room in product design primarily aimed at commercial and transactional goals such as speed and efficiency. We suggest a new category of products to promote deeper and more meaningful experiences, specifically those offering liminality, transcendence, and personal transformation. This paper introduces a conceptual framework and three-step design approach looking at narrative participation in design through abstractions to promote, hold and deepen more complex emotions. We explore implications from a theoretical point of view and suggest product examples for how the model might be applied in practice.

KEYWORDS

liminality, narrative, design transcendence, user experience, awe, technology

1. Introduction

> "We shall not cease from exploration. And the end of all our exploring. Will be to arrive where we started. And know the place for the first time."—T.S Eliot, Wasteland

Social systems from the beginning of humanity have included activities and sacred places of contemplation in which to hold "liminal experiences": events that facilitate transcendence, interconnectedness, and feeling part of something larger than ourselves. The concept of liminality refers to the transitional phases in a human's life; phases that involve ambiguity and the dissolution of order that open a fluid or malleable space in which new ideas, practices and identities may emerge and develop (see e.g., Turner, 1974). The last 20 years' shift towards ubiquitous technology that mediates a lion's share of interactions with others and the world around us is instead focused on information sharing, ease of use, transactional speed, and platform integration. Users get two-dimensional renderings on a screen and words in messages, but rarely any deeper experiences beyond that.

In this paper, we argue that liminality is the missing design element for technology to better set the stage and open the door to real connections, more focus, and memorable experiences—all requiring some level of transcendence. For this, we need a new product-development framework looking beyond traditional user experience (UX) design and its predominant focus on instrumental,

commercial, or pleasurable experiences. Liminal Design, by contrast, includes the perspective that any memorable, engaged, and meaningful participation with technology requires us to rethink interactions as social situations that also provide a safe path for the user's suspension of disbelief and the creation of a desire to consider and play with alternative narratives of the world—two prerequisites, we pose to experiences of transcendence. Such experiences will challenge targeted beliefs about us and our reality, and thereby enable a deeply felt sense of personal disruption, surprise, and personal transformation.

Self-transcendence is a concept that has been used to describe both a process of expanding oneself beyond its local confines and a trait that develops because of this process, ending in a broader worldview (Garcia-Romeu, 2010). The concept of psychological transcendence has been widely explored in the fields of psychology, psychiatry, philosophy, and spirituality. Depending on the discipline and focus, one will find very different approaches to investigate this phenomenon (Kitson et al., 2020). One of the earliest and most influential perspectives comes from Abraham Maslow's hierarchy of needs (Maslow, 1943, 1971) which posits that self-actualization, or the realization of one's full potential, is the highest level of human motivation. Maslow argued that it involves a transcendence of one's ego and a realization of one's interconnectedness with the larger world. More recent research on psychological transcendence focuses on the relationship between self-transcendence and well-being (Piedmont, 1999; Granqvist et al., 2002). These studies have found that an individual who score high on measures of self-transcendence tend to report greater life satisfaction and a stronger sense of purpose. Yaden et al. (2017) used the term 'self-transcendent experiences' (STEs) to describe transient mental states involving the dissolution of boundaries between the sense of self and "other," in which the subjective sense of oneself as an isolated entity briefly fades into an experience of unity with other people or one's surroundings. According to these authors, such experiences encompass several states, including Flow, Mindfulness, Awe, Peak Experiences, and Mystical-Type Experiences (Yaden et al., 2017). Similar to Nour et al. (2016) conceptualize self-transcendence as the loss of identity, including two main conceptions of ego consciousness. First, ego-dissolution, often referred to as "dissolved ego-boundaries," as "the related experience of increased oneness with one's environment." The second construct, ego-inflation, is defined as "the distinct and largely antithetical experience of unusually elevated self-assuredness and confidence." So, self-transcendence would then be the presence of ego-dissolution and absence of ego-inflation. However, self-transcendence is not just a subjective experience, but also a complex process that involves both psychological and neurobiological aspects involved in self-awareness and empathic processing (Lopez et al., 2004).

In this context, we think about liminality as the space between two opposite notions. An experience in this partially undefined and contradictory in-between state both allows us, and forces us, to consider new ways of being—to transform. In liminality, we know that what we see is not our existing world, yet we experience an immediate feeling of something very real. This creates a need for accommodation between these two levels of "reality." Think, for example, of an adolescent who is in a transformative state from a child to an adult identity, which requires them to explore a new understanding of their personal reality (see Larson et al., 1996). If we venture too far into the undefined, it becomes meaningless, random, and chaotic, not to mention terrifying. Stay too close to what is familiar and safe, and we become bored, calcified, and unable to adapt to change. This ties liminality directly to narrative structures: the idea that all stories need to be "inevitable yet surprising" at the same time.

We rationalize sensory input by creating causal models of the world around us, how it works, why and—based on that—what might happen next. These are narrative models. Putting on hold some beliefs from our existing narrative and entering a liminal space allows us to safely test, play with and consider alternative narratives (Gaggioli, 2016; Kitson et al., 2019). It is this process of re-evaluating and changing one's own narrative of the world and self that is the essence of personal transformation. We can think of Liminal Design as a version of the Cartesian notion of the "pineal gland": a stage to imagine the self, and to create narrative meaning out of the sensory inputs from the world around us.

Are all good user experience designs liminal? No, not all designs require liminality, nor do they necessarily seek transformation of any kind. In this context, the goal of Liminal Design is to provide principles to guide the design of experiences that help individuals find new meaning, enhance their emotional and moral abilities, increase inspiration, creativity and imagination and support transcendence. Designing liminal spaces also means helping people to explore new "spaces of the self."

The goal of most traditional UX is to increase usability, pleasure, and satisfaction (Norman, 2004), whereas Liminal Design tries to go beyond these pragmatic and hedonic aspects and explicitly addresses the eudaemonic sphere of wellbeing (i.e., autonomy, meaning, purpose, self-actualization, and transcendence, see Ryan and Deci, 2001). Clearly, when designing liminal experiences, one needs to work at a higher level of abstraction, which reduces the possibility of directly translating "user needs" into "design requirements." Liminal Design is, in this respect, more like the process of artistic creation than conventional design. Consequently, this highly dynamic context requires us to look well past simple technological fixes to create meaning, and instead consider problems and solutions as meaningful social situations created through interplay between the narrative expectations we arrive with and the design we experience through participation.

This contribution is structured in four sections. The first gives a short overview of previous work that explored how design can stimulate and facilitate experiences that extend beyond simple pleasure or satisfaction. In the second, we provide a short look at the seminal work that has come before us connecting transformation and liminality and explain the motivation and background for our framework. In the third, we outline the foundational assumptions of Liminal Design and a practical design model illustrated by examples and potential applications. In the fourth and last section, we discuss higher-level implications of Liminal Design.

The manuscript includes four images. By means of visual metaphors they provide figurative representations of our key assumptions and ideas. The style aligns with our notion of liminality as a space that provides sufficient openness to allow for exploration and play with narratives of the world. The images aim to communicate through association with abstractions of individuals, spaces, actions, and interactions.

2. Previous work on design beyond pleasure and efficiency

Traditional UX design focuses on usability, pleasure, and satisfaction. Various design researchers have challenged this dominant perspective and explored how the UX repertoire can be enriched beyond the purely utilitarian and hedonic. To start, several researchers have proposed that the traditional focus on generalized pleasure in design

research does injustice to the differentiated nature of human emotion. Design can evoke a diverse palette of distinct (positive) emotions, for example, hope, pride, fascination, relief, or love (Desmet, 2002). Although all positive, these emotions are essentially different – both in terms of the conditions that elicit them and in terms of their effects on human-product interaction. For example, whereas fascination encourages a focused interaction, joy encourages an interaction that is playful (Fredrickson and Cohn, 2008). Various frameworks have been introduced to support this more granular understanding of pleasure. Desmet (2012) introduced a typology of 25 positive emotions that provides a fine-grained yet concise vocabulary of positive emotions in human-product interactions. More recently, this typology was developed further into a detailed online emotion database.[1] Even though not all positive emotions are transcendent, the typology opens up a design space that goes beyond simple pleasure by including complex experiences with transformative qualities, such as elevation, serenity, and awe. Yoon et al. (2013) introduced four design tools that can help leverage this differentiated nature of positive emotions in design processes. One of these tools is a card deck: the "Positive Emotional Granularity Cards" that aims to increase the designers' so-called positive emotional granularity, which reflects the degree to which a person can represent positive emotions with precision and specificity (Tugade et al., 2004).

Other authors have gone even further in scrutinizing pleasure in design usage by exploring how negative emotions can make a meaningful contribution to user experiences. Fokkinga and Desmet (2012, 2013) proposed that designers can enrich user experiences by purposefully involving negative emotions in user-product interaction. They introduced a framework of rich experiences, which explains how and under what circumstances negative emotions make a product experience richer and even more enjoyable. Through several design explorations, they demonstrated that negative emotions are a viable and interesting starting point for creating emotionally rich product experiences. This proposition aligns with the work of various authors who explored how product experiences can more truthfully mirror the richness of real-life experiences, and even enrich and expand our experience of everyday life. Hassenzahl (2010) suggested that product experiences should be "worthwhile" or "valuable" to avoid the pitfall of aiming for shallow pleasure in experience design. Likewise, Arrasvuori et al. (2010) investigated the possibilities to create more engaging consumer products by using the wide range of emotions that people typically experience when playing video games. With their concept of "design noir," Dunne and Raby (2001, p. 45) even proposed a new genre of design to complement the prevailing "Hollywood" tradition of products that offer a limited experience.

Similar to the critique on basic pleasure, various authors have challenged the narrow operationalization of usability as a measure of effectiveness and efficiency, especially in behavioral design (i.e., design that aims to stimulate altitudinal and behavioral change). Laschke et al. (2015) introduced a design approach in which "situated friction" plays a central role (see also Laschke et al., 2014; Hassenzahl and Laschke, 2015; De Haan et al., 2021). This approach creates frictional feedback to disrupt routines and stimulate people to imply alternative courses of action. By deliberately reducing usage efficiency, friction inspires reflection and meaning making. The authors present several design cases that explore how frictional feedback can be experienced as acceptable and meaningful, while stimulating the intended reflection. In a similar fashion, Rozendaal et al. (2011) and Boon et al. (2018) introduced a design perspective that emphasizes ambiguity (i.e., affording multiple interpretations) and open-endedness (i.e., affording multiple courses of action). While design ambiguity and open-endedness typically reduce usability in a traditional view, these authors explored how these qualities can contribute to user experience, leaving room for autonomy and creativity of end users in solving problems, creating meaning, and determining product usage.

As a final note, we should mention that several authors have started to explore how technology can be used to create experiences that can be described as spiritual or transcendent (for a recent review, see Buie, 2018; Blythe and Buie, 2021). While diverse, all these inquiries focus on design for a sense of openness and unity — experiences of connection with something that is larger and more permanent than oneself, which comes with emotional experiences that are deeper, more impactful, and more profound that simple pleasure, such as experiences of ecstasy, tranquility, gratitude, awe, and reverence. To explore transcendence design, researchers have experimented with design spaces that are ineffable, ephemeral, or paradoxical.

These initiatives exemplify an increasing awareness in design research and practice that a mere focus on basic usability, pleasure, and satisfaction represents design intentions that are inherently narrow, and that knowledge and methodology are required that enable and support the pursuit of design that better represents the infinitely complex and rich repertoire of human experience. On a more general level, these initiatives recognize a need for "alternative ways of knowing" to compliment today's apparent ethos of consumerism and materialism that is stimulated by the high rates of scientific and technological progress. They explore a new space for the development of a material culture that is in greater harmony with one's inner development and their outer morality and (self) compassion (for a discussion, see Walker, 2013). A current challenge is that little guidance is available on how to design for this kind of transformative design. With our Liminal Design model, we aim to contribute to this progress by providing a structured approach to transformative design that provides the user with a safe space for their personal and complex inquiry towards transitional development through value formation, interconnectedness and feelings of unity. Self-transcendent mental states can have a transformative impact at the psychological level by fostering a sense of belonging, promoting positive interpersonal relationships and prosocial behavior, including feelings of purpose and meaning in life (Granqvist et al., 2002; Gaggioli, 2016; Yaden et al., 2017).

3. Foundations for Liminal Design

Many of us multitask our way through activities traditionally designed for a separate and committed time and space, with their own rules, hopes and expectations. Wildly different types of activities and tasks are streamlined onto a single technological platform, leaving disparate experiences mashed up on a single screen filtered through a single branded aesthetic and interface—all to be found in the very same geographic location as the rest of our daily routine and no longer requiring the physical movement that once helped distinguish between them. A contemporary example is the increased use of video conferencing tools that arguably has left us drained (Wiederhold, 2020; Fauville et al., 2021) and at times thinking that a simple phone call in a

1 https://emotiontypology.com

quiet place might deliver more intimacy. Liminality has been pushed aside in favor of platform efficiency. The sublime state is struggling to find room in a digital reality built for commerce.

The concept of the sublime refers to a typically intense, contradictory, but ultimately pleasing, aesthetic experience in response to an object or event that exhibits startling vastness or power (Clewis, 2021). The description of the Alps in Samuel Taylor Coleridge's poem "The Rime of the Ancient Mariner" is a well-known example of the sublime in literature. The Mariner feels little and insignificant when he first sees the mountains, which is described as a moment of transcendence and wonder. Among others, Immanuel Kant and Edmund Burke investigated the idea of the sublime, contending that it is a reaction to experiencing something that is beyond our capacity for comprehension or understanding. Frequently linked to the sublime is the emotion of awe, which is a feeling of respect or adoration toward something that is regarded as profoundly large, big, or powerful. Following the seminal definition by Keltner and Haidt (2003) psychologists commonly view awe as a response to a *vastness* (either perceptual or mental vastness), followed by the *need for accommodation*, i.e., the urge to make meaning of the experience in terms of one's conceptual framework. Awe demands a shift in viewpoint oral reevaluation or revision of one's ideas or way of thinking. However, although they are frequently closely connected, the sublime and awe are not the same thing (Clewis, 2021). While awe can be evoked in response to a wide range of stimuli, such as scientific discoveries, religious experiences, or wonder, the sublime is more closely linked to aesthetic experiences and the admiration of beauty or power. There is an important opportunity for design here to take back what we have lost and to push human experiences into new, deeper, and more interesting realms. To further contextualize the need for a shift in design approach, we should also consider macro shifts in the economy: from an industrial core in the 1800s, to information-based in the 1970s, and more recently to the so-called "experience and transformation economy" (Pine and Gilmore, 1999; Pine and Gilmore, 2019). Despite this latest advance, tools, methods, and technologies have struggled to manifest its theoretical promise (Gaggioli, 2016). We are still using outdated industrial and information models to solve a new era of experience problems. The big technology companies are struggling with this shift for similar reasons: their models rely on enormous scale, uniformity, and predictability to support a particular commercial driver, a financial platform often decoupled from the core value proposition of the technology delivered.

We are, however, not interested in piling more of the same onto the now-familiar tech skepticism stemming from writings such as "The Filter Bubble" (Pariser, 2011) and "The Age of Surveillance Capitalism" (Zuboff, 2019). Instead, a new practical design framework is urgently needed: not to look for incremental improvements within established product strategies, but to explore and develop radically new ones.

In this spirit, the Liminal Design model we propose always starts with first principles to define the right problem that we should focus on solving. Only then can it establish a practical process to highlight and sequentially organize quintessential concepts of liminality, transcendence, and transformation in the shape of new products. This process will always need to first consider the why as the foundation for the narratives that we invite users to. Without a narrative that we can care about and can want to make a personal investment in, no technology can deliver what we need for liminality.

Winnicott (1971) described a "potential space" as a metaphorical expanse that is intermediate between fantasy and reality, an area of experiencing which opens new possibilities for imagination, symbolization, and creativity. According to Winnicott, potential space is inhabited by play. "It is in playing and only in playing that the individual child or adult is able to be creative and to use the whole personality, and it is only in being creative that the individual discovers the self" (p. 54).

The notion of liminality (from the Latin term limen: threshold, boundary) was first introduced by the ethnologist van Gennep (1960) to describe the initiation rites of young members of a tribe, which fall into three structural phases: separation, transition, and incorporation. Van Gennep defined the middle stage in a rite of passage (transition) as a "liminal period." Elaborating on van Gennep's work, anthropologist Turner (1974, 1981) argued that, in postindustrial societies, traditional rites of passage had lost much of their importance and have been progressively replaced by "liminoid" spaces. They are defined by Turner as "out-of-the-ordinary" experiences set aside from productive labor. These liminoid spaces have similar functions and characteristics as liminal spaces, disorienting the individual from everyday routines and habits and situating him or her in new circumstances and narratives that deconstruct the "meaningfulness of ordinary life" (Turner and Turner, 1985, p. 160). The metaphors of potential space and liminality/liminoid space provide a platform for further elaborating the purpose of transformative design as the realization of interactive systems that allow participants to experience generative moments of change. However, as open-ended "experiments of the self," such interactive, transformative experience may also situate the participants in situations of discomfort, disorientation, and puzzlement, which are turning points out of which new possibilities arise (Gaggioli, 2016; Riva et al., 2016; Kitson et al., 2019).

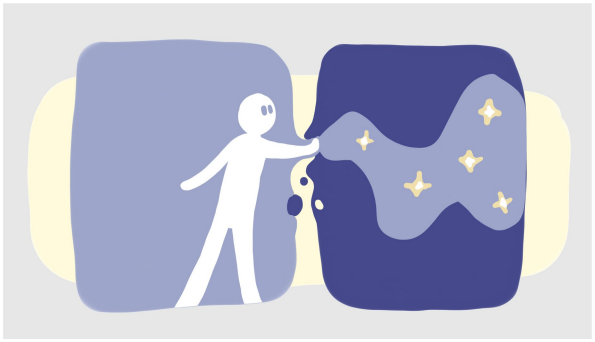
The Liminal Design model is built around four foundational assumptions, illustrated in Figure 1:

> Assumption 1: Designed Liminal experiences are narrative in nature.

The purpose of liminality is the creation of a space within which we are allowed to play with—and consider—new narratives of the world and of ourselves within it. Humans organize experiences and sensemaking in a narrative form (Bruner, 1991; Brockmeier, 1995, 2009) that requires semiotic distinctions or borders to be meaningful (Picione and Valsiner, 2017): me versus not-me, here versus there, past versus future. The liminal space is a semipermeable reality between where we have enough stability to retain a sense of self without threat of chaos and disintegration, and—at the same time—enough openness to the un-narrated outside and its endless possibilities. The ambiguity between the two calls for us to accommodate by creating our own new narrative to better hold the contradiction. For designed liminal spaces—in contrast to general awe or external catastrophic disruption—the dialogue suggested between one reality and the other is both targeted and specific, i.e., it offers an experience that suggests a certain narrative path of personal transformation. Picione and Valsiner (2017) beautifully explore this complex interplay between semiotic structure and narrative liminality:

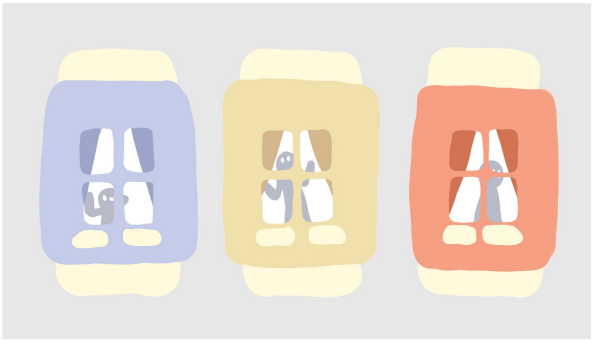
"The peculiar dynamics and the semiotic structure of borders generate a liminal space, which is characterized by instability, by a blurred space–time distinction and by ambiguities in the semantic and syntactic processes of sense-making. The psychological processes that occur in liminal space are strongly affectively loaded, yet it is exactly the setting and activation of liminality processes that lead to novelty and creativity and enable the creation of new narrative forms." (p. 1).

Assumption 1: Designed Liminal experiences are *narrative in nature*



Assumption 2: Liminal Design can only be experienced through *suspension of disbelief*

Assumption 3: Liminal spaces are conducive to *personal transformation*



Assumption 4: Liminal spaces are *sui generis* – in a class in and by itself

FIGURE 1
Four foundational assumptions of the Liminal Design model.

However, both awe and liminality can involve a sense of being confronted with something that is beyond one's usual frame of reference or understanding. In both cases, the individual may feel a sense of wonder or amazement, and may be motivated to explore and learn more about the experience in order to make sense of it.

> Assumption 2: Liminal Design can only be experienced through suspension of disbelief.

The space that Liminal Design suggests is by nature overtly different from our day-to-day reality. It is a construction to be experienced for a limited period for the explicit purpose of creating liminality within a specific narrative. To play a part and experience anything in it, we must first decide to enter it and be open to leaving some assumptions about ourselves and our world behind for a moment: to suspend disbelief. Instead of simply rejecting the liminal construction as untrue or unreal, we are asked to play with—and to have first-hand experiences of its suggested possibilities.

The success of suspension of disbelief is derived from a dialectical relationship between our desire to experience something new and a safe but immersive-enough violation of expectations inside the liminal space to confirm that we are closer to something intangible that we desire. This is the narrative continuously unfolding and being made as we stay in the liminal space. To allow oneself to be lost in the highly constructed universe of a book or a film is analogous to this experience, as is any profound experience of art (see Schaper, 1978). The true beauty of suspension of disbelief is that of being freed from the limitations of "reality" and therefore open to a glimpse of what is infinitely bigger than our own narratives: the sublime.

The famous quote from Samuel Taylor Coleridge, who first coined the term suspension of disbelief (Biographia Literaria, Chapter XIV, 1817), certainly captures the promise of what we have in mind:

"…to give the charm of novelty to things of every day, and to excite a feeling analogous to the supernatural, by awakening the mind's attention from the lethargy of custom, and directing it to the loveliness and the wonders of the world before us."

> Assumption 3: Liminal spaces are conducive to personal transformation.

The very present and yet un-real experience of a designed liminal environment challenges our assumptions and semiotic borders and thus questions our canonical narratives of self. To reconcile this unreal narrative universe with what we so unmistakably feel are very real emotions, we consider and play with new personal narratives.

So, as we exit the liminal space and return to our regular reality, the most basic hope is that the experience and new ideas generated within still resonate, thus allowing us to see our old world in a slightly new light and with more agency to choose how we play a part in it. The experience has transformed us, leading to a deeper understanding of ourselves or the world around us and eventually to a change in our attitudes or values (Gaggioli, 2020; Chirico et al., 2022).

> Assumption 4: Liminal spaces are sui generis – in a class in and by itself.

All liminal spaces are sui generis, meaning that they are a class in and by itself that extends beyond conventional genre boundaries. This implies that they cannot be approached or understood outside of—or as part of—any other structure or hierarchy than themselves. It is precisely their lack of attachment to practical functionality or existing taxonomy that creates their liminality, and thus allows room to experience a violation of the expected. Because we are interested in designing liminality to promote personal transformation, it is specifically the semiotic ambiguity between the profane and the sublime that we exploit for purposes of a given narrative, i.e., that narrative is not part of an already existing construct. The liminal space experienced, the space between two opposites, is always experienced in its entirety, not as a smaller part of something established. This makes it sui generis.

"This interstitial passage between fixed identifications opens up the possibility of a cultural hybridity that entertains difference without an assumed or imposed hierarchy" (Bhabha, 2012).

In addition, we must consider presence—our participation in the liminal—as sui generis as well. The singularity of a liminal experience and its ability to transform the self can only be found in the dialectical play between opposites: me versus not-me, here versus there and past versus future (Marsico, 2011, 2016; Gaggioli, 2016; Picione and Valsiner, 2017).

4. An approach to Liminal Design

The practical approach to Liminal Design consists of three sequential steps (see Figure 2): Narrative Desire (i.e., selecting and building a narrative stage), Optimized Abstraction (i.e., optimizing the space for the targeted experience), and Suspension of Disbelief (i.e., creating desired participation from start to finish). By re-infusing created experiences with these elements, the design opens existing spaces for imaginative and even transcendent engagement with the world and with others. The goal is not a faithful restoration of analogue physical experiences, but rather a plumbing of new types of interpersonal contact and imaginative experience not possible prior to today's technology.

The Liminal Design approach is not intended as a formula to mechanically follow. As with all creative endeavors, good solutions will require a committed leap from strategy to the specifics of implementation and manifestation in the design. A technological design change cannot be considered in isolation, but only has meaning in the context of the dynamic interplay between narrative and participation, mirroring our three steps below (Dorst and Cross, 2001).

4.1. Step one—Narrative Desire

Narrative Desire is the articulation of the expectations and attitudes we want users to approach our experience with. There are many ways that we can set this context: marketing and PR, packaging, stories, instructions, and product mythology. All of these can prepare the user to understand and navigate an abstract liminal space. At the same time—and with the same message—this context must also create a real desire to participate and seek the intangible of what can only be had inside the liminality offered up by the product.

As we discuss in step two below, abstraction is essential to designing and experiencing liminal spaces. Narrative Desire gives the collective abstractions purpose and direction. When the product holding the liminal space is designed properly, every step in the experience leads us deeper towards the desired transcendent target. It should be noted, as with all narrative and story, that although each individual part of the experience cannot—and should not—hold the entire narrative, all parts need to have a role and a function in an efficient, singular, and coherent overarching narrative.

It cannot be stressed enough that for all stages of Liminal Design, it is imperative that we choose a Narrative Desire that is important enough to care about and will trigger our imagination. A transactional goal might be of great business necessity, but to trigger a desire that tickles our imagination and have us desire to move more fully into an experience to project ourselves into the narrative must appeal to the

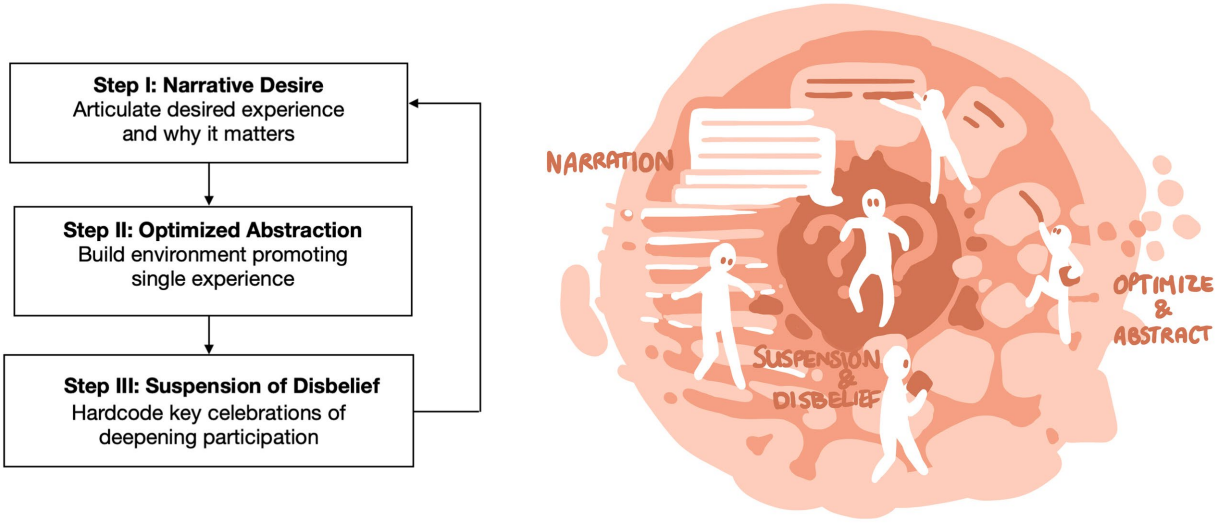


FIGURE 2
Three-step approach to design for liminal experiences.

potential of what might change how we view ourselves and the world around us. As with all great stories, if we do not care about the narrative personally, we will not invest in the experience with our imagination and consequently never make the commitment necessary to make possible liminality, transcendence, and transformation.

4.2. Step two—Optimized abstraction

Once the Narrative Desire is clear, two key components guide the design of a liminal space to manifest the narrative: how we *optimize* and *abstract* a suitable stage for a user's transcendence that promotes the specific target experience.

Optimization and *Abstraction* are coupled here because each is embodied through the other. We *optimize* by deleting what we do not need, and thereby keep front and center what we want the experience to focus on. This purposeful reduction of everyday reality creates *abstraction*. In reducing the distractions of the environment to highlight and promote a specific singular experience, Abstraction becomes Optimization. When we participate and have experiences in abstractions, we experience a liminal space.

To *Optimize*, we deconstruct the desired narrative experience: its quintessential elements and their sequence. It is important to note that the design does *not* deliver the desired experience. It simply holds the user in an optimal environment for the targeted experience to be had. For example, focus is typically required for immersion: an immersive experience should therefore provide the right single focal point and design the rest of the space to eliminate all distractions, physical, and digital.

Abstraction—understood separately from Optimization—creates room for us to bring and project a narrative onto an experience. Even if objects in our designed experience are familiar, they will still be curated or designed objects, functioning as tokens, visuals, and icons (Mitchell, 2015) that are separated from their usual reality and context. In other words, they are abstracted. They will then have to be filled with new meaning, within the context of the liminal space, by the user projecting themselves into a version of the Desired Narrative that is meaningful to them. Religious practices and places of worship often use and then fill ordinary objects with story and grant them sacred status as part of creating a liminal place.

Our work is directly related: we are attaching meaning to objects needed to play out an alternative narrative experience. We are not replicating reality. We are creating a new one. This is part of the abstraction and will therefore, as part of how it is constructed and experienced, be sui generis in nature.

If an object in our space is still part of its traditional and contextual reality—a button to turn the experience off or adjust the volume, etc. We would probably be well served to make sure it does not contradict or distract from the desired narrative. Keeping non-abstract functional objects out of sight is often the best solution to keep non-narrative stimuli to a minimum. And if we cannot hide them, there are often ways to visualize and ceremonialize these functions and actions to turn them into tokens of meaning in the liminal narrative context.

Now, all narratives experience changes and morph through their arcs: no experience should feel the same at the beginning as it does at the end. Optimizing for the arc supports different targeted changes throughout the experience. These changes anticipate and manifest key emotional aspects of the targeted narrative experience, much like the music score of a film helps amplify the experience the filmmaker wants us to have and cue where they want to transport us next. A deep understanding of how the narrative arc maps to a user's emotional arc is imperative and should be unique to each desire and its design implementation. Early stage user testing and prototyping will help validate assumptions of how arc, desire and design play together best together. When done right, the design will support and hold each step as one step on an emotional journey and conclude to create enough desire for the user to seek the deepening of the experience in the step coming up next: all steps taken together creating the full experience, again akin to that of acts in a play or film, together playing out the complete narrative from opening to the very end.

4.3. Step three—Suspension of disbelief

All the experiences we have discussed are personal to the user and intentionally encountered by them. But no matter how well we choose a Narrative Desire, or how perfectly we optimize the abstraction of our stage for the experience, there's no causal effect that we can rely on to trigger transcendence. *Suspension of Disbelief* can, however, be promoted at key points in the experience arc: first by establishing an *independent space* for liminality, then by *ritualizing* and *celebrating* targeted behavior through the experience arch. And lastly by allowing enough *narrative room* in the experience to afford users flexibility to make the experience their own. These three aspects all support immersion into—and throughout—the liminal space and its narrative, i.e., suspension of disbelief.

Independent space—physically and spatially dedicating a space to the target experience is the most straightforward solution to designing a liminal space. Even the earliest settlements, created as far back as 15,000 years ago in Turkey, show humans distinguishing between everyday spaces and spaces dedicated to worship. An optimized space is not liminal until we have clearly defined its perimeter as different from that of our ordinary reality. A space can be both external (a theater, church, tearoom, or nightclub, etc.) and internal (closing our eyes before sleep, meditating, praying, taking psychedelic drugs, listening to a story etc.), but in all cases it relies on a semiotic distinction to create the very border we are to traverse.

Research shows that imagination and memory are in part spatially organized (Robin, 2018). The mnemonic device "Memory Palace" (Yates, 1966) is one example of this. Consequently, our minds have evolved to partly reset as we move between defined spaces. "The Doorway Effect" is a common phenomenon where we might walk into the kitchen only to forget why we did so (Radvansky et al., 2010). Since our goal is immersion in the liminal space, clarity to that moment when we cross from one space to another aids suspension of disbelief: demanding a decision and commitment from us to either stay in our ordinary reality *or* to step across the border and into the liminal journey. The latter choice relies on us pushing aside the noise and concerns of the existing world and being ready for something new and different. It is often meaningful to think about Liminal Design as the creation of an attitude conducive to transformation. It again speaks to the dynamic nature of this task: the continuous dialectical play between user, space, and narrative.

4.3.1. Ceremony

In this context, *Ceremonies* are targeted celebrations of steps that support the underlying sequential narrative helping us to stay present

in, and to move us from the beginning to the end of the liminal experience by. What tactile, aural, and visual feedback can we design to manifest mile-markers of where we are in the narrative arc, and more importantly, to highlight that narrative to create a desire to continue.

Ceremony can be an agreed-upon ritual: applause and cheers between songs at a rock concert, a sports team's huddle before the game, a writer clearing the desk of clutter before a day of writing. It can also be hard-coded into the design, content, or UX. "Intro titles" (or main titles) for films and television are one very direct example of Liminal Design: they leverage the required disclosure of production credits in order to bring a "fresh audience" into the specific fictional—or liminal—universe of a film or television series using abstracted audio-visual and narrative cues. Another example is intentional phenomenology in architecture: how a building's design deliberately provides different choreographed experiences and feedback depending on place, angle of view, time of day, etc. An interactive UX might change the soundscape to protect and gently anticipate the upcoming targeted experience, putting it into clearer focus as an act of creating desire.

4.3.2. Narrative room

Lastly, it can be tempting to be prescriptive in articulating Narrative Desire. Clarity about why the experience is to be desired is important, but a too tightly held notion of *how* a user must experience every detail of it will run the risk of not leaving enough *Narrative Room* for the individual user to make the journey their own. As happens with all stories, we make it relevant to us by projecting our own hopes and fears into the narrative. The design of the story must provide room for these projections to be made.

This is even more true with liminal spaces. The bigger and more complex emotions that we are designing for can run a higher psychological risk in letting go of one reality and losing control of the familiar. Transcendence is very personal, as are the psychological hurdles we must clear to participate fully. Therefore, all liminal experiences are abstract. Transcendence is and must be a personal experience of becoming part of something greater. Conversely, when abstraction is replaced with detailed instruction, there is no longer space for us to imagine ourselves in a different reality and to participate through projection and on our own terms.

It is only when the imagination is stirred—giving us a glimpse and hope of what we desire—that Suspension of Disbelief is likely to take place. And when it does, liminality can offer up personal experiences far more intense and sublime than what is merely prescribed. Striking the right balance between guiding the targeted Narrative Desire and offering enough narrative openness for the user through abstractions is the core creative work of Liminal Design.

With the proper Narrative Room, users of liminal spaces can also show a very useful opportunism in what they choose to incorporate into the narrative and how. For example, the active suspension of disbelief during a video conferencing call might include users ignoring the common knowledge that their screen just presents a mediated digital image of someone real far away. At the same time, to mitigate their shyness or hesitation about intimacy, they might simultaneously hold a contradictory fact as part of their narrative: that the other user is thousands of miles away, thus making the experience less threatening. Only with enough Narrative Room and a motivated user will we unlock the unique power of liminality: to create heightened experiences and personal transformation. In addition, a liminal experience—when explored opportunistically and beyond the limits or reality—has the potential to be more profound and more intense than any real-world alternative.

For all aspects of the Liminal Design model, it should be emphasized that liminality per definition must—contrary to the goal of most other UX work—avoid smooth, routine, or transactional relationships with the user. Designing for liminality is always an effort to encourage focus and renew deep commitment and investment in interesting and meaningful experiences. The latter is done by making a user's participation a clear choice and then manifesting its meaning through an intentional narrative. And we can only know that narrative from the friction we experience—and the hurdles that we chose to clear—because of it. There is no story without conflict.

5. Liminal design in practice: Remote conversations

To illustrate our Liminal Design model and the three related design steps with a concrete example, let us go back to our earlier mention of connecting through video conferencing (VC). We explored an alternative design solution for video conferencing; one that permits the experience of deep presence and connectedness. Figure 3 is a visual representation of a conventional online conversation, and Figure 4 is a visual representation of the conceptual design space that emerged in this process. Below we describe step-by-step how this design space can be created.

Although using ubiquitous applications such as Zoom, Microsoft Teams or Google Meet offers an almost live image of other participants, its increase in use over the last few years has highlighted many of its shortcomings in providing real social connection, as well as the well-documented exhaustion often referred to as "Zoom fatigue" (Bailenson, 2021; Aagaard, 2022). Let us look at some of the existing research and explore how liminality might offer new ways to frame up the problem space.

Since the seminal work of Mehrabian (1972) in the late 1960s, we know that a significant part of human communication is carried out through non-verbal cues. In any face-to-face interaction between two people, both participants are continuously exchanging a variety of social signals (i.e., gestures, facial expressions, posture, body orientation, etc.). To achieve successful communication, we must process incoming signals and send back meaningful signals at a suitable pace. Indeed, the lack of nonverbal cues has been proposed by early theories as a causal factor in accounting for the (in general negative) differences between computer-mediated and face-to-face communication (Short et al., 1976; Daft and Lengel, 1984; Kiesler et al., 1984). The lack of visible non-verbal cues in most VC mediation, it has been argued, will not simply have us pause our instinct to try to read others as we have been taught by thousands of years of evolution, but will instead have us continuously *try harder* to read what is not available in the low-fidelity image, causing higher cognitive load and fatigue. The work of Hiroshi Ishii (Isii and Ulemr, 1997), head of the Tangible Media Group at MIT, is also relevant here: suggesting that our highly evolved tactile skills are yet another missing piece in most digitally mediated communication.

However, other models suggest that an *excess* of non-verbal cues could be just as deleterious to an effective mediated communication experience. For example, in examining the potential psychological causes of so-called "Zoom fatigue" Bailenson (Bailenson, 2021) proposed the main causes to be: excess of eye gaze at close distance (to the screen); disproportionate size of head compared to regular field of

FIGURE 3
A conventional online conversation.

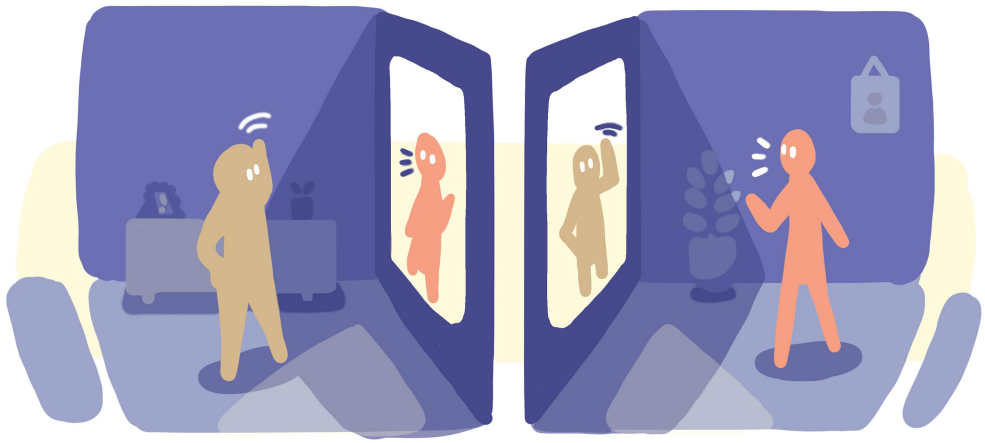


FIGURE 4
Liminal Design in practice. A space for deep presence in online conversations.

view; unnatural body positions, as we need to stay still *in camera* view to be seen; and gestures needing to be exaggerated to be understood and not always being the same as in a face-to-face interaction.

Some research would take all this even further and argue that our most common VC applications, from a social perspective, are likely to do more harm than good. For example, although the lack of direct eye contact has a very clear explanation with the camera placed above our gaze on the screen, our subconscious will still tell us that the person not looking us in our eyes is trying to deceive us (Bekkering and Shim, 2006), eroding both trust and connection.

Whether we get too much or too little information, overwhelming evidence suggests that our most-used VC tools come up short in delivering even the most basic social functions of in-person conversations. That said—and this is key in how we must approach Liminal Design – the corporate context in which most VC calls take place, even in-person conversations are likely to leave us wanting more in terms of deeper discussions, purpose, intimacy, and connection. This is the main reason the United States and other developed countries are experiencing an unprecedented rate of employees leaving their jobs, a phenomenon recently referred to as "The Great Resignation" (U.S. Workers Give Employers High Marks for Supporting Them During the Pandemic-WTW, n.d.). Simply increasing the resolution of VC applications will not solve this.

Therefore, the first task for Liminal Design is to better align a solution with a narrative that participants are willing to invest in. As with any book or film, if the story and the stakes aren't important, we will simply not invest in a narrative enough to make it our own. Without participation in a narrative, abstraction with meaning and liminality will be absent, thus never presenting the user with an opportunity for transformation. There is no Liminal Design without an ambitious narrative. This is where

we must start. Below, we report the three steps to design for liminal experiences (as communicated in Figure 2) that we took in our thought exercise towards a space for deep presence in online conversations (see Figure 4).

5.1. Liminal Design in practice: Step 1—Narrative Desire

Our focus here is not just any solution, but one that achieves liminality. As we think about connecting two people, it therefore seems natural that we skip past transactional or casual chats to instead look closer at conversations that are deep and intimate. Think of two people fully immersed in conversation at a busy restaurant: leaning in over the table, completely focused on each other and allowing space, time and reality around them to fade away. Together they create a singular interconnectedness in a real-time shared space—an experience that psychologists define as "group flow." The social and psychological benefits of such experience have been well researched: empathy, trust, and creativity, to mention a few (Sawyer, 2006; Gaggioli et al., 2011, 2013).

Given this problem space, a good Narrative Desire statement for a creative design brief to work from can be: *a liminal space to inspire, hold and engage two people thousands of miles apart in important conversations leading to interconnectedness as deep as—or deeper than—in-person meetings*. With this articulation of purpose, we would then be able to move to the next two steps of our model: to optimize the design as abstractions (see below step 2) and to create the appropriate suspension of disbelief (see below step 3).

It is important to note here that the articulated Narrative Desire is not for *all conversations*, but for *important conversations*. This clearly delineates our effort from the many times Zoom is used for transactional exchanges where a simple email might suffice, thus not requiring any liminality to work. This is the foundation of Narrative Desire: to clearly align the design with a meaningful narrative target that can only be found on the other side of some level of transcendence. This perspective of a meaning created in a dialectical relationship between the design and Narrative Desire implicitly argues that our issues with Zoom might be addressed, not by changing the product, but instead by changing the narrative that we contextualize and use the product within.

From a corporate perspective, this is a big and important problem to solve in a world adjusting to remote work, increased focus on the environmental cost of business travel and long-term trends continually pushing towards more internationally distributed work groups. The articulation of Narrative Desire is a foundation to guide the design work while simultaneously creating inspiration and motivation for the user to participate in the experience.

5.2. Liminal Design in practice: Step 2—Optimized abstraction

Let us go back and look closer at the scenario we are solving: two people absorbed in a conversation and the deeper presence associated with it. What elements are required, and to what extent can we replicate them in a remote and mediated setting? There is existing research available to inform both—four critical elements often mentioned are:

1. Direct eye-gaze: This we can easily provide with a one-way mirror setup akin to how a teleprompter works.
2. Non-verbal cues: High-resolution camera, screen for audio and video and a low-latency network would likely do a good job of communicating more fidelity than most in-person settings. Ideally, we should be able to read more than just the face and crop the image of both participants just below the hips, including gesturing and resting hands.
3. Natural scale and distance: If we use a large enough screen (55 inches) to render part of a human at natural size, placed at natural conversational distance from the other participant (about 4 feet), this aspect should be covered. It should also be sufficient to handle non-verbal cues per above.
4. Shared sense of space: As we are designing a remote and mediated setting, this requirement is different: we would have to rely on illusion rather than a functional solution. We could again borrow from the established world of theater and cinemas: to hold the experience in darkness on both ends and only portrait-light the participants. This would hide the technological mediation and allow participants to fully focus on each other during the conversation in what appears to be a shared space of darkness.

This prototype suggesting the shape of a cinematic VC booth embodies both *abstraction* and *optimization*. The space provides the necessary ingredients for in-depth conversations as well as an almost complete reduction of all things that might distract from the same. As a separate space—say a black painted booth dedicated to important conversations, nothing else—in an otherwise regular office environment—the abstraction is materialized through its own semiotic distinction coupled with the expectation that deep connection will be provided despite mediation. Through use and participation, we agree to be part of and to help create the illusion.

5.3. Liminal Design in practice: Step 3—Suspension of disbelief

This last part of *agreeing to be part of the illusion* is Suspension of Disbelief. What might we do and design into the experience to encourage it, hold it and hopefully encourage an arc of deepening participation in the narrative? Let us explore this through the lens of our Liminal Design model:

5.3.1. Dedicated space

With the above notion of a black remote conversation booth, the dedicated space is already well articulated. We can add to this by ensuring colors, style and materials are different from the corporate normative pallet. In addition, marketing, instructions, PR as well as icons and UX would stay clear of vernacular used with traditional VC applications ("meeting," "call") and instead emphasize the more intimate universe and Narrative Desire it is setting up: *the corporate meeting is dead, long live important professional conversations*.

5.3.2. Ceremony

Consistent with the idea of reducing noise and stimuli that do not support the focus on the other and immersion in the space, we might ask participants to leave devices such as mobile phones and computers outside. This is likely to feel unnatural to many, but, as discussed above, it is this friction and hurdle that commits us to a different experience.

We are ritualizing part of the optimized abstraction and literally manifesting the shedding of our ordinary universe to step across the threshold to another one.

It might also be that our prototype could be further enhanced to nudge the experience by gradually cropping the image (zooming in)—moving imperceptibly closer—as the conversation progresses, and at the same time having the voices render deeper and the lighting gradually move to a lower color temperature. The aim would be to mimic a real-world conversation of two people moving closer as they get more interconnected. The warmer light would signal intimacy. This, we argue—if done delicately without breaking the trust in the experience—is likely to have participants act accordingly and reinforce the arc of Narrative Desire of a successful and deep conversation.

5.3.3. Narrative room

The suggested product design and the articulation of Narrative Desire envisioned here does not run the risk of being too prescriptive or exclusive. This is proportionally important to the elements of friction we have designed, which require a heightened commitment to an experience that is potentially both highly intimate and intense. For example, if you are shy, you might choose to keep in mind the actual geographic distance to the person you are connecting with in another country—not the distance to the screen you are watching that creates the illusion of someone's nearby presence. You opportunistically navigate and fill out the abstraction of our product's dark environment to support the desired narrative and, if needed, your highly individual needs for participating fully. Similarly, it is worth noting for this example that this sound-proof, dark, optimized, and abstract space has the potential of producing a higher degree of presence and interconnectedness than a real-world environment: a hyper presence of sorts (Edensor, 2015).

Setting aside both technical and form factors, the noteworthy difference between the type of video-conferencing that most of us experience today on our computer-screens with Zoom or Teams etc., contrasted by the above exploration of a separate abstracted space committed to deep remote conversations, is how expectations are consequently set for the users. The low commitment required for a Zoom call will not reward full participation and allow without much cost a low level of ditto, whereas the suggested prototype above will highlight the degree to which we participate non-verbally and thus require significantly more work by both participants. It is therefore likely that the above suggested design will be used primarily when a high level of engagement is desired: for more intimate and deeper discussions and as a result help achieve the same. Liminality, as we have argued here, is in part an attitude.

6. Other application examples

As we quickly touch on each example below, it should be clear that any solution offered is but one example of how we might approach and leverage liminality to target a specific narrative goal. It is not the *only one*, or the *right* one—it is just one theoretical example of the process applied.

6.1. A restaurant

A restaurant is in many respects already a separate and liminal space: clear separation from other services and places, enforced through rules of social conduct and legislation. We must decide what aspect of the restaurant we want to tackle and make our Narrative Desire problem statement, and then explore how we might make that aspect more interesting through liminality. We would of course make very different design choices if we wanted to deepen social interaction, highlight wine selection, enhance the bar's dating scene, or call attention to the ethnicity of the cuisine. Let us pick one of the most basic: elevating the taste experience of food.

One possible approach to deliberately optimize and abstract, would be to strip away one whole category of sensory stimuli, such as sight and host the dining experience in complete darkness. It's a significant and deliberate violation of routines and habits around dining presented as safe for exploration. Liminality is offered. Because the space it is labeled restaurant, albeit slightly different, the Narrative Desire is clear even if implicit. As guests, we are now allowed—perhaps even forced—to focus more attention on the sensory inputs left: in particular, taste. In addition, because we cannot see the food that we eat, there is an additional heightened sense of anticipation and risk that plays up the personal commitment necessary to activate this particular liminality. Based on the 1999 Blindekuh restaurant in Zurich, there are now an estimated dozen "dark dining experiences" around the world, including CamaJe Bistro in New York, the three Opaque restaurants in California as well as Dans le Noir in Paris.[2]

The contrast between dining at a "regular" high end dining restaurant, and experiencing haute cuisine in complete darkness is how the latter directly plays to liminality by destabilizing guests and their expectations, and then using that very same abstraction (darkness) to amplify one singular sensory input: taste. The first might be good, but the latter is likely leaving us transformed with an altered sense of what and how food is able to taste like.

6.2. Amazon shipment

After an order has been placed with e-commerce giant Amazon, any subsequent wait time until delivery might be considered liminal in the negative sense of the word: there is little to be gained from the waiting and nothing to lose should the company be able to be more efficient. This situation lacks all Narrative Desire and stands naked as transactional logistics. But should we look closer at this as a first-principle problem, many of us will remember waiting for a present during childhood as being the *best* and most memorable part of the present.

We could create a Narrative Desire that mirrors that emotion. Likely we would first designate what type of orders we want to apply this to, and what orders we do not really desire but simply deem a necessary evil. For *desired products*, the metaphor of sexual foreplay—another liminal space—might be even more useful: the creation of desire through withholding. We should consider capturing this by revealing gradually more about the product and its attractive qualities and features as the package makes its way closer to delivery (no pun intended). It is not the reveal of new product features that is at the core of creating desire, but the playful hints of what has yet to arrive that rekindle desire

2 Eating in The World's Dark Restaurants Spot Cool Stuff Travel (n.d.), http://travel.spotcoolstuff.com/unusual-restaurants-eating-in-the-dark, accessed 14 June 2022.

when coupled directly to the wait and the tracked delivery process though the logistics system.

The difference between waiting for an Amazon order as it already exists today, and what is suggested above hits to the core of liminality: a move from transaction to experience by placing the experience in between two opposites (see assumption 1 above.) The latter, engaging our imagination intentionally and thus creating a narrative space between what is revealed, and what has yet to be fully delivered.

6.3. Commodity retail

With over 30,000 stores worldwide, we chose the recent commoditization of Starbucks' coffee as the targeted problem. Stores are designed for effective throughput and commerce, not meaningful experiences. We do not necessarily have to reverse the streamlined logistics of making, receiving, and paying for coffee. But we do have to create new expectations and liminality. We could, for example, *slow down time* to create enough sensory violation: semi-transparent windows holding the stores as liminal borders that also play out film scenes at half speed showing people from around the world calmly drinking coffee, watching each other and the world pass by. Perhaps reading. Abstracting the slow imagery as monochrome would further its role as ambience, not content there to distract or, like all else in the stores with bright and colorful screens, pander for attention. The difference between our approach and previous similar ones, for example, Slow Technology (Hallnäs and Redström, 2001) is our clear target in a specific Narrative Desire on the other side of liminality and not just the holding of attention.

Secondly, with the core product of coffee itself we could play up the substance's history and qualities as a drug. The smell and darkness, its exotic origins, and the paraphernalia for making it are all easy to re-contextualize with branding, naming, packaging, and rituals borrowed from other illegal substances, especially those with long and colorful histories such as opium dens and ceremonies around ayahuasca. The targeted effect would be a heighten value by infusing the main product with mythological meaning and the drinking with a stronger sense of a desired narrative liminality: a treat for oneself, to break away from the noise and speed of the modern world; a small potential transformation through relaxed introspection and a quick phygital flirt with brewed darkness.

The Starbucks example above and its contrast to the familiar stores already in existence, once again highlights a central theme of Liminal Design: how we aim to change the *transactional* to become *experiential*, and with that invite imaginative participation that presents new ways for us to see and be ourselves.

6.4. Metaverse

Considering the vast and profoundly undefined nature of commercial metaverses as application, it is potentially most interesting to explore how liminality can work in a space that is already so artificial and, arguably, liminal. That said, metaverses are not inherently transformational. We can play an immersive video game and be acutely present in that specific universe without feeling the need to change anything about ourselves.

The Liminal Design model can apply the same way as in our other examples, but with one expectation: the suspension of disbelief must consider what universe we are leaving behind—not just the one we left to enter the metaverse, but also the metaverse we come from at time of entry. Like a film's or book's story within a story, the separate liminal space inside the metaverse has all the powers to make us be fully present in a new narrative but also requires us to look at the specific border we are asking someone to traverse, not just a border in general. Our suggestions here echo J. G. Ballard's 1962 manifesto "Which Way to Inner Space?," advocating a shift from outer to inner space.

The transformational opportunities inside a metaverse, although unlikely to be a priority for commercial interests, are significant (Gaggioli, 2016; Glowacki et al., 2022).VR and AR are already used for mental health interventions and have shown consistent results in clinical trials (Riva et al., 2016). It is unlikely, however, that deep interconnectedness between humans will be lastingly generated simply by meeting as avatars compared to the more involved example of remote presence given above. However, if a liminal place inside the metaverse offered a safe place to discuss and explore, for example, addiction, loss, or depression—that liminal space would offer a similar liminality as a support group for care workers or Alcoholics Anonymous meetings.

This, however, still does not take full advantage of the metaverses unique digital potential: what we know of participants and their actions, the liminal space's ability to morph and to optimize the virtual world and alter interactions based on the global design target coupled with a fluid, local in-the-moment user-level story, and overarching narrative and real-time feedback. A perhaps radical, but technically possible and narratively interesting part of our Meta Liminality could explore the fluidity applied to the concept of other "actors" in the space. For example, we might mix and only partially disclose which participants are regular users and which are trained actors, experts, or digital agents. This creates another level of liminality that both breaks and holds what theater-arts refer to as the "fourth wall." This type of meta-theater inside a given narrative would be conducive to highly transformative experiences—the focus of this paper—because our sense of self is challenged on several levels at the same time.

In addition, the digital realism possible in a VR metaverse does offer other unique possibilities for generating empathy (Herrera et al., 2018). There is a key distinction between two types of *cognitive empathy*—the difference between "imagine-self" and "imagine-other" perspective taking. The latter, requiring more active participation, is akin to Marshall McLuhan's "cold media"" (McLuhan, 1964). We argue that cold media is likely to create deeper empathy here, for example by putting the user in "someone else's shoes." A graphic example to showcase the potency of this in the metaverse would be to see the cows' perspective through a raw, loud and intense "first person view" of what the final 10 min is like at a slaughterhouse. What this idea lacks in commercial prospect, it likely makes up for in its power to create very real empathy.

The core difference with a Liminal Design approach, to what has been developed so far by the major suppliers of metaverses, is how a liminal focus attempts to use the digitally constructed space to turn our gaze inwards for self-reflection and possibly transformation, not simply present of a new external space. Or, more simply put and circling back to J.G. Ballard: highlighting the difference between outer and inner space in setting goals for the experience we are designing.

7. Conclusion

Liminal Design can provide an approach to work with design spaces that are characterized by inherent ambiguous and transformative

qualities. Traditional structured approaches to experience (UX) design reduce the complexity of human experience by narrowing it down to transactions: qualities that can be managed in scalable, and predictable design processes, such as aesthetic pleasure, marketability, ease of use, or momentary desirability. Liminal Design chooses another approach: in a structured way, it explores the phenomenology of experiential design while embracing the impalpable, incorporeal, and transformative nature of deep real-life human experiences. There is a need for these kinds of approaches to support the practice of design for experiences that extend beyond those dictated by efficiency and simple pleasure. The Liminal Design model is a first attempt to address transformative experiences; it will require further work to mature. Nonetheless, its essence, the design framework of undefined and contradictory in-between states that allow and stimulate us to consider new ways of being, addresses an urgent deficiency in the current landscape of commercial design.

The concepts used in this paper can make it sound like we are designing a new religion or a vending machine for Stendhal syndrome. But the design task in Liminal Design inevitably includes a level of transcendence. Big or small, the very same principles and dynamics hold true. The technology and the product we design might be very commercial, but our ultimate design task is always far from it and striving for the sublime.

This is also why Liminal Design is likely to be a struggle for many of the big tech companies favoring the lowest common denominator to brand access and technology platforms before suggesting any deeper experience that might be emotionally complex and highly personal. The fundamental requirement that any Narrative Desire must promise something truly meaningful to work further complicates simple engagement with most corporations.

Had we asked someone 20 years ago what they hoped computers and the Internet would bring humanity by the time of this article, a survey of today's technological landscape would be sure to disappoint. Re-approaching technology through the lens of Liminal Design pries open more doors for development and innovation and fundamentally challenges today's transactional and commercial nature through the different goals it sets and the questions it asks.

We trust that the beautiful complexity that comes with Liminal Design delivers not only experiences that we have lost, but also aspirations for what we have never seen. Like all changes in behavior, it is not about bending small parts of a narrative, but rather providing new ones that speak of hope more directly to our imagination. There is no one single way to apply Liminal Design. And in its wider acceptance as part of product development, we hope that the multitude of solutions it offers will also lead to the unlimited inclusiveness of just as many profound experiences.

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.

Author contributions

JL and AG conceived the rational and wrote the first draft. PD revised the manuscript and provided relevant suggestions and improvements. 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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Stephen Schueller,
University of California,
Irvine, United States

REVIEWED BY
Hongming Cheng,
University of Saskatchewan,
Canada
Annamaria Campanini,
IASSW, Italy

*CORRESPONDENCE
Beihai Tian
✉ tianbeihai@mail.hzau.edu.cn

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How does social media use impact subjective well-being? Examining the suppressing role of Internet addiction and the moderating effect of digital skills

Bin Wu[1], Tianyuan Liu[2] and Beihai Tian[1]*

[1]Rural Construction & Management Research Center, Huazhong Agricultural University, Wuhan, China, [2]School of Sociology, Wuhan University, Wuhan, China

Introduction: Previous studies have explored the impact of social media use on people's subjective well-being, but there is a lack of discussion on the relationship between social media use, Internet addiction, and subjective well-being, and the research on the influence of digital skills on this relationship is not sufficient. This paper aims to fill these gaps. Based on the flow theory, this paper takes Chinese residents as the research object and uses CGSS 2017 data to analyze the impact of social media use on people's subjective well-being.

Methods: Our study used multiple linear regression models for analysis. To test the hypotheses and the moderated mediation model, we adopted PROCESS models with 5000 bias-corrected bootstrap samples and 95% confidence intervals. All analyses were conducted using SPSS 25.0.

Results: The empirical analysis shows that social media use has a positive direct effect on subjective well-being, and Internet addiction plays a suppressing role in the relationship between social media use and subjective well-being. In addition, we found that digital skills moderated the positive effect of social media use on Internet addiction and the indirect effect of social media use on subjective well-being through Internet addiction.

Discussion: The conclusion of this paper supports our previous hypothesis. Besides, the theoretical contribution, practical significance, and limitations of this study are discussed based on the results of previous studies.

KEYWORDS

social media use, Internet addiction, subjective well-being, digital skills, flow theory

Introduction

With the changes of modern society, the Internet has penetrated into our daily life (Negroponte, 1995). In recent years, with the rise of social media applications and their growing number of users (Guo and Chen, 2022), more and more people are using social media as an important means of communication and entertainment. Social media are web-based channels through which people can present themselves and engage in continuous, unfettered interactions with familiar and unfamiliar people (Carr and Hayes, 2015). Users can also obtain the information they are interested in, browse short videos and shop online through social media, which brings satisfaction and convenience to them.

Based on these facts, the use of social media is generally believed to increase an individual's subjective well-being (SWB). SWB is a state of overall satisfaction and happiness with life (Diener et al., 1997). It is also a self-judgment of life circumstances (Lifshitz et al., 2018). Numerous studies have shown that the use of social media has both direct and indirect positive effects on improving SWB. For example, research has found that entertainment-motivated social media use (SMU) can

enhance self-disclosure (Kim et al., 2014). Image-based platforms such as Instagram and Snapchat provide a sense of intimacy and reduce users' loneliness (Pittman and Reich, 2016), and reading or writing through social media can boost SWB (Yang, 2020). In addition, social media is also considered to satisfy people's basic need to connect with others (Baumeister and Leary, 1995), thus promoting people's social inclusion (Wei and Gao, 2017), which in turn enhances SWB (Pang, 2018).

However, some studies have reached the opposite conclusion, implying that SMU may have a negative impact on SWB (Shakya and Christakis, 2017). These studies suggest that SMU may exacerbate people's social comparisons (Liu et al., 2019; Ozimek and Bierhoff, 2020), and problematic SMU may lead to boredom (Bai et al., 2021). Moreover, some scholars have pointed out that passive SMU weakens self-concept clarity (Lin et al., 2021), which further reduces SWB.

On either side of the divide, few studies have addressed the potential risk of Internet addiction associated with SMU. In particular, research on Internet addiction in China focuses on adolescents, students, and online games (Wang et al., 2013; Jiang, 2014; Wu et al., 2016). In practice, the newly revised *Law of the People's Republic of China on the Protection of Minors* has added regulations to prevent minors from indulging in online games, and relevant game platforms have further upgraded their protection measures for minors to limit play and re-charging amounts. Face recognition and verification will be needed when minors log in to games and make payments (CNNIC, 2021). But there is less discussion on the relationship between SMU and Internet addiction in the general population (Li et al., 2021). In our opinion, all of these different effects should be included in the analysis. On the one hand, when people use social media, they can share their lives through writing, posting photos and short videos, and they can also interact with others through likes, comments, and private messages. These activities may bring positive feedback to users, making them feel happy and relaxed. On the other hand, people may also indulge in this way of obtaining happiness, resulting in Internet addiction and further adversely affecting their normal life and health. Further, how to preserve the positive impact of SMU on SWB as much as possible and reduce the risk of Internet addiction is less discussed.

In fact, China has experienced the rapid development of the Internet in the past few decades. According to the data of CNNIC (2021), as of June 2021, the number of netizens in China is 1.011 billion. Among netizens, 99.6% use mobile phones to access the Internet, and the Internet penetration in urban and rural areas reached 78.3% and 59.2%, respectively. The male-to-female ratio of netizens is 51.2:48.8, which is basically consistent with the male-to-female ratio of the overall population. In respect of age distribution, the percentage of netizens aged 30.39% was 20.3%, which was the highest among all age groups. The percentage of netizens aged 40–49 and 20–29 was 18.7% and 17.4% respectively, it ranks second and third in all age groups. In addition, under the joint efforts of the government, enterprises and society, the proportion of middle-aged and elderly netizens has increased significantly. By June 2021, netizens aged 50 or above accounted for 28.0%, an increase of 5.2% over June 2020. Moreover, in terms of different uses of the Internet, social media accounts for first place among Chinese netizens. With the rapid development of WeChat, QQ, and TikTok, social media has formed a huge user group among Chinese netizens. To be specific, the number of users of instant messaging social media reached 983 million, and the number of users of online video social media reached 944 million. The utilization rates of the two types of social media reached 97.3% and 93.4%. China's large number of netizens and social media users provide sufficient conditions for our research. With social media nearly ubiquitous in China and happiness being the life goal of many people around the world (Tay et al., 2015), it is necessary to clarify how SMU affects people's SWB directly, and whether SMU increases the risk of Internet addiction and reduces SWB.

This study is based on flow theory to explain the relationship between SMU and SWB in the context of Chinese society. Flow theory holds that when people devote their energy or "body and mind" to a certain activity, they may enter a state of flow, which in turn produces a high sense of excitement and fulfillment (Csikszentmihalyi, 2008). People may enter a state of flow when they are concentrating on using social media, which brings them a sense of pleasure and thus may boost their SWB. However, they may further maintain this state by increasing the frequency and duration of SMU, which exacerbates the risk of addiction (Csikszentmihalyi, 2008). Internet Addiction negatively affects their normal life and work, thereby lowering their SWB. Based on flow theory, we suggest that Internet addiction acts as a suppressor between SMU and SWB. Furthermore, digital skills may have moderated this relationship. According to the flow theory model, people need a balance between skill level and task difficulty to enter a flow state, and when people's skill level exceeds the challenge they are dealing with, people will gradually feel bored and get out of this state (Csikszentmihalyi, 2000). Therefore, high skill levels may attenuate the relationship between SMU and Internet addiction, as well as the mediating effect of Internet addiction on SMU and SWB.

In summary, this study has two contributions to the SMU and SWB literature. First of all, there is little discussion on the relationship between SMU, Internet addiction, and SWB in existing research. To fill this gap, we apply the flow theory to demonstrate why SMU promotes SWB and how Internet addiction plays a suppressing role between SMU and SWB. Secondly, by testing the moderating mechanism of digital skills, the boundary conditions of SMU on Internet addiction and the mediating effect of Internet addiction on SMU and SWB were revealed. The conceptual model is shown in Figure 1.

Literature review

Direct effect of social media use on subjective well-being

SWB is people's evaluation of life on the whole, which includes constructs such as happiness, life satisfaction, and morale (Kozma and Stones, 1980). Diener (1984) divided SWB into two types: cognitive SWB and affective SWB. The cognitive SWB includes life satisfaction, and the affective SWB includes the evaluation of emotional states such

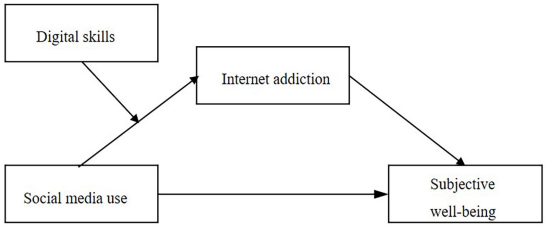

FIGURE 1
The conceptual mode of this research.

as happiness. People are considered to be at higher SWB levels when they have higher life satisfaction, more positive emotions, and less negative emotions (Diener et al., 1997). However, in the Chinese language culture, SWB is a general concept. People usually regard SWB as the overall feeling of happiness, which essentially includes satisfaction with life. In this study, we mainly focus on affective SWB, specifically, people's overall evaluation of happiness.

Social media is a set of Web applications based on the ideas and technologies of Web 2.0. They allow people to create, share, and exchange content through their platforms (Kaplan and Haenlein, 2010). In the Chinese context, multiple types of social media serve different needs. For example, people can communicate with others through WeChat, share their lives on Weibo and WeChat Moments, acquire knowledge from Zhihu, relax by watching short videos through Tik Tok, and even go shopping by watching live broadcasts.

Flow theory suggests that when people focus on completing an activity or challenge to achieve some goals, they may enter a state of flow (Csikszentmihalyi, 2008), which makes them feel fulfilled, cognitively efficient, motivated, and happy (Moneta and Csikszentmihalyi, 1996). In other words, flow enhances people's SWB. Three conditions must be met to enter a flow experience: (a) perceived challenge with a clear goal; (b) a balance between challenge difficulty and skill level; and (c) immediate feedback on progress (Csikszentmihalyi, 2000). The moderately challenging, enjoyable, and controllable nature of social media and its ability to provide immediate feedback to users make it possible to create an immersive experience for users, thus, social media has become an important source of flow experiences (Pelet et al., 2017) and beneficial to people's SWB.

Along this line, when people use social media more frequently, they devote more of their attention to social media. While achieving their goals (such as chatting with friends on WeChat, and sharing their travel photos on Weibo), they may also receive positive feedback from their interactions with others. Through this flow experience, people gain relaxation and positive emotions, which directly improves their SWB (Kim et al., 2017). Therefore, we can make the following hypothesis:

> *H1*: Social media use has a direct positive effect on subjective well-being.

Suppressing effect of Internet addiction

Internet addiction is a broad term, and most scholars define it from the symptoms of addiction. Young (1998) believes that Internet addiction can be identified when an individual has 5 or more of the 8 symptoms. The 8 symptoms include: (1) addicted to the Internet; (2) need to spend more time online for gratification; (3) failed to quit Internet use; (4) reduced Internet use leads to negative emotions; (5) time spent online often exceeding expectations; (6) disrupting normal life due to the Internet; (7) concealing from others that one is overusing the Internet; (8) using the Internet as a way to escape problems and negative emotions. In general, when an individual is addicted to the Internet, surfing the internet will become his dominant activity, regulating his mood and further making him spend more time on the internet. This will bring him into conflict with the people around him, which will affect his work and life. In such a situation, preventing him from surfing the Internet will cause him to have negative emotions and adverse physical reactions, and it is easy to relapse even if the addiction is under control (Griffiths, 2000).

Flow theory states that when people are in a state of flow, they become so immersed in a stimulus that they lose the sense of time passing without noticing the potential harm. And they will repeatedly engage in activities that generate the flow experience to enjoy this happy state once again (Csikszentmihalyi, 2008), which greatly increases the likelihood of addiction.

When people use social media, the flow experience they get will increase their loyalty to these platforms (Zhou et al., 2010) and the frequency of SMU (Pelet et al., 2017), which boosts the risk of Internet addiction (Leung, 2014). Empirical research evidence suggests that internet addiction is detrimental to people's mental health and that excessive internet use reduces people's subjective well-being (Büchi et al., 2019; Guo et al., 2020; Balcerowska et al., 2022). In a word, the use of social media may increase the risk of Internet addiction, and thus reduce people's SWB. The reasoning above suggests that SMU benefits people's SWB, so Internet addiction may suppress the positive effects of SMU. This leads us to hypothesis 2:

> *H2*: Internet addiction suppresses the positive relationship between social media use and subjective well-being.

Moderating effect of digital skills

Digital skills are one of the prerequisites for using social media. van Laar et al. (2017) and other scholars believe that the core digital skills in the 21st century should include a total of seven aspects: technical, information management, communication, collaboration, creativity, critical thinking, and problem solving. It can be considered that digital skills not only include basic skills such as installation, opening, and browsing applications but also include advanced skills such as using digital tools to collect information, identify information, release information, deal with affairs, and communicate with others. Therefore, the level of digital skills will affect the breadth and depth of a user's SMU.

According to the flow theory model, people's flow state is a kind of dynamic balance that requires matching their skill level with the difficulty of the task. When people's skill level exceeds the difficulty of the task, this balance will be upset and people will start to feel bored, while when people's skill level cannot meet the requirements of the task, people will feel anxious (Csikszentmihalyi, 2000).

In this study, the skills people needed to achieve a flow experience were digital skills, and the task was to get pleasure and satisfaction from using social media to achieve goals. According to flow theory (Csikszentmihalyi, 2000), achieving a state of flow through SMU requires a balance between digital skills and the difficulty of the task. As a mass media with a very wide audience, social media has relatively low barriers to use and technical difficulty.

As a result, even low levels of digital skills are compatible with the difficulty of using social media, making it easier to have a flow experience and thus more likely to become addicted to it. However, people with high digital skills, whose skill level is higher than the difficulty of using social media, may feel bored soon after they enter the state of flow and choose to stop using social media or pursue a more difficult way of using it, so they are not easy to indulge in it (Moneta and Csikszentmihalyi, 1996). Thus, we suggest that digital skills may moderate the relationship between SMU and Internet addiction, and people with higher levels of digital skills may have a lower risk of Internet addiction. We propose the following assumptions:

> *H3*: Digital skills moderates the relationship between social media use and Internet addiction. Specifically, this relationship will be weakened when people have higher digital skills.

In addition, based on the above hypothesis, when people's digital skill level is higher, the positive effect of SMU on Internet addiction is weaker, while Internet addiction is negatively correlated with SWB. Accordingly, it can be speculated that when people's digital skill level is higher, the negative indirect effect of SMU on SWB through Internet addiction is weaker. Consequently, we propose the following hypothesis:

> *H4*: Digital skills moderates the indirect effect of social media use on subjective well-being via Internet addiction. Specifically, the indirect effect will be weakened when people have higher digital skills.

Materials and methods

Sampling

The data for this study come from the Chinese General Social Survey 2017 (CGSS 2017). CGSS was founded and conducted by RUC (Renmin University of China), one of China's top universities, and funded by the "985" Foundation and the Scientific Research Foundation and implemented by the China Survey and Data Center of RUC. Since 2003, it has conducted a continuous cross-sectional survey of more than 10,000 households in all provinces and autonomous regions of the Chinese mainland once a year. CGSS systematically and comprehensively collects data at multiple levels of society, community, family and individual, summarizes the trend of social change, discusses issues of great scientific and practical significance, provides data for international comparative research, and acts as a multidisciplinary economic and social data collection platform. At present, CGSS has become the most important data source for the study of Chinese society, which is widely used in scientific research, teaching, and government decision-making. It is the earliest national, comprehensive, and continuous academic survey project in China.

In terms of sampling design, CGSS adopts multi-stage stratified PPS random sampling, which is divided into three sampling stages. In the first stage, the sampling unit is county, and a total of 100 counties are selected; in the second stage, the sampling unit is community, 4 communities are selected in each county; in the third stage, the sampling unit is household, 25 households are selected in each community. The questionnaire was collected by face-to-face interview. The interviewees will receive a letter of introduction and a small gift when the investigator enters their homes, and will participate in the survey on a voluntary basis. CGSS strictly adheres to the ethics of scientific research and Chinese laws and keeps all personal information provided by the interviewees confidential.

As for research topics, CGSS 2017 is divided into three modules: core module, social network and Internet society module, and family questionnaire module. The core module collected demographic information, socio-economic information, such as education level, family income, occupation information, and social attitude. The social network and Internet society module collected information about respondents' social networks, social interactions, social participation, and Internet use. The family questionnaire module collected information about the respondents' family structure information, old-age support, the family values and so on. It is particularly worth mentioning that CGSS 2017 data contains questions about respondents' use of the Internet, which is a rare and nationally representative data on individual Internet use in China. The data of this study contains 783 variables. After data cleaning and variable screening, a total of 2,137 samples were finally included in this study.

Measurement

The complete measurement items and reliability and validity test results of the main research variables are shown in Table 1.

Subjective well-being

As described above, this study focuses on affective subjective well-being (SWB), which mainly refers to the level of happiness in the current life. To measure SWB, previous researchers have developed many scales, such as Satisfaction with Life Scale (SWLS; Diener et al., 1985) and Scale of Positive and Negative Experience (SPANE; Diener et al., 2010). Some scholars also use a single item to measure SWB, such as by asking respondents to rate their overall happiness (0 = completely unhappy, 10 = completely happy) to measure their SWB (Arampatzi et al., 2018). CGSS referenced this measurement and redesigned the options to a 5-scale scale. Specifically, the SWB was measured in CGSS by answers to the question "In general, how happy would you say your current life is?" (Liu et al., 2020; Ding et al., 2021). There were 5 options for this question, and they were assigned a value from 1 to 5, namely "very unhappy," "unhappy," "neither happy nor unhappy," "happy" and "very happy." These scores were used to measure respondents' subjective well-being (M = 3.910, SD = 0.802).

Social media use

Respondents were asked how often they had engaged in a range of online activities in the past year, including communication, self-presentation, online rights protection, entertainment, gaining information, and online transactions. Each item has 5 options, and the values are 1 to 5 (1 = "never"; 5 = "always"). These scores were added and averaged, which were used to measure the social media use (SMU; M = 3.021, SD = 0.782).

Internet addiction

Respondents were given a list of 11 statements to rate their level of agreement on a 1–5 scale (1 = "strongly disagree" to 5 = "strongly agree") in CGSS 2017. These statements are based on the Chinese Internet Addiction Scale (Chen et al., 2003) and include some symptoms of Internet addiction and its negative effects, such as "I spend more time online than before" and "Because of the internet, my eyesight has deteriorated." The scale contains three dimensions, namely "Symptoms of addiction," "Interpersonal and daily life problems" and "Health problems." The scores were averaged to form a measure of Internet addiction (M = 2.668, SD = 0.749). The reliability for the scale as indicated by Cronbach's a was remarkably high at 0.872.

Digital skills

Some scholars believe that digital skills include six core dimensions, namely technical, information management, communication, collaboration, creativity, and critical thinking (van Laar et al., 2017). CGSS partly refers to the division of this dimension and designs the Digital Skills Scale according to the Chinese context. The scale consists of six items such as "I can use the computer to open the website" and "When I want to express myself online, I know how to do it." The items cover basic digital skills, information

TABLE 1 Reliability and validity test of the scale and confirmatory factor analysis properties.

Construct	Factor loadings	CR	AVE
Digital skills			
I can use the computer to open the website	0.777***	0.901	0.606
I can download and install apps using my smartphone	0.839***		
It is not hard to find the information you want on the Internet	0.868***		
When I see important news forwarded by people around me on the Internet (such as WeChat and Weibo), I will verify it before I believe it	0.646***		
When I want to express myself online, I know how to do it	0.799***		
When making payments or transactions online, I will observe the usage environment to determine whether to use	0.719***		
Internet addiction			
Symptoms of addiction			
I spend more time online than before	0.689***	0.790	0.487
When I am in a bad mood, I surf the Internet so that I feel better	0.690***		
I often stay online longer than I planned	0.782***		
I get restless if I do not surf the Internet for a while	0.620***		
Interpersonal and daily life problems			
Because of the Internet, my daily life has been affected	0.824***	0.800	0.506
Because of the Internet, my work has been affected	0.786***		
Because of the Internet, I have become more estranged from the people around me	0.619***		
My family complains that I spend too much time online	0.585***		
Health problems			
Because of the internet, I spend less and less time going out	0.710***	0.738	0.485
Because of the internet, my eyesight has deteriorated	0.691***		
Because of the internet, my shoulders and cervical spine hurt	0.687***		

Standardized coefficients reported; ***$p < 0.01$; AVE, Average variance extracted; CR, Composite reliability.

collection, information identification, information creation and self-expression, and information security. Each item has 5 options, and the values are 1 to 5 (1 = "strongly disagree"; 5 = "strongly agree"). The scores were averaged to measure the level of digital skills (M = 3.882, SD = 1.022). Cronbach's alpha for this scale was 0.900.

Control variables

Control variables included 4 sets of variables: demographic information, subjective socioeconomic status, perceived health status, perceived social equality, and perceived social trust. The demographic information included gender (0 = "female"; 1 = "male"), age(year), education level (1 = "elementary"; 2 = "intermediate"; 3 = "advanced"), marriage status (0 = "single/widowed/divorced"; 1 = "married"), hukou (0 = "rural hukou"; 1 = "urban hukou"), and current residence (0 = "rural area"; 1 = "urban area"). Subjective socioeconomic status was measured by asking "Taken together, which level of society are you currently at?." The answers ranged from 1 (the bottom) to 10 (the top). Perceived health status was measured by respondents' self-rated health scores (1 = "unhealthy"; 5 = "very healthy"). Perceived social equality was measured by asking respondents about their overall perceptions of equality and trust in today's society (1 = "totally unequal"; 5 = "completely equal"). Moreover, respondents were asked "In general, most people in this society can be trusted?" to assess their perceived social trust (1 = "strongly disagree"; 5 = "strongly agree").

Data analysis

In our study, SWB, SMU, digital skills, and Internet addiction were considered as continuous variables, so we used multiple linear regression models for analysis. To enhance the robustness of regression results, all control variables are included in the model. To test the hypotheses and the moderated mediation model, we adopted PROCESS models with 5,000 bias-corrected bootstrap samples and 95% confidence intervals. If the effect does not include 0 in the 95% confidence interval, it is statistically significant. All analyses were conducted using SPSS 25.0.

Results

Survey reliability, validity, and common method bias testing

Before testing the research hypotheses, we first tested the reliability and validity of the two scales and the common method bias of this study. For survey reliability, we used composite reliability (CR) to measure the reliability of the two scales in the study. The results in Table 1 showed that the composite reliability of the four factors all exceeded the recommended value of 0.7. Therefore, the reliability of the scale used in this study is high.

Regarding survey validity, we performed confirmatory factor analysis to calculate standardized factor loadings for each item in the two scales. The Bartlett sphericity test statistic values of the two scales were significant at the 0.1% level, and the KMO values were all greater than 0.7, which were suitable for factor analysis. The standardized factor loadings of all items of the two scales ranged from 0.585 to 0.868, which were all greater than the threshold of 0.5 (Hair et al., 2014). In addition, the AVE (average variance extracted) value of the Digital Skills Scale exceeded 0.5, while two of the three AVE values of the Internet Addiction Scale were close to 0.5 and one exceeded 0.5, indicating that this study has relatively good discriminant validity.

To reduce the common method bias, the data collection process of CGSS followed strict procedures, and a large number of reverse scoring items were designed. We also adopted Harman's single-factor analysis using exploratory factor analysis (Podsakoff et al., 2003). The results showed that the single factor explained 22.352% of the variance, which is less than the 40% standard proposed. Therefore, it can be considered that there is no serious problem of common method bias in this study. SPSS 25.0 and Mplus 8.0 were used to calculate all the indicators above.

Descriptive statistics

Table 2 shows the descriptive statistical results and correlations of the core variables of this study, including the means, standard deviations, and correlation coefficients. There were close relationships between the core variables in the study. For example, SWB was positively correlated with SMU ($r = 0.082$, $p < 0.01$) and digital skills ($r = 0.118$, $p < 0.01$), and negatively correlated with Internet addiction ($r = -0.056$, $p < 0.01$). As expected, SMU was significantly associated with Internet addiction ($r = 0.451$, $p < 0.01$). In addition, digital skills was positively correlated with SMU ($r = 0.679$, $p < 0.01$).

Hypothesis testing

Hypothesis 1 of this study posits that SMU directly improves SWB. The regression results in Table 3 showed that SMU has a positive impact on SWB (ß = 0.055, $p < 0.05$; Model 3), supporting Hypothesis 1.

TABLE 2 Results of the correlation analysis.

	SWB	SMU	Digital skills	Internet addiction
SWB	1.000			
SMU	0.082***	1.000		
Digital skills	0.118***	0.679***	1.000	
Internet addiction	−0.056***	0.451***	0.378***	1.000
Mean	3.910	3.021	3.882	2.668
SD	0.802	0.782	1.022	0.749

*$p < 0.1$; **$p < 0.05$; ***$p < 0.01$; SWB, Subjective well-being, SMU, Social media use.

Hypothesis 2 assumes that Internet addiction will suppress the positive impact of SMU on SWB. First, the control variables and the independent variables were entered into Model 1. The regression result of Model 1 indicated that SMU had a positive relationship to Internet addiction (ß = 0.363, $p < 0.01$; Model 1). Second, Model 3 included Internet addiction, SMU, and all control variables. Regression results represented that Internet addiction is not conducive to SWB (ß = −0.071, $p < 0.01$; Model 3). In the mediation model, when the coefficients of the direct and indirect effects have opposite signs, it is a suppressing effect (Tzelgov and Henik, 1991). Therefore, we believe that Internet addiction attenuates the positive effect of SMU on SWB as a suppressor. Hypothesis 2 was supported.

For Hypothesis 3, the moderated causal step approach was adopted for testing. Hypothesis 3 assumes that digital skills moderates the relationship between SMU and Internet addiction. As Table 3 showed, the interaction significantly and negatively affected Internet addiction (ß = −0.073, $p < 0.01$; Model2), supporting Hypothesis 3. This indicates that under the condition of a certain level of SMU, people with higher digital skills are less likely to become addicted to the Internet. We then calculated the slope of digital skills at low (Mean − 1SD) and high levels (Mean + 1SD) and plotted the moderation patterns. As shown in Figure 2, when individuals had a low level of digital skills, SMU exerted a stronger positive influence on Internet addiction than the individuals who had a high level of digital skills. Hypothesis 3 was verified again.

In addition, bootstrap sampling was performed 5,000 times to further examine the direct effect, suppressing effect, and moderating effect. If the 95% confidence interval does not contain zero, the effect is significant. The analysis results in Table 4 showed that SMU had a significant direct effect on SWB (ß = 0.055, Boot SE = 0.026, CI = [0.004, 0.105], CI did not contain 0), which again confirmed Hypothesis 1. Besides, the path coefficient of SMU affecting SWB *via* Internet addiction was significantly negative (ß = −0.026, Boot SE = 0.009, CI = [−0.044, −0.008]) and the confidence interval did not include 0, which verified Hypothesis 2 again. At last, the results in Table 5 also showed the indirect effect of SMU on SWB *via* Internet addiction was significant and negative, regardless digital skills was high or low, and the absolute value was the lowest when digital skills was at high level (ß = −0.017, Boot SE = 0.006, CI [−0.031, −0.005]). The index of moderated mediation was also significant (ß = 0.005, Boot SE = 0.002, CI [0.001, 0.010], CI did not contain 0). Hence, these findings provided support for Hypothesis 4.

Discussion

Summary of findings

This study mainly explored the direct effect of SMU on people's SWB, and the specific mechanism. Data analysis of 2,137 Chinese residents shows that SMU has a positive direct effect on SWB, and SMU has a negative indirect effect on SWB through Internet addiction. Furthermore, people with low digital skills are more likely to become Internet addicts through SMU than those with high digital skills. In addition, the level of digital skills also moderated the indirect effect of SMU on SWB through Internet addiction. Our research also has some theoretical and practical implications, which we will discuss in the next section.

TABLE 3 Results of the mediation model and moderation model regression analysis.

	Model 1	Model 2	Model 3
	S	S	SWB
Predictor			
Social media use (IV)	0.363***	0.593***	0.055**
	(0.022)	(0.069)	(0.026)
Suppressor			
Internet addiction(S)			−0.071***
			(0.024)
Moderator			
Digital skills(W)		0.257***	
		(0.048)	
Interaction			
IV*W		−0.073***	
		(0.017)	
Control variables			
Age	−0.008***	−0.007***	0.003*
	(0.001)	(0.001)	(0.002)
Gender	0.012	0.004	−0.042
	(0.029)	(0.029)	(0.032)
Education level	0.034	0.023	0.078**
	(0.028)	(0.029)	(0.031)
Marriage status	−0.108***	−0.127***	0.217***
	(0.037)	(0.037)	(0.041)
Hukou	−0.007	−0.020	0.024
	(0.037)	(0.037)	(0.041)
Current residence	−0.015	−0.019	−0.017
	(0.040)	(0.039)	(0.043)
Subjective socioeconomic status	0.000	−0.002	0.064***
	(0.009)	(0.009)	(0.010)
Perceived health status	−0.055***	−0.059***	0.175***
	(0.016)	(0.016)	(0.018)
Perceived social equality	−0.015	−0.016	0.139***
	(0.015)	(0.015)	(0.016)
Perceived social trust	−0.024	−0.024*	0.096***
	(0.015)	(0.014)	(0.016)
Constant	2.256***	1.493***	1.817***
	(0.128)	(0.199)	(0.151)
N	2,137	2,137	2,137
R^2	0.234	0.245	0.195

*$p < 0.1$; **$p < 0.05$; ***$p < 0.01$; Cell entries are unstandardized coefficient with standard errors in parentheses; SWB, Subjective well-being.

Theoretical implications

The use of social media is becoming more and more common today. Scholars have done a lot of research on the influence of SMU, especially on SWB. However, few studies have considered Internet addiction as a possible mechanism between SMU and SWB. Also, there has been insufficient discussion of the impact of digital skills on this mechanism. The role of digital skills in reducing the likelihood of Internet addiction should be emphasized. To fill these research gaps, we take them as important research questions and conduct empirical analysis in the Chinese context. Therefore, the results of this study have theoretical significance.

First, this study explores the direct effect of SMU on SWB. Although many empirical studies have demonstrated the positive effects of SMU on SWB, some studies have proved that SMU is not conducive to SWB. To examine the role of SMU on SWB, this study introduced Internet addiction as a suppressor into the analysis model and included all control variables. The results showed that SMU had a positive direct effect on SWB, which was in agreement with some researches (Kim et al., 2014; Pittman and Reich, 2016; Yang, 2020). Therefore, the results further confirmed the positive direct impact of SMU on people's SWB.

Secondly, according to the flow theory, the important mechanism of SMU's influence on people's SWB is revealed. Specifically, SMU lowered people's SWB through the suppressing effect of Internet addiction. At the same time, SMU will increase people's risk of Internet addiction, which means that SMU has a positive impact on people, but also increased the potential harm. Therefore, our research also contributes to the study of Internet addiction.

Finally, based on the flow theory model, this study demonstrates the role of digital skills in moderating the relationship between SMU and SWB. Specifically, people with higher levels of digital skills have less difficulty using social media and get bored soon after the flow experience. Therefore, they are not easy to indulge in SMU and give full play to the positive direct effect of SMU on SWB. In contrast, for people with lower levels of digital skills, SMU matches their skill levels and is therefore prone to a sustained flow experience, which increases the risk of Internet addiction and further reduces their SWB. In conclusion, the results confirm the boundary condition of SMU leading to Internet addiction, and further expand the research on SMU.

Practical implications

Given the positive direct effects of SMU on SWB, the suppressing effect of Internet addiction, and the moderating effect of digital skills, this study has some practical implications.

On the one hand, the government and relevant departments should continue to guide the public to use social media moderately, so that social media can play a positive role and improve people's SWB. Relevant companies should make social media more practical, interesting, and easy to use so that more people can benefit from it. For example, develop new functions to attract more user groups, and add children mode and elderly mode to facilitate different groups.

On the other hand, digital skills are essential for the survival of the public today. The government, schools, and enterprises should focus on improving the public's digital skills to reduce the risk of Internet addiction caused by SMU and lower its negative impact on SWB. To be specific, people should be helped to learn basic digital skills, while enhancing their ability to use social media to manage

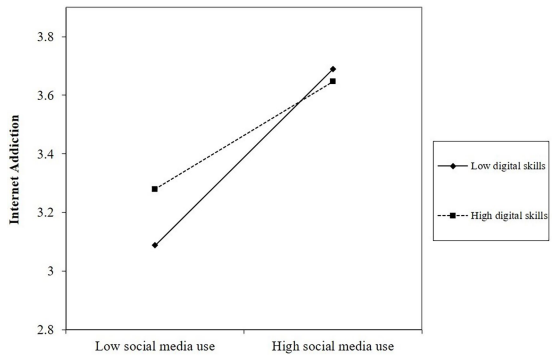

FIGURE 2
The moderation effect of digital skills on the relationship between SMU and Internet addiction.

TABLE 4 Non-standardized mediation analysis results.

Paths	Effect	Boot SE	LLCI	ULCI
Direct effect				
IV → DV	0.055	0.026	0.004	0.105
Indirect effect				
IV → Internet addiction→DV	−0.026	0.009	−0.044	−0.008

IV, Social media use; DV, Subjective well-being; Bootstrap resample = 5,000; Control variables are included in the analysis.

information, create information, express themselves and facilitate their lives, as well as promote information security awareness. In addition, we also need to guide people to use social media moderately to prevent Internet addiction and reduce SWB. Enterprises and departments also need to step up the development of anti-addiction systems to help people avoid excessive use of social media.

Limitations and future directions

Although our research has some theoretical and practical significance, it still has some limitations. First of all, the sample of this study is from CGSS based on the Chinese social context, and people's perception of SWB and specific SMU may be different from other countries. More studies of different countries are needed in the future to facilitate cross-cultural comparisons. Also, we did not segment respondents by age group. Does the relationship between SMU and SWB differ among different age groups? Are the underlying mechanisms consistent? Meanwhile, in the context of the COVID pandemic in recent years, are there any new changes in the role of social media and its impact on people's SWB? These require further exploration.

Secondly, this study integrates multiple social media use activities and examines the impact of SMU on internet addiction and SWB. However, different types of SMU may have different outcomes. In future research, we can classify and compare the risk of internet addiction brought by different types of SMU and their effects on SWB.

TABLE 5 Moderated mediation results.

Paths	Effect	Boot SE	LLCI	ULCI
IV → Internet addiction → DV				
Digital skills = Mean-1SD	−0.027	0.010	−0.047	−0.008
Digital skills = Mean	−0.022	0.008	−0.038	−0.007
Digital skills = Mean + 1SD	−0.017	0.006	−0.031	−0.005
Index of moderated mediation	0.005	0.002	0.001	0.010

IV, Social media use; DV, Subjective well-being; Bootstrap resample = 5,000; Control variables are included in the analysis.

Third, limited by the research design of CGSS, we were able to obtain relevant variables of SMU only in the CGSS 2017 data and not in the data for subsequent years. While CGSS asked respondents about their SMU in the past year, it asked about their current feelings when collecting information about SWB. Therefore, there is a time lag between the two variables, which partly explains why the SMU is the cause and the SWB is the result. Nevertheless, causality in our study still needs to be further validated with longitudinal study data or more rigorous experimental design, which is also an important work to be done in future studies.

Finally, restricted to the questionnaire design, SWB is measured using the respondents' overall assessment of their current life, which may not provide more comprehensive information. Future studies should consider the differences between different SWB dimensions when studying the relationship between SMU and SWB.

Conclusion

Previous studies have not sufficiently discussed the relationship between SMU, Internet addiction and SWB, and the possible influencing mechanism of digital skills in this relationship is still unclear. Based on the Chinese context, this study explores the relationship between SMU, Internet addiction, and SWB. The results of empirical analysis confirmed that SMU had a positive direct effect on SWB, and Internet addiction as a suppressor weakened the positive effect of SMU on SWB. Furthermore, digital skills is an important moderating factor, negatively moderating the indirect effects of SMU and SWB. Also, the findings of our research provide a perspective to understand the benefits of SMU for SWB and the potential risk of Internet addiction, which can help relevant authorities recognize the important role of digital skills and reduce the adverse effects through relevant measures.

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.

Author contributions

BW contributed in writing the original draft, conceptualization, data curation, formal analysis, and methodology. BT contributed in editing and supervision of the paper. TL contributed in data curation,

methodology, 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

Supplementary material

The Supplementary material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fpsyg.2023.1108692/full#supplementary-material

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Stephen Schueller,
University of California,
Irvine,
United States

REVIEWED BY
Elliot Panek,
University of Alabama,
United States
Ikram Hossen,
Jahangirnagar University,
Bangladesh

*CORRESPONDENCE
Jennifer L. Heyman
✉ heymanj@mit.edu

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Did smartphones enhance or diminish well-being during the COVID-19 pandemic?

Jennifer L. Heyman[1]* and Kostadin Kushlev[2]

[1]Department of Psychology, McGill University, Montreal, QC, Canada, [2]Department of Psychology, Georgetown University, Washington, DC, United States

Introduction: As smartphones have become increasingly integrated into people's lives, researchers have attempted to answer whether they are beneficial or detrimental to well-being. Of particular interest to the current study is the role that smartphones played during the first year of the COVID-19 Pandemic.

Methods: In an intensive longitudinal study, we explore how varying uses of smartphones relate to well-being using the Displacement-Interference-Complementarity framework.

Results: Consistent with pre-pandemic research, we show that people felt better, calmer, and more energetic when they used their phones more for complementary purposes (i.e., to access information, entertainment, and connection not otherwise available). In contrast to most pre-pandemic research, however, we find no evidence that any type of phone use predicted lower well-being during the pandemic.

Discussion: Overall, this study lends support to the idea that smartphones can be beneficial for individuals, particularly during times when face-to-face interaction is limited.

KEYWORDS

smartphones, well-being, COVID-19, pandemic (COVID-19), social distancing

Introduction

Smartphones have become an essential part of our everyday lives and can play an important role in our well-being. People report using their smartphones for almost every activity including shopping, banking, entertainment, and relationship maintenance (Brown, 2019). Additionally, people report that their smartphones are an integral part of their lives that they could not live without (Perrin, 2017). This reliance on smartphones has become even more apparent during the COVID-19 Pandemic whereby people were required to social distance from one another. However, little research has examined the relationship between smartphone use, social distancing, and well-being (but see Marinucci et al., 2022). Did smartphone use benefit well-being during times of social distancing, acting as a lifeline to connect people and maintain productivity? Or was smartphone use detrimental to well-being during these times by replacing or interfering with other activities?

The current study aims to examine these questions by focusing on how three different forms of smartphone use (i.e., displacement, interference, and complementarity) relate to several indicators of well-being. Furthermore, the study examines the extent of social distancing as a previously unexplored moderator that can shed light on the relationship between smartphone use and well-being.

Mobile phones and well-being

In recent years, there has been much effort to understand whether and when smartphone use is beneficial or detrimental to our well-being. Much of the previous research has found smartphone use to be related to lower levels of well-being (Khan, 2008; Augner and Hacker, 2012; Hall and Baym, 2012; Gentile et al., 2013; Harwood et al., 2014; Lepp et al., 2015; Roberts and David, 2016). However, the majority of research examining how smartphone use relates to well-being has focused on the amount of time that people spend on their screens: Those who spend more time in front of a screen have been shown to have lower levels of well-being (Przybylski and Weinstein, 2017; Twenge et al., 2018). Importantly, this relationship appears to be nonlinear, with those who spend a moderate amount of time on a mobile device having higher levels of well-being compared to those who spend no time or an excessive amount of time on their devices (Przybylski and Weinstein, 2017; Twenge and Campbell, 2019). Other evidence, however, suggests that the overall effect of screentime on well-being is negligible (Orben and Przybylski, 2019). Thus, recent research has shifted from examining the effects of simple screentime toward examining how the different ways in which people use their smartphones affect well-being.

The Displacement–Interference–Complementarity Framework, for example, posits three distinct mechanisms about how smartphones affect well-being (Kushlev and Leitao, 2020). First, the Displacement Hypothesis posits that phone use will relate to well-being to the extent that it replaces time spent doing other activities. For example, using one's phone to replace face-to-face interactions—an established factor in higher well-being—may relate to lower levels of well-being (McDaniel et al., 2021). Conversely, phone use should relate to higher levels of well-being if it replaces time spent engaging in activities that are detrimental to well-being, such as ruminating on problems (Li et al., 2021). In this case, the displacement caused by the smartphone would allow for less time spent on the detrimental activity, thus improving one's well-being.

The second mechanism, termed the Interference Hypothesis, states that phone use will relate to well-being to the extent that it interferes with concurrent activities. Past research suggests that distraction can be an effective emotion regulation strategy at least in the short term, dampening the impact of both positive (Quoidbach et al., 2010) and negative events (Sheppes and Meiran, 2007). Thus, people distracted by their smartphones during face-to-face interactions, for example, have been shown to experience lower levels of well-being (David et al., 2015; Kushlev et al., 2016; Roberts and David, 2016; Dwyer et al., 2018; Kushlev and Dunn, 2019). However, just as with the displacement hypothesis, it is possible that interference from smartphones will benefit well-being if it interferes with harmful activities. For example, if one is ruminating on a problem outside of their control, an alert or notification from their smartphone may break the cycle, thus allowing them to direct their attention to more beneficial activities.

Finally, the Complementarity Hypothesis posits that phone use will relate to well-being to the extent that it provides information or opportunities not otherwise available. For example, using a phone to stay in touch with others who are not geographically close would relate to higher levels of well-being (Neustaedter and Greenberg, 2012; Hampton et al., 2017; Holtzman et al., 2021). It is also possible, though, that complementary phone use would relate to lower levels of well-being if it allows for greater access to information or engagement in activities that are harmful to well-being, such as access to disturbing news stories or receiving negative feedback on a social media post.

Overall, the Displacement–Interference–Complementarity Framework states that smartphones will affect well-being in different ways depending on how and when they are used. The COVID-19 Pandemic drastically changed the ways in which we use our smartphones. That is, our social environments were suddenly changed at the onset of the Pandemic, thereby reducing the activities that phone use could replace or interfere with and enhancing the importance of phone use to maintain social contact. Therefore, it is important to consider how this global phenomenon has influenced the relationship between smartphone use and well-being.

Mobile phone use during COVID

The onset of the COVID-19 Pandemic drastically altered every aspect of people's lives around the world. In the United States, a total of 42 states issued an official and mandatory stay-at-home order by the end of May 2020 (Moreland et al., 2020), thereby limiting social interactions with others to (a) those with whom one shares a dwelling or (b) those with whom one interacts *via* digital devices. As a result of this, the importance of mobile phones skyrocketed during this time. Indeed, people appear to be spending more time on their phones compared to pre-pandemic times, with one study finding a 10-h increase in weekly recreational screentime from pre-pandemic to pandemic times in children (McArthur et al., 2021). But how does this increased reliance on smartphones during the COVID-19 Pandemic relate to well-being?

In terms of the Displacement Hypothesis, it is possible that the increased screentime during times of social distancing may relate to lower levels of well-being as research has shown that high levels of screentime predict lower well-being and mental health (Przybylski and Weinstein, 2017; Twenge and Campbell, 2019). Indeed, higher levels of screentime have been shown to be related to poorer mental health during the COVID-19 Pandemic (Smith et al., 2020). Furthermore, smartphone use during the COVID-19 Pandemic has been shown to be related to poorer sleep quality and duration (Islam et al., 2021; Koban et al., 2022), which could have negative effects on well-being (Mac Cárthaigh et al., 2020). However, this effect may not be as prominent during the COVID-19 Pandemic, seeing as those who work from home experience greater flexibility in their schedules and are not bound by the typical 8-h workday (Fukumura et al., 2021; Routley, 2021; Koban et al., 2022). It is also possible that smartphone use may increase levels of well-being as people use it as an escape from the stressful life events surrounding the COVID-19 Pandemic (de Freitas et al., 2022; Potas et al., 2022). That is, people may be using their smartphones to replace time spent ruminating on the personal and global issues surrounding the Pandemic, thus mitigating the effects of COVID-19 related rumination.

Similarly, smartphone interference has been shown to be related to lower levels of well-being (David et al., 2015; Kushlev et al., 2016; Roberts and David, 2016; Kushlev and Dunn, 2019). For example, work-related email notifications have been shown to interfere with leisure activities outside of work hours (Derks and Bakker, 2014; Derks et al., 2015), which can reduce levels of well-being and the quality of time spent with family (Belkin et al., 2016). This effect could

be heightened during the COVID-19 Pandemic as the lines between work and leisure have become less distinct (Routley, 2021). However, just as with the Displacement Hypothesis, the increased schedule flexibility, both in work and personal lives, may result in a reduced perception of interference, thus mitigating the negative effects of smartphone interference on well-being.

Finally, in line with the Complementarity Hypothesis, mobile phone use could benefit well-being by giving people the opportunity to interact with others when face-to-face interaction is not available. Indeed, people have been able to receive sufficient social support *via* online interactions during the pandemic, thus increasing levels of well-being (Canale et al., 2020). Furthermore, David and Roberts (2021) found that social distancing was related to lower levels of social connection and well-being, but only for those who had low levels of smartphone use. In contrast, those who used their smartphones more frequently did not experience lower levels of social connection and well-being as a result of social distancing. In other words, smartphone use mitigated the negative effect of social distancing on well-being. Consistent with the Complementarity Hypothesis, then, smartphone use may relate to higher levels of well-being by providing access to social support and communication that would otherwise not be available due to the social distancing measures during the COVID-19 Pandemic. However, it is also possible that the increased access to information related to the COVID-19 Pandemic afforded by smartphones will relate to lower levels of well-being. Indeed, previous research has found that the constant access to news about the COVID-19 Pandemic was related to higher levels of anxiety and psychological distress (Stainback et al., 2020). Therefore, it is possible that using one's smartphone to access information that would otherwise not be available would relate to lower levels of well-being if the information that is being provided is distressing.

The present research

While there is a large amount of interest in examining the role of digital media during the COVID-19 Pandemic, no research has examined the moderating role of social distancing in the relationship between smartphone use and well-being. As such, the current study focuses on two primary research questions:

RQ1: How does mobile phone use relate to well-being during the COVID-19 Pandemic?

RQ2: What is the role of social distancing in the relationship between mobile phone use and well-being?

To gain a cohesive understanding of how smartphone use relates to well-being, we examine smartphone use through the lens of the Displacement-Interference-Complementarity Hypothesis. That is, how does the extent to which phone use (a) displaces time spent doing other activities, (b) interferes with concurrent activities, and (c) complements concurrent activities relate to well-being, and what is the role of social distancing in these relationships? Much of the previous research has found displacement and interference to predict lower levels of well-being during pre-pandemic times (David et al., 2015; Kushlev et al., 2016; Roberts and David, 2016; Przybylski and Weinstein, 2017; Kushlev and Dunn, 2019; Twenge and Campbell, 2019), but will these negative effects still be present during the COVID-19 Pandemic? In contrast, much of the previous research has found phone complementarity to predict higher levels of well-being (Neustaedter and Greenberg, 2012; Hampton et al., 2017; Holtzman et al., 2021). Will this effect remain positive during the COVID-19 Pandemic, given the importance of smartphones to maintain contact with others? Or will it be more negative given the constant access to distressing information that is afforded by smartphones?

To answer these questions, we conducted a longitudinal study examining the relationships between smartphone use, well-being, and social distancing during the COVID-19 Pandemic. Using a community-based sample, we conducted weekly surveys over a six-month period to examine the extent to which smartphone use relates to well-being and the role that social distancing plays in this relationship. This study was pre-registered[1] and all data and exclusions can be found here.[2] Based on our preregistered power analyses, we aimed to recruit at least 200 participants reporting at least 779 episodes overall.

Methods

Procedure

Participants were asked to complete a baseline survey assessing demographics, mobile phone use habits, social distancing measures, and well-being. The baseline survey also included our primary measures of interest in this report, including mobile phone use and social distancing over the previous 24 h. Participants then completed brief surveys every 2 weeks for a total of 11 surveys assessing their well-being, mobile phone use, and social distancing over the previous 24 h. The final survey was administered in October 2020[3].

Participants

A total of 202 people were recruited through Mechanical Turk in May 2020 for this study (112 man/trans-man, 82 woman/trans-woman, 8 other; $M_{age} = 37.37$, $SD_{age} = 11.10$; for detailed description of *a priori* power analysis).[4] In total, 132 participants completed at least two of the brief weekly surveys (70 men/trans-men, 58 women/trans-women, 4 other; $M_{age} = 40.02$, $SD_{age} = 12.64$); 41 participants completed the final, 11th weekly survey (19 men/trans-men, 21 women/trans-women, 1 other; $M_{age} = 40.49$, $SD_{age} = 13.38$); 11 participants completed all 12 surveys (4 men/trans-men, 6 women/trans-women, 1 other; $M_{age} = 49.82$, $SD_{age} = 13.88$). To see a more detailed description of participant demographics for each week, see Tables 1A and 1B.

1 https://doi.org/10.17605/OSF.IO/6TZGF

2 https://doi.org/10.17605/OSF.IO/B6ZDU

3 In our preregistration, we stated that we plan to end the study by July 2020 when we had assumed that things would 'return back to normal' by then. Since the pandemic was far from over in July 2020, we continued data collection until October.

4 https://doi.org/10.17605/OSF.IO/6TZGF

TABLE 1A Demographic data for participants who completed each week of surveys.

Survey number	*N*	M_{age} (SD_{age})	Gender
Baseline	202	37.37 (11.10)	112 man/trans-man, 82 woman/trans-woman, 8 other
Week 2	75	39.51 (11.71)	36 man/trans-man, 35 woman/trans-woman, 4 other
Week 3	59	39.15 (12.99)	24 man/trans-man, 32 woman/trans-woman, 3 other
Week 4	79	39.71 (12.69)	35 man/trans-man, 40 woman/trans-woman, 4 other
Week 5	66	39.71 (12.69)	33 man/trans-man, 31 woman/trans-woman, 2 other
Week 6	59	40.66 (12.67)	29 man/trans-man, 27 woman/trans-woman, 3 other
Week 7	44	41.95 (12.48)	21 man/trans-man, 22 woman/trans-woman, 1 other
Week 8	42	42.05 (12.92)	19 man/trans-man, 22 woman/trans-woman, 1 other
Week 9	34	43.35 (13.14)	15 man/trans-man, 18 woman/trans-woman, 1 other
Week 10	40	41.48 (13.63)	19 man/trans-man, 20 woman/trans-woman, 1 other
Week 11	41	40.73 (13.64)	20 man/trans-man, 20 woman/trans-woman, 1 other
Week 12	41	40.49 (13.38)	19 man/trans-man, 21 woman/trans-woman, 1 other

TABLE 1B Demographic data for participants who completed each number of surveys.

Survey count	*N*	M_{age} (SD_{age})	Gender
1	202	37.37 (11.10)	112 man/trans-man, 82 woman/trans-woman, 8 other
2	132	37.75 (11.70)	70 man/trans-man, 58 woman/trans-woman, 4 other
3	103	38.29 (11.76)	54 man/trans-man, 45 woman/trans-woman, 4 other
4	79	39.77 (12.23)	41 man/trans-man, 34 woman/trans-woman, 4 other
5	59	39.75 (12.63)	27 man/trans-man, 30 woman/trans-woman, 2 other
6	57	41.06 (12.86)	22 man/trans-man, 27 woman/trans-woman, 2 other
7	41	42.68 (13.14)	17 man/trans-man, 23 woman/trans-woman, 1 other
8	35	43.91 (13.40)	13 man/trans-man, 21 woman/trans-woman, 1 other
9	28	46.50 (13.18)	9 man/trans-man, 18 woman/trans-woman, 1 other
10	22	45.59 (14.47)	7 man/trans-man, 14 woman/trans-woman, 1 other
11	19	45.42 (15.21)	6 man/trans-man, 12 woman/trans-woman, 1 other
12	11	49.82 (14.50)	4 man/trans-man, 6 woman/trans-woman, 1 other

Measures

Phone Use

Displacement

Our operationalization was based on the premise that time is a finite resource, so any time people spend on their phones is time they do not spend doing something else. Phone displacement was measured with three items. First, screentime in bed was measured with the item "How much time did you spend on a screen IN BED before falling asleep?" (in Hours: $M = 0.80$, SD = 0.55). Phone overuse was measured with the item "In the past 24 h, I spent more time on my phone than I wanted to" using a 1 (not at all) to 7 (very much) scale ($M = 3.60$, SD = 1.76). Finally, total screentime was measured with the item "In the past 24 h, how much time did you spend in front of a screen across all your devices, NOT including time for work or homework (in hours)?" ($M = 5.66$, SD = 3.13). Although this item does not examine phone use directly, previous research examining the displacement hypothesis has examined overall screentime (Hiltunen et al., 2021). These items were weakly to moderately correlated with one another ($0.32 < rs < 0.57$) and internal consistency was good ($\alpha = 0.69$). Therefore, these items were combined to form a single standardized "displacement" item.

Interference

Phone interference was measured with three items. Exogenous distraction was measured with the item "In the past 24 h, how often did you get distracted by alerts and notifications?" using a 1 (never) to 5 (very often) scale ($M = 2.62$, SD = 1.12). Endogenous distraction was measured with the item "In the past 24 h how often did you get distracted by checking your phone (without being prompted by a notification)?" using the same 1 (never) to 5 (very often) scale ($M = 2.64$, SD = 1.08). Finally, total phone distraction was measured with the item "In the past 24 h, how often did your phone fragment your attention on other tasks and activities?," again using the same 1 (never) to 5 (very often) scale ($M = 2.69$, SD = 1.15). These items were all highly correlated with one another ($0.62 < rs < 0.68$) and showed high internal consistency ($\alpha = 0.84$), so they were combined to form a single standardized "interference" item.

Complementarity

Phone complementarity was assessed with three items. Phone information was measured with the item "In the past 24 h, my phone allowed me to access information when I needed it (e.g., news, weather, direction, reviews, etc.)" using a 1 (not at all) to 5 (very much) scale ($M = 3.63$, SD = 1.03). Phone entertainment was measured with the item "In the past 24 h, my phone provided a source of entertainment (e.g., videos, games, etc.)" using the same 1 (not at all)

to 5 (very much) scale ($M = 3.30$, SD = 1.14). Finally, phone communication was measured with the item "In the past 24 h, my phone allowed me to talk with people I would otherwise be unable to reach (e.g., friends and family who live far away)," again using the same 1 (not at all) to 5 (very much) scale ($M = 3.53$, SD = 1.11). These items were all moderately correlated with one another ($0.41 < rs < 0.50$) and showed high internal consistency ($\alpha = 0.72$), so they were combined to form a single standardized "complementarity" item.

Well-being

Participants completed three items assessing their well-being (Schimmack and Grob, 2000). Specifically, this scale assesses a three-dimensional model of affect. First, participants were asked to indicate how they were feeling over the past 24 h using a-3 (very bad) to 3 (very good) scale ($M = 1.05$, SD = 1.42). This item has been used in previous research to examine current mood (e.g., Killingsworth and Gilbert, 2010). We refer to this item as 'feeling good' and used it as our primary indicator of well-being.

In addition to current mood, as per Schimmack and Grob (2000), we measured two other aspects of affect. Tense arousal was measured by asking participants to indicate how they were feeling over the past 24 h using a −3 (very tense/anxious) to 3 (very relaxed/calm) scale ($M = 0.65$, SD = 1.49). Similarly, energetic arousal was measured by asking participants to indicate how they were feeling using a—3 (very tired) to 3 (full of energy) scale ($M = 0.67$, SD = 1.59). We refer to these items as "feeling calm," and "feeling energetic," respectively.

Social distancing

Participants were asked to indicate the extent to which they practiced social distancing over the past 24 h using a 1 (not at all) to 4 (completely) scale ($M = 3.12$, SD = 0.89).

Data analytic procedure

As per the preregistration, we examined both within-and between-person effects of the extent to which phone displacement, interference, and complementarity relate to well-being. To calculate between-person variables, we first calculated each person's average level of displacement, interference, and complementarity across the six-month study period (their person-mean) before grand-mean centering these scores. The between-person variables thus indicate the extent to which each person's phone displacement, interference, and complementarity compare to the average across the entire sample. Within-person variables were calculated by subtracting each participant's person-mean from their raw level of displacement, interference, and complementarity each week. The within-person variables thus indicate the extent to which each person's phone displacement, interference, and complementarity compare to their unique average across the six-month study period.

To examine how phone use relates to well-being, we used a multilevel model using R's (R Development Core Team, 2015) lme4 package (Bates et al., 2014) using the following equation:

Equation 1a:

$$\begin{aligned}\text{WellBeing}_p = {} & ß_{0p} + ß_{1p}\text{DisplacementWithin}_p \\ & + ß_{2p}\text{DisplacementBetween}_p \\ & + ß_{3p}\text{InterferenceWithin}_p \\ & + ß_{4p}\text{InterferenceBetween}_p \\ & + ß_{5p}\text{ComplementarityWithin}_p \\ & + ß_{6p}\text{ComplementarityBetween}_p \\ & + ß_{7p}\text{Time}_p + e_p \\ ß_{0p} = {} & \gamma_{00} + U_{0p}.\end{aligned}$$

Here, WellBeing_p represents participant p's well-being (as indicated by the extent to which they felt either good, calm, or energetic). $ß_{1p}\text{DisplacementWithin}_p$, $ß_{3p}\text{InterferenceWithin}_p$, and $ß_{5p}\text{ComplementarityWithin}_p$ represent the within-person effects of phone displacement, interference, and complementarity on well-being. That is, does participant p's well-being differ on days when their phone displacement, interference, or complementarity is different than their own average level across the experimental period? Similarly, $ß_{2p}\text{DisplacementBetween}_p$, $ß_{4p}\text{InterferenceBetween}_p$, and $ß_{6p}\text{ComplementarityBetween}_p$ represent the between-person effects of phone displacement, interference, and complementarity on well-being. That is, does participant p's well-being differ for those who have higher levels of phone displacement, interference, or complementarity compared to others in the study? Finally, $ß_{7p}\text{Time}_p$ represents the change in well-being over the course of the experimental period. We allowed intercepts to vary by participant. However, due to convergence issues, we did not allow slopes to vary randomly by participant. To examine the role of social distancing in the relationship between phone use and well-being, we added within-and between-centered social distancing as a moderator of each slope in the models using the following equation:

Equation 1b:

$$\begin{aligned}\text{WellBeing}_p = {} & ß_{0p} + ß_{1p}\text{DisplacementWithin}_p \\ & + ß_{2p}\text{DisplacementBetween}_p \\ & + ß_{3p}\text{InterferenceWithin}_p \\ & + ß_{4p}\text{InterferenceBetween}_p \\ & + ß_{5p}\text{ComplementarityWithin}_p \\ & + ß_{6p}\text{ComplementarityBetween}_p \\ & + ß_{7p}\text{Time}_p + e_p\end{aligned}$$

$$ß_{0p} = \gamma_{00} + U_{0p}$$

$$\beta_{1p} = \gamma_{10} + \gamma_{11}\text{SocialDistanceWithin}_p + U_{1p}$$

$$\beta_{2p} = \gamma_{20} + \gamma_{21}\text{SocialDistanceBetween}_p + U_{2p}$$

$$\beta_{3p} = \gamma_{30} + \gamma_{31}\text{SocialDistanceWithin}_p + U_{3p}$$

$$\beta_{4p} = \gamma_{40} + \gamma_{41}\text{SocialDistanceBetween}_p + U_{4p}$$

$$\beta_{5p} = \gamma_{50} + \gamma_{51}\text{SocialDistanceWithin}_p + U_{5p}$$

$$\beta_{6p} = \gamma_{60} + \gamma_{61}\text{SocialDistanceBetween}_p + U_{6p}$$

Here, social distancing was added as a moderator of the displacement (γ_{11}, γ_{21}), interference (γ_{31}, γ_{41}), and complementarity (γ_{51}, γ_{61}) slopes. Positive interactions would therefore indicate that higher levels of phone displacement, interference, or complementarity was related to higher levels of well-being during times of higher social distancing. Negative interactions would indicate that higher levels of phone displacement, interference, or complementarity was related to higher levels of well-being during times of lower social distancing.

In addition to estimating the associations of each predictor with well-being while controlling for the other two predictors in MLM models, we also estimated the bivariate correlations between each predictor and outcome. The within-subjects correlations are available in Table S1a and the between-subjects correlations are available in Table S1b (see Supplementary Online Materials). Finally, because we had three outcome measures—feeling good, calm, and energetic—we used Bonferroni corrections for all our *p*-values, whereby we multiplied *p* by 3 to reduce the incidence of Type 1 error.

Results

How does mobile phone use relate to well-being during the COVID-19 pandemic?

Does the way in which people use their phones influence how they feel? At the within-person level, we found that phone complementarity was significantly positively associated with feeling good ($b = 0.67$, $z = 5.88$, $p_{bonf} < 0.0001$; Figure 1), feeling calm ($b = 0.38$, $z = 3.85$, $p_{bonf} = 0.0004$; Figure 2), and feeling energetic ($b = 0.44$, $z = 4.79$, $p_{bonf} < 0.0001$; Figure 3), while controlling for displacement and interference (see Table 2). That is, on days when people reported using their phones for more complementary purposes, they reported better mood, feeling calmer, and feeling more energetic. These effects were small-to-medium in size (Table 2). In contrast, indicators of phone displacement and interference were not significantly associated with feeling good (Figure 1), feeling calm (Figure 2), or feeling energetic (Figure 3; Table 2).

We found a similar pattern at the between-person level, such that phone complementarity was significantly positively associated with feeling good ($b = 0.71$, $z = 6.17$, $p_{bonf} < 0.0001$), feeling calm ($b = 0.71$, $z = 5.93$, $p_{bonf} < 0.0001$), and feeling energetic ($b = 0.52$, $z = 3.83$, $p_{bonf} = 0.0005$), while controlling for displacement and interference. In other words, those who reported using their phones for more complementary purposes compared to others in the study reported better mood, feeling calmer, and feeling more energetic. These effects were medium-to-large (Table 3). Similarly, phone displacement was significantly positively associated with feeling energetic at the between-person level ($b = 0.42$, $z = 2.45$, $p_{bonf} = 0.05$), although it was not significantly associated with feeling good ($b = 0.20$, $z = 1.38$, $p_{bonf} = 0.51$) or feeing calm ($b = 0.19$, $z = 1.25$, $p = 0.64$; Table 2). Phone interference was not significantly associated with feeling good ($b = -0.14$, $z = -1.02$, $p_{bonf} = 0.93$), feeling calm ($b = -0.15$, $z = -1.05$, $p_{bonf} = 0.88$), or feeling energetic ($b = -0.08$, $z = -0.49$, $p_{bonf} > 0.99$).

Does social distancing play a role In The relationship between mobile phone Use and well-being?

At the within-person level, all of the associations with phone complementarity and feeling good, calm, and energetic hold after controlling for the extent to which people socially distance (all

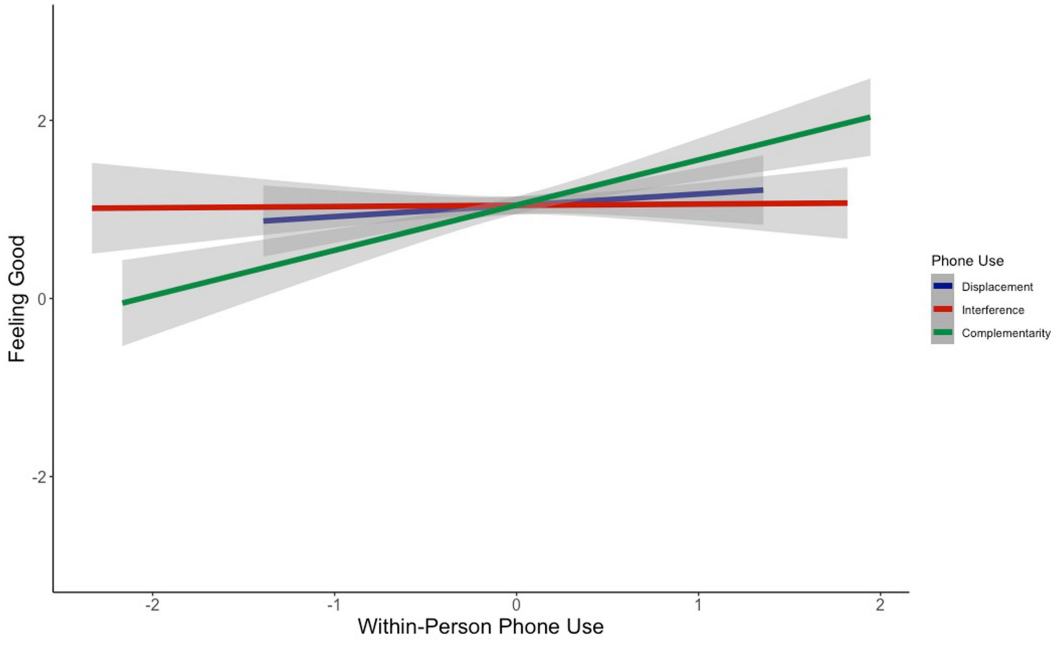

FIGURE 1
Association between within-person phone use and feeling good.

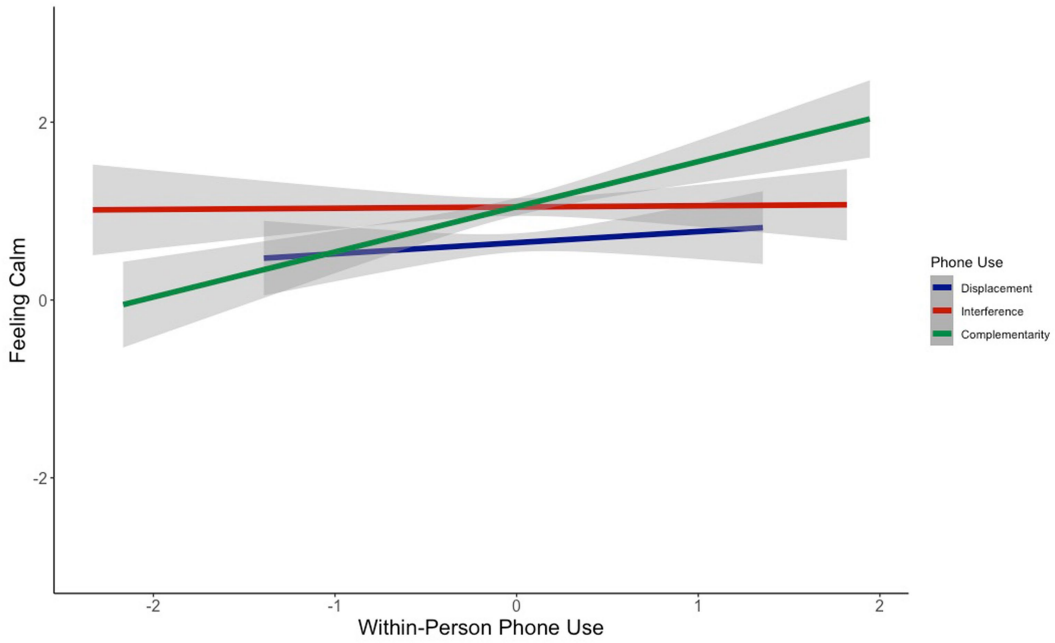

FIGURE 2
Association between within-person phone use and feeling calm.

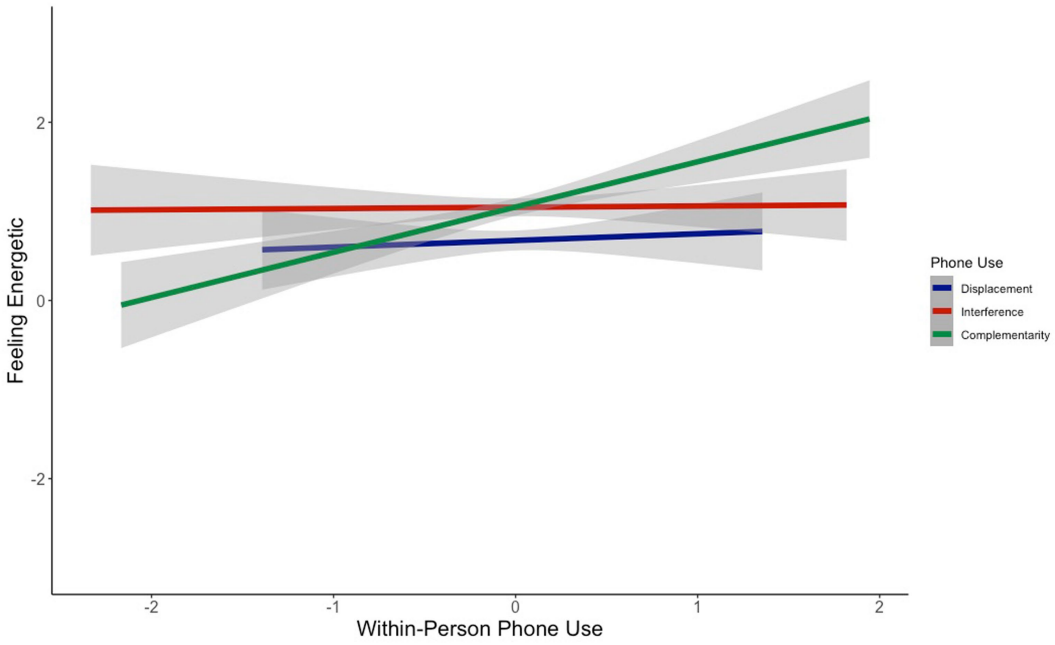

FIGURE 3
Association between within-person phone use and feeling energetic.

$p_{\text{bonfs}} < 0.0005$). But does the relationship between phone use and how people feel differ depending on the extent to which they socially distance? Since the study was conducted in the early stages of the pandemic, the extent to which people varied in their social distancing from week-to-week practices was low (SD = 0.58 on our four-point scale). Accordingly, social distancing generally did not significantly interact with the phone use indicators to predict feeling good, calm, or energetic. However, social distancing did significantly interact with phone displacement to predict feeling calm. Specifically, phone displacement and social distancing significantly positively interacted to predict feeling calm ($b = 0.63$, $z = 3.48$, $p_{\text{bonf}} = 0.002$). In other words, using one's phone to replace other activities was related to feeling calmer, especially on days when people reported social distancing more. However, given the

TABLE 2 Within-person associations between phone use indicators and feeling good, calm, and energetic.

	Feeling good ($n_{episode}$ =782)			Feeling calm ($n_{episode}$ =781)			Feeling energetic ($n_{episode}$ =782)		
	b (*se*)	*z*	*r* [95%CI]	*b* (*se*)	*z*	*r* [95%CI]	*b* (*se*)	*z*	*r* [95%CI]
Displacement	0.13 (0.109)	1.20	0.01 [−0.08, 0.34]	0.14 (0.113)	1.24	0.04 [−0.08, 0.36]	0.04 (0.104)	2.45	0.01 [−0.16, 0.25]
Interference	−0.11 (0.095)	−1.14	0.06 [−0.29, 0.08]	−0.11 (0.100)	−1.17	0.04 [−0.31, 0.08]	0.14 (0.091)	1.59	0.06 [−0.03, 0.32]
Complementarity	0.56*** (0.100)	5.88	0.04 [0.38, 0.75]	0.38** (0.100)	3.85	0.14 [0.19, 0.57]	0.44*** (0.092)	4.79	0.17 [0.26, 0.62]

b = unstandardized regression coefficient; SE = standard error. *r* = Pearson's Correlation Coefficient. 95% confidence intervals for bs are provided. ***$p_{bonf} < 0.001$, **$p_{bonf} < 0.01$.

TABLE 3 Between-person associations between phone use indicators and feeling good, calm, and energetic.

	Feeling good			Feeling calm			Feeling energetic		
	b (se)	*z*	*r* [95%CI]	*b* (se)	*z*	*r* [95%CI]	*b* (se)	*z*	*r* [95%CI]
Displacement	0.20 (0.146)	1.38	0.09 [−0.08, 0.49]	0.19 (0.152)	1.25	0.05 [−0.11, 0.49]	0.42* (0.170)	2.45	0.09 [0.08, 0.75]
Interference	−0.14 (0.141)	−1.02	0.02 [−0.42, 0.13]	−0.15 (0.146)	−1.05	0.04 [−0.44, 0.13]	−0.08 (0.165)	−0.49	0.02 [−0.40, 0.24]
Complementarity	0.71*** (0.115)	6.17	0.02 [0.49, 0.93]	0.71*** (0.120)	5.93	0.21 [0.48, 0.94]	0.52** (0.137)	3.83	0.14 [0.26, 0.79]

b = unstandardized regression coefficient; SE = standard error. *r* = Pearson's correlation coefficient. 95% confidence intervals for bs are provided. ***$p_{bonf} < 0.001$, **$p_{bonf} < 0.01$, *$p_{bonf} < 0.05$.

lack of a main effect, these interactions should be interpreted with caution.

Similarly, at the between-person level, the associations between the phone use indicators and feeling good, calm, and energetic hold after controlling for social distancing (all $p_{bonfs} < 0.05$). The extent to which people varied in their social distancing practices was also low at the between-person level (SD = 0.71). Unsurprisingly, then, phone use indicators did not significantly interact with social distancing to predict feeling good, calm, or energetic.

Discussion

We find that in a time of high social distancing during the COVID-19 pandemic, people reaped the benefits of phone use for well-being without incurring the costs associated with phone use in pre-pandemic research. Specifically, consistent with pre-pandemic research (e.g., Kushlev et al., 2017), we find that people who used their phones in a complementary way—to access information, entertainment, and connection not otherwise available—felt better, calmer, and more energetic. Furthermore, we show that the same individuals felt better, calmer and more energetic on days when they used their phones for complementary purposes. Pre-pandemic research also shows, however, that phone use often undermines well-being, especially when it displaces (Lanaj et al., 2014; Hughes and Burke, 2018) or interferes with other activities (Dwyer et al., 2018; Kushlev and Dunn, 2019). In contrast, we found no evidence that phone interference or displacement predicted lower well-being during the initial stages of the pandemic. Thus, though the pre-pandemic literature has generally linked phone use and screentime with poorer well-being (Twenge and Campbell, 2019), we find that phone use during the pandemic was associated with higher, not lower well-being.

In line with previous research, phone complementarity was related to higher levels of well-being. That is, the greater affordance to information and opportunities provided by a phone was related to people having better moods, feeling calmer, and feeling more energetic. The ease of access to information and opportunities may have become even more important during the COVID-19 Pandemic when face-to-face social contact was severely limited, which significantly increased people's level of stress (Halliburton et al., 2021). Therefore, using one's phone to maintain existing relationships and gain access to information may have facilitated in maintaining some semblance of pre-pandemic life, thus predicting higher well-being.

People typically feel worse when their phone use displaces activities critical for well-being, such as sleep (Lanaj et al., 2014). We find little evidence that phone displacement undermined well-being during the pandemic. This may be because there were fewer positive activities that phone use could displace during the pandemic when social activities and events were discouraged. Presumably, however, people needed just as much sleep during the pandemic as they did pre-pandemic. As lockdowns disrupted routines, sleep–wake cycles were delayed during the pandemic (Sinha et al., 2020). Thus, in the relative lack of routine during the pandemic, phone use may have been less likely to displace sleep. Finally, as the pandemic introduced new stressors, phone displacement might have been beneficial for well-being by displacing more stressful activities (Kushlev and Leitao, 2020) and introducing a welcome source of distraction (Sheppes and Meiran, 2007; Quoidbach et al., 2010).

In contrast to pre-pandemic research, we found no evidence that phone interference predicted lower well-being. Just as with displacement, this lack of effect may be due to the relative lack of rewarding activities associated with social distancing. Indeed, most previous research on the interference effects of phones has shown that phones decrease well-being precisely by interfering with face-to-face social interactions (Dwyer et al., 2018; Kushlev and Dunn, 2019). In addition, during the COVID-19 Pandemic, phones may have also interfered with activities harmful to well-being, such as rumination. Overall, then, though null findings should be interpreted with caution, our evidence suggests that phone use may not have been as harmful during the COVID-19 Pandemic.

Our findings were generally consistent with the Displacement–Interreference–Complementarity Framework: During a time of limited rewarding activities, complementary phone use continued to predict higher well-being, whereas well-documented phone interference and displacement effects were absent. According to the framework, however, at higher levels of social distancing, phone complementarity effects should have been stronger and phone displacement and interference effects should have been weaker. But

we found little evidence that these effects depended on how much people socially distanced. Other research during the pandemic, however, showed that the benefits of online social interactions for well-being were greater when social distancing measures were more extreme (Marinucci et al., 2022). Specifically, online social interactions predicted lower distress only during the severe isolation stage in Italy that included prohibiting people from leaving their homes except for work and urgent health reasons. The social distancing measures that our participants in the United States experienced were much milder in comparison and participants, on average, reported high but not extreme levels of practicing social distancing ($M = 3.12$ on a scale from 1–not at all to 4–completely). Relatedly, people in our sample did not differ much in the extent to which they practiced social distancing, potentially preventing us from detecting moderating effects. Indeed, the extent to which people varied in their social distancing practices was low in this sample at both the within (SD = 0.58) and between (SD = 0.71) person levels.

This study had several important limitations that should be discussed. First, participants self-report on their levels of phone displacement, interference, and complementarity. However, people tend to misestimate the extent to which they use their phones. Future research should use more objective techniques, such as phone tracking, or peer reports in accordance with self-reports to gain a better understanding of how people are using their phones and the extent to which it relates to well-being. In addition, we used *ad hoc* measures of displacement, interference, and complementarity. Though theoretically justified, it is important for future research to develop validated measures of these constructs. For example, we measured phone displacement as the amount of time people spent on their phones in bed, the extent to which they used their phones more than they wanted to, and their total screentime. This crude measure of displacement fails to distinguish between screen time that displaces positive versus negative activities. As such, future research should utilize more precise measures of phone displacement, perhaps by explicitly asking people if they chose to use their phones over partaking in specific other activities. Furthermore, this study was conducted solely in the United States. However, other countries tend to use their phones in different ways (Langer et al., 2017) and have had different responses to the COVID-19 Pandemic (Kennedy et al., 2020). Therefore, future research should collect a more diverse sample to improve the generalizability of these results.

In sum, there is consistent evidence to suggest that using one's phone for complementary purposes is associated with increases in well-being, as indicated by better mood, feeling calmer, and feeling more energetic, whereas spending more time on one's phone and reporting that one's phone interferes with daily life are generally not significantly associated with feeling good, calm, or energetic. Furthermore, we do not find consistent evidence that social distancing influences these associations. This study highlights the idea that phone use can be beneficial to individual's well-being if it is used to complement their existing experiences.

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/b6zdu/?view_only=1c85c73f75fb4ead99bac948c6457982.

Ethics statement

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

Author contributions

KK designed the studies, conceptualized the research question, and collected the data. KK and JH analyzed the data and wrote the manuscript. 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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Supplementary material

The Supplementary material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fpsyg.2023.1094196/full#supplementary-material

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EDITED BY
John F. Hunter,
Chapman University, United States

REVIEWED BY
Carmen Moret-Tatay,
Catholic University of Valencia San Vicente Mártir, Spain
Jinyuan Liu,
Vanderbilt University, United States

*CORRESPONDENCE
Berkley Petersen
✉ berkley.petersen@concordia.ca

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The association between information and communication technologies, loneliness and social connectedness: A scoping review

Berkley Petersen[1]*, Najmeh Khalili-Mahani[2,3], Caitlin Murphy[4], Kim Sawchuk[5], Natalie Phillips[6], Karen Z. H. Li[1] and Shannon Hebblethwaite[7]

[1]Laboratory for Adult Development and Cognitive Aging, Department of Psychology, Concordia University, Montreal, QC, Canada, [2]Media Health Lab, Department of Design and Computation Arts, Milieux Institute for Arts, Culture and Technology, Concordia University, Montreal, QC, Canada, [3]McGill Centre for Integrative Neuroscience, McGill University, Montreal, QC, Canada, [4]Centre for Interdisciplinary Research in Rehabilitation (CRIR), Lethbridge-Layton-Mackay Rehabilitation Centre, Montreal, QC, Canada, [5]Aging and Communication Technologies (ACT), Department of Communication Studies, Concordia University, Montreal, QC, Canada, [6]Laboratory of Cognition, Aging and Psychophysiology (CAP), Department of Psychology, Concordia University, Montreal, QC, Canada, [7]Department of Applied Human Sciences, Concordia University, Montreal, QC, Canada

Older adults are at a higher risk of loneliness, compared to other demographics. The use of Internet Communication and Technologies (ICTs) among older adults is steadily increasing and given ICTs provide a means of enhancing social connectedness suggests they may have positive effects on reducing loneliness. Therefore, the aim of this scoping review was to examine the research that explores how ICTs may be implicated in mitigating loneliness and increasing social connectedness among older adults. After the examination of 54 articles, we identified three major themes within the literature: (1) ICTs were associated with a reduction in loneliness and increase in wellbeing. (2) ICTs promoted social connectedness by facilitating conversations. (3) Factors such as training, self-efficacy, self-esteem, autonomy, and the design/features, or affordances, of ICTs contribute toward the associations between ICT use and wellbeing. The heterogeneity of methodologies, statistical reporting, the small sample sizes of interventional and observational studies, and the diversity of the experimental contexts underline the challenges of quantitative research in this field and highlights the necessity of tailoring ICT interventions to the needs and contexts of the older users.

KEYWORDS

information and communication technologies, older adults, loneliness, social connectedness, wellbeing, scoping review

1. Introduction

1.1. What is known about the impact of loneliness and social isolation on older adults' wellbeing

Later-life events, such as retirement, relocation, and death or illness among friends and family, impact both the quantity and quality of older adults' social interactions, increasing risk of social isolation and loneliness (Ashida and Heaney, 2008). Research highlights that older adults experience a higher risk of loneliness and social isolation, as compared to other demographics (O'Rourke and Sidani, 2017; O'Rourke et al., 2018). Loneliness–the subjective feeling of lacking social resources and connections to turn to for support, companionship, and sense of security–is a consequence of social isolation (Victor et al., 2001, 2002). Evidence exists in the literature, for the serious health consequences of both loneliness (Patterson and Veenstra, 2010; Luo et al., 2012; Chopik, 2016), and social isolation (Holt-Lunstad et al., 2010; Steptoe et al., 2013; Saito et al., 2020). Among those health hazards, are increased depressive symptoms (Chopik, 2016; Santini et al., 2020), accelerated cognitive decline (Donovan et al., 2017; Griffin et al., 2020) and reduced physical activity (Schrempft et al., 2019).

The Canadian Longitudinal Study on Aging (CLSA), which contains data from a sample of Canadians aged 45–85, indicates the prevalence of loneliness (10.2%) and social isolation (5.1%) within this population (Latham-Mintus et al., 2019). Victor's (2012) review of the prevalence of loneliness illustrates that the severity of loneliness (as measured by quantitative scores) in long term care homes is at least twice that of community-dwelling populations: 22–42% for the long-term care home population compared to 10% for the community population (Victor, 2012). A review article of 38 studies suggests that being female, non-married, older, having a poor income, a lower educational level, living alone, a low quality of social relationships, poor self-reported health, and functioning are all associated with loneliness in older adults (Cohen-Mansfield et al., 2015). There is literature that points to the need for nuance in determining how loneliness, social isolation and age are inter-related. Age is not the only cause. Data from the Statistics Canada's General Social Survey demonstrates age is not significantly associated with loneliness when personal and social engagement characteristics are accounted for de Jong Gierveld et al. (2015).

How might we, as a society, mitigate or pre-empt the myriad of problems that are associated with loneliness and social isolation? Research indicates that increasing social engagement may be one way to instigate wellbeing and improve quality of life (Erickson and Johnson, 2011; Myhre et al., 2017). A data-driven meta-analysis by Holt-Lunstad et al. (2010) that examined 148 studies following more than 300,000 individuals over a period of 7.5 years, indicates that an individuals' experience of social support is a significant moderator of mortality rates (increasing odds ratio by 50%), suggesting that social integration is an important predictor of survival in health interventions (Holt-Lunstad et al., 2010). A 2015 survey in the US, which recorded changes in older adults' confidant (close contact) networks over a period of about 5 years, documents that more than 80% of participants surveyed cultivated new confidant relationships and that the growth of these confidant networks can be associated with improvements in their self-reported psychological and functional health (Cornwell and Laumann, 2015). Greater social networks with friends (in terms of size and frequency of contact) protect against depression in older adults (Singh et al., 2016), and are associated with improved wellbeing (Chen and Feeley, 2013). Additionally, individuals with higher quality social relationships defined by high level of social supports and low social strain experienced from a spouse/partner, other family members, children, or friends, seem more motivated to engage in leisure activities and reap more health benefits than those with fewer or less meaningful social relationships (Chang et al., 2014).

1.2. Older adults use of information and communication technologies for increasing social connections

According to Pew Research Center (2017), the use of ICT among those 65 and above has grown considerably in the past decade (Faverio, 2022). Indeed, the COVID-19 pandemic presented us with the reality that ICTs are a necessity rather than a luxury for living in digitally driven, networked societies. More than a decade ago, a meta-analysis of Internet use among older adults reported a positive association with mental health and psychosocial covariates, specifically enhanced interpersonal relationships, greater access to community resources and social inclusion (Erickson and Johnson, 2011). Various other association studies since have indicated that internet use is positively associated with active decision-making with respect to one's health and finances, increased self-confidence, self-efficacy, and quality of life (James et al., 2013; Heo et al., 2015; Cajita et al., 2016; Khalaila and Vitman-Schorr, 2018; Silva et al., 2018). Yet, in terms of the influence of Internet use on loneliness and social isolation, the results are inconsistent.

A scoping review by Fakoya et al. (2020) identified 33 review articles describing loneliness and social isolation interventions for older adults. They reported inconsistency arising from how interventions are categorized and defined. They identified six types of ICT interventions which involved administering use or training users to interact with or learn how to use an ICT device. For example, telephone befriending, pet companions, computer and internet training, and smart technology were different types of ICTs proposed to try and improve communication and social connectedness.

The adoption of ICTs by older adults is not without its challenges. Researchers have demonstrated that a host of socioeconomic, cultural, geographical, and personal factors must be accounted for in studying older adults' relationships with technology (Hong and Cho, 2017; Siren and Knudsen, 2017; Arcury et al., 2020; Yoon et al., 2020). Older adults often are selective in their technology use, however, social relations are important drivers for ICT use in this population (Newman et al., 2021). The use of at least one social media site among older adult Americans 65 years and older has increased from 3% in

2005 to 45% in 2021 (Pew Research Centre, 2021). Access to modern ICTs with improved and simplified user experience is steadily growing. A study of 940 residents living in 20 retirement homes in Switzerland, indicated that 21% of residents have reported using the internet, 13% have used a smartphone, and 5% have used a tablet (Seifert and Cotten, 2020). In a review of 34 studies exploring ICT use among older adults, (Khosravi et al., 2016) found that older adults interacted with at least eight types of ICTs to maintain social connections (email, video games, personal reminder information and social management systems, asynchronous peer support chat rooms, social network sites, Telecare, and 3D virtual environments). However, a similar systematic review noted that only 1 out of 25 ICT interventions effectively reduced social isolation (Ibarra et al., 2020). A qualitative study of Technologies in Later Life (TILL) in 37 rural communities indicates that older adults may welcome the introduction of ICTs to their lives by their children, and deem them useful for creating connections, while at the same time acknowledging that the adoption of ICTS do not fully correspond to their actual needs or interests (Freeman et al., 2020). Issues surrounding older adults' adherence and acceptance of ICTs in randomized controlled trials (RCTs) has been documented by Khalili-Mahani and Sawchuk (2022). Furthermore, there remains inconsistency as to whether ICTs are efficacious in reducing loneliness and increasing social connectedness as measured with RCTs. While older adults remain at a heightened risk of loneliness and social isolation, they also demonstrate increased ICT adoption. Given the importance placed on ICTs for staying socially connected, to what extent are ICTs associated with loneliness and social connectedness in older adults? To answer this question and uncover other factors contributing to these associations we conducted a scoping review of the literature. While more recent research has focused on ICT use and wellbeing during the COVID-19 pandemic (Llorente-Barroso et al., 2021; Veiga-Seijo et al., 2021; Dhakal et al., 2022) this scoping review maps the research evidence on the associations between ICT use and loneliness and social connectedness pre-pandemic. Importantly, this review serves as a point of comparison and emphasizes the importance of in-person social contact when examining these associations, a construct that would have been omitted in the pandemic literature.

2. Methods

A scoping study "aims to map *rapidly* the key concepts underpinning a research area and the main sources and types of evidence available and can be undertaken as stand-alone projects in their own right, especially where an area is complex or has not been reviewed comprehensively before" (Mays et al., 2001) (pp. 194). The framework proposed by Arksey and O'Malley (2005) was selected to identify key trends in the literature regarding whether ICTs are associated with loneliness and/or social connectedness among older adults.

Importantly, in following the guidelines provided by Arksey and O'Malley (2005) we did not "address the issue of 'synthesis,' that is the relative weight of evidence in favor of the effectiveness of any particular intervention" or device (pp. 30). While it is important to study loneliness and social isolation in older adulthood, we chose to narrow our focus to loneliness and social connectedness. Incorporating the relation between social isolation and ICTs would have produced a much larger data set and complicated the synthesizing of our current findings.

2.1. Step 1: Identifying the research questions

The following research questions were developed.

The goal of our scoping review is to examine the following questions:

1. To what extent does the research literature indicate that ICTs are associated with reduced loneliness and increased social connectedness?
2. What types of ICT devices are used in the literature to examine the association among ICTs, loneliness and improved social connectedness?

2.2. Step 2: Identifying relevant studies

This study was conceived in the early days of the social distancing laws coming to effect in Canada (March 2020), to protect against COVID-19 contagion. We aimed to examine the existing empirical evidence to date, to guide upcoming programming and research projects that aimed to mitigate the risks of loneliness and social isolation created by the social distancing laws. In July 2020 we performed a comprehensive literature search using the electronic databases PubMed, SCOPUS, PsycINFO, Cochrane, SPORTDiscus, Academic Search Complete, and SocINDEX. The search focused on three variables: older adults, Information and Communication Technology and loneliness. The search terms were as follows: (older adults OR elderly OR seniors) AND (ICT OR digital media OR digital technology OR digital games) AND (recreation OR leisure OR social inclusion OR loneliness OR Social connectedness). Given the distinct changes in digital socialization and communication habits emerging during the COVID-19 pandemic, we have refrained to include data emerging in the past 2 years in this scoping review. The aim of the current review is thus to serve as a baseline against which emerging evidence can be compared.

2.3. Step 3: Study selection

The database searches yielded 8,294 records (see **Figure 1**). The titles were reviewed by two of the authors (BP, CM) to determine eligibility. In the case of a disagreement, a third author intervened. Titles needed to include any terms relating to older adults, a form of ICT and/or a social outcome measure. Titles were excluded if they focused on any forms of health-related problems as it is beyond the scope of this review, or if the article was part of gray literature. This reduced the number of titles to 236. We then reviewed the bibliographies of these 236 articles and included an additional 147 titles meeting the criteria from these bibliographies (total $N = 383$).

The abstracts were then screened by the same two authors using the following inclusion criteria:

- participant(s) were required to be 60 years of age or older in good general health,
- the study had to include Information and Communication Technologies.
- social outcomes (e.g., social connectedness, loneliness, social support, social engagement, inclusion, and leisure) had to be reported in the results and
- the article had to be written in English.

Exclusion criteria included:

- studies that were based solely on health-based interventions without attention to social engagement.
- studies that did not report original results for the previously mentioned criteria (e.g., Literature Reviews, Editorials and commentaries, Protocols without empirical data).
- Gray literature.

Applying the inclusion and exclusion criteria yielded 83 abstracts. To further determine if the abstracts fully met inclusion/exclusion criteria the full text articles were read with a final 54 meeting the applicable criteria and were included in the scoping review (**Figure 1**).

2.4. Step 4: Charting the data

Articles that met the selection criteria were reviewed to extract the following information into an excel spreadsheet: year of publication, geographic location, research methodology (survey, intervention, meta-analysis, qualitative research, registered clinical trials, cohort studies, and case series), sample size, sample characteristics (age, gender, social, or medical specifics), type of ICT device. See **Table 1** for some characteristics of the studies.

2.5. Step 5: Summarizing and answering research questions

Once the data were charted, we then applied our research questions to the data. Specifically, we examined the types of interventions (e.g., what device or procedure), study and participant characteristics (study setting, demographics) and the reported impact or associations with loneliness (qualitative, quantitative, and inconsistencies) and social connectedness to create a narrative summary of the study objectives and findings. This allowed us to determine the relation among ICTs and older adults' wellbeing.

3. Results

This review consists of the results of our examination of the characteristics and conclusions obtained from cross-sectional surveys and interviews/focus groups, quasi-experimental designs, randomized controlled trials, case series, and cohort studies.

Interventions are defined as studies where older adults were interacting or training with an ICT device either alone or in groups over a designated period of time, followed by providing feedback on how the interactions or training impacted their wellbeing *via* questionnaires or interviews. Of the case series, 16 out of 19 were longitudinal interventions that involved studying 1 group of older adults. The other non-intervention studies involved collecting user preferences at one point in time (i.e., scenario engagement) (Wherton and Prendergast, 2009; Papa et al., 2016) or conducting interviews with a single group of older adults on their ICT use (Ivan and Hebblethwaite, 2016). The cohort

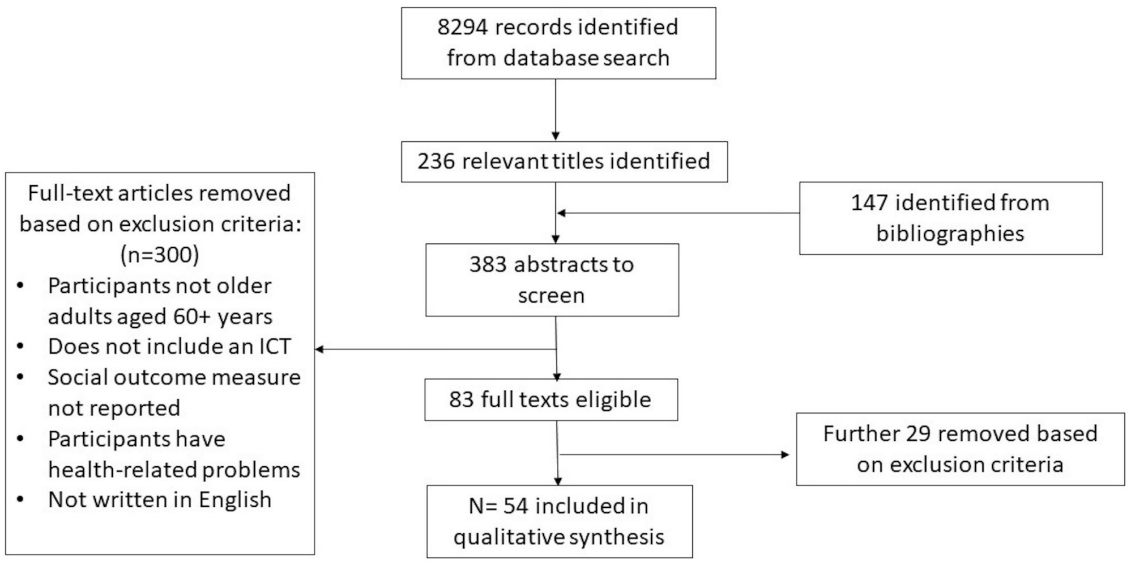

FIGURE 1
Article screening process.

TABLE 1 Study outcomes and characteristics.

References	*N*	Design	ICT type	Outcome	Age	% Female
Agmon et al., 2011	7	Case series	Digital Game- Wii Fit Exergames	Older adults enjoyed playing games with their grandchildren. The bonding time was a motivator despite the 2-month learning curve	M = 84, SD = 5, R = 78–92	57%
Gajadhar et al., 2010	40	Cross-sectional	Digital Game-Wood Pong	Co-located co-play was more enjoyable than virtual or mediated co-play for older adults	M = 68.6, SD = 4.7, R = 61–78	22.50%
Xu et al., 2016	122	Mixed quasi-experimental	Digital Game-Kinect Exergames	Reduction in social anxiety and increase in scalability for young-old participants playing with youths. Sociality improved for old-old participants playing with peers. Significant decrease in loneliness after exergaming but minimal differences across play types or age groups	Playing with elderly person: M = 75.91, SD = 6.002 playing with adolescent M = 76.0, SD = 7.43 playing alone: M = 73.06, SD = 9.38	77%
Osmanovic and Pecchioni, 2015	9	Cross-sectional-focus groups	Digital games (candy crush, Minecraft, Clash of clans, etc.)	Digital games used to stay connected to younger generations; preference for cooperative games over competitive	M = 64.78, SD = 3.46, R = 59–71	66.60%
Nap et al., 2009	10	Cross-sectional-focus groups	Digital games	Some participants enjoyed playing games with grandchildren, but reported no need for others to participate; played to relax or for leisure	Focus group 1: M = 67.8, SD = 3.6 focus group 2: M = 70.0, SD = 4.7	80%
Arthanat et al., 2014	12	Case series	iPad-variety	Participants reported that training increased use of iPad capabilities for leisure. Social interaction increased in proportion to importance allocated by individual	M = 70.6, SD = 6.3, R = 62–83	92.30%
Delello and McWhorter, 2016	19	Case series	iPad-variety	Participants reported that the iPad technology enhanced their communication with existing network	M = N/A, SD = N/A, R = 61–99	84.20%
Barbosa Neves et al., 2017	12	Case series	iPad-communication app	Participants reported that the App increased social interactions, but social connectedness was dependent on existing social capital	M = 82.5, SD = N/A, R = 74–95	66.70%
Tsai et al., 2015	21	Cross-sectional-interviews	iPad/tablet	Participants reported that Tablet use helped increase perceived connectedness with family, friends and the world.	M = 79.5, SD = N/A, R = 69–91	57%
Ballesteros et al., 2014	41	RCT	Prototype-AGNES–controlled social network with sensing and interaction methods to stimulate bidirectional communication	Experimental group showed significant increases in the affection dimension of wellbeing (confidence, social acceptance and satisfaction within social network) ($p < 0.05$, $\eta^2 = 0.34$) compared to control. No change in cognitive state, depression or activities of daily living	Exp: M = 74, SD = N/A, R = 65–80 control: M = 75, SD = N/A, R = 68–85	Exp: 64.0%, control: 68.7%
Garattini et al., 2012	19	Case series	Prototype-building bridges	System provided participants opportunities to meet new people. Women were more frequent users than men. Those who reported loneliness used the system more often. Frequent users became frustrated with disengagement from others	M = 74, SD = N/A, R = 65–88	58%
Wherton and Prendergast, 2009	50–90 (focus groups) 5–10 (intervention)	Case series-focus groups and intervention	Prototype-building bridges	Older adults should be involved in the design of communication ICT for their age group	Age: 60+	N/A
Mitzner et al., 2019	150	RCT design but data reported only on experimental group	Proto-type-PRISM	Executive function and self-efficacy associated with continued computer use ($p < 0.05$); depression negatively correlated with mid and long-term use	M = 77.0, SD = 7.3, R = 65–98	79.30%
Czaja et al., 2018	300	RCT	Prototype-PRISM	Experimental group had greater increase in perceived social support ($p < 0.004$, $d = 0.28$), greater decreased loneliness ($p < 0.04$, $d = 0.17$); compared to control at 6 months, but difference gone at 12 months, potentially due to novelty. At 12 months experimental group reported greater increase in wellbeing ($p < 0.02$, $d = 0.27$).	M = 76.15, SD = 7.4, R = 65–98	78%

(Continued)

TABLE 1 (Continued)

References	*N*	Design	ICT type	Outcome	Age	% Female
Zaine et al., 2019	4	Case series	Prototype-media parcels	Participants reported increased feelings of closeness and contact with others when using prototype	*M* = 75, *SD* = N/A, *R* = 72–82	75%
Waycott et al., 2015	N/A	Case series	Prototype-Enmesh–simplified photo and message communication	Participants reported that the prototype facilitated social engagement in home-care setting	Age: 65+	N/A
Tsai et al., 2012	52	Cohort-scenario engagement	Prototype-ShareTouch–social media platform–multimedia and games	Enrichment of social experience was dependent on self-efficacy, which was lower in the oldest-old group	*M* = 79, *SD* = N/A, *R* = 64–91	67.30%
Papa et al., 2016	40	Case series-scenario engagement	Prototype-easy reach smart TV	System perceived as useful in combatting isolation and loneliness through communicating with existing family and friends not new people	*M* = N/A, *SD* = N/A, *R* = 66–70	48%
Huang and Hsu, 2014	10	Case series	Prototype-Home TeleHealth System	Participants reported that the prototype reduced conversation gap between participant and family, encouraged family involvement in monitoring older adult health	Nine participants were over 65 years old (five participants were over 70 years). One participant was a 57-year-old male	N/A
Bobillier Chaumon et al., 2013	17	Case series	Prototype-activital software	Participants reported gains in self-esteem and bonding over ICT experience within care home, but required support and coaching	*M* = 87, *SD* = N/A, *R* = N/A	88.20%
Chi et al., 2017	10	Case series	Prototype-pet avatar	Participants reported that pet companionship was enjoyable, and they appreciated instant assistance/conversation, but conversations were superficial. Privacy, development of dependence and cost were concerns	*M* = 78.3, *SD* = N/A, *R* = 68–69	100%
Cornejo et al., 2012	1	Case study	Prototype-social media-based exergame	Participants reported the prototype facilitated bonding with younger grandchildren	*M* = 87	100%
Ballantyne et al., 2010	4	Case series	Prototype-about my age (social media platform)	Participants felt their loneliness decreased and their connectedness to the world increased	*M* = N/A, *SD* = N/A, *R* = 69–85	25%
Billipp, 2001	40	RCT	Computer-variety	Groups completing weekly computer training with either a nurse ($p = 0.05$, Effect = 0.43) or significant other ($p = 0.03$, Effect = 0.68) had improved self-esteem compared to control. Only the group with a weekly nurse computer trainer had significant change in lower levels of depression compared to control ($p = 0.01$, Effect = 0.49)	*M* = 73, *SD* = N/A, *R* = N/A Control = 10 experimental groups ($n = 3$) = 30 (breakdown not provided)	82%
Blažun et al., 2012	45	Quasi-experimental	Computer-variety	Reduction in self-reported loneliness at follow-up compared to baseline ($p = 0.001$) but over 90% of participants from both groups did not feel lonely at baseline. Significant positive correlations between email use and number of existing friends ($r = 0.343$, $p = 0.017$) and email use and number of friends made after training intervention ($r = 0.635$, $p = 0.020$)	Finland: *M* = 66.29, *SD* = 6.57, *R* = 58–80 Slovenia: *M* = 77.0, *SD* = 8.30, *R* = 58–93	Finland: 52.3% Slovenia: 66.1%
Cotten et al., 2013	205	RCT but used cross-sectional analyses on pretest data due to ongoing data collection	Computer-variety	Higher frequency of going online associated with lower levels of loneliness ($p = 0.001$) but not with lower levels of perceived social isolation ($p = 0.06$) among residents in assisted and independent living communities	*M* = 82.8, *SD* = 7.7, *R* = N/A	82.40%
Woodward et al., 2010	83	RCT	Computer-variety	Experimental group reported significantly greater self-efficacy and higher quality of life ($p < 0.05$) compared to control. No group differences in loneliness or depression	*M* = 71.85, *SD* = 7.09, *R* = 60–89	71%
Winstead et al., 2012	43	Case series	Computer-variety	Learning to use ICTs helped participants in assisted living setting overcome social barriers and connect or reconnect with others. Minimal evidence it helped overcome spatial barriers	*M* = 83.0, *SD* = 1.4, *R* = N/A	79.1%

(Continued)

TABLE 1 (Continued)

References	*N*	Design	ICT type	Outcome	Age	% Female
White et al., 2016	23	Quasi-experimental	Computer-variety	Trend toward reduced loneliness in intervention group as compared to control group	Exp: $M = 77$, $SD = 7$, R = N/A control: $M = 80$, $SD = 8$, R = N/A	Exp: 84%, control: 75%
Straka and Clark, 2000	84	Case series	Computer-variety	After intervention participants felt apart of society again, it strengthened social networks. Training expanded social networks with teachers/volunteers, and participants experienced greater self-efficacy. Joy of learning mentioned by 1/3 of participants	$M = 85.5$, SD = N/A, $R = 68–98$	70%
Shapira et al., 2007	48	Quasi-experimental	Computer-variety	In comparison to the control group, the training group showed decreased levels of depression ($p < 0.01$, $\eta^2 = 0.23$), and loneliness ($p < 0.001$, $\eta^2 = 0.51$) and improvement in life satisfaction ($p < 0.001$, $\eta^2 = 0.55$), sense of control ($p < 0.001$, $\eta^2 = 0.29$) and life quality ($p < 0.01$, $\eta^2 = 0.18$) at post-assessment	Exp: $M = 80.25$, $SD = 6.50$, $R = 70–93$ control: $M = 82.60$, $SD = 5.90$, $R = 70–93$	Exp: 59.1%, control: 65.4%
Pfeil et al., 2009	31	Cross-sectional-interviews	Computer-online communities	Older adults often felt uneasy when using online support communities and emails. However, online communication complemented offline communication	$M = 69.75$, SD = N/A, $R = 55–91$	67.70%
Nimrod and Ivan, 2019	184	Cross-sectional focus groups	Computer-general ICT	Participants reported that ICT facilitated leisure and connections, but wasted time	M = Varied by country, SD = N/A, $R = 65–88$	100%
Melenhorst et al., 2016	48	Cohort study-focus groups	Computer-email	Older adults use ICTs based on their advantages. Email and telephone were beneficial to keeping in touch over long distances	M = N/A, SD = N/A, $R = 65–80$	60.4%
Khvorostianov et al., 2011	32	Cross-sectional interviews	Computer-variety	Communicating with family and friends was main motivation for using ICT. ICTs provided virtual connection to homeland culture and leisure	$M = 76$, SD = N/A, $R = 69–89$	47%
Pak et al., 2020	1,698	Cross-sectional survey	Computer-variety	Web-connected ICT users were less lonely and had greater autonomy compared to non-ICT users ($p < 0.001$), and non-web ICT users ($p < 0.001$)	$R = 80–103$ no ICT $M = 86.91$, $SD = 4.38$ non-web ICT $M = 84.73$, $SD = 3.55$ web ICT: $M = 83.92$, $SD = 3.26$	No ICT: 46.3% non-web ICT 35.5% web ICT: 18.2%
Sims et al., 2017	445	Cross-sectional survey	Computer-variety	ICT use motivated by social opportunities with family. ICTs helped participants connect to friends and family more than learning new information ($p < 0.001$). Using more devices was associated with higher life satisfaction, lower loneliness, higher goal attainment, better subjective health and fewer functional limitations ($ps \leq 0.008$)	$M = 84$, $SD = 3$, $R = 80–93$	64%
White et al., 2010	93	RCT	Computer-variety	A trend toward decreased loneliness ($p < 0.52$) and depression ($p < 0.39$) in intervention group compared to controls at post testing but not significant	Exp: $M = 71$, $SD = 12$, R = N/A Control: $M = 72$, $SD = 11$, R = N/A	Exp: 71% control: 82%
Quittschalle et al., 2020	999	Cross-sectional survey	Computer-variety (health-related)	ICT use associated with better quality of life ($p = 0.006$), lower levels of depressive symptoms ($p = 0.04$) and wider social network size ($p = 0.01$)	$M = 80.49$, $SD = 4.69$, $R = 75–99$	59.10%
Teo et al., 2019	1,424	Longitudinal survey	Computer-variety	Users of video chat had lower depressive symptoms compared to those who did not use video chat ($p < 0.001$); no association of depression score with social media, email or instant messaging use	$M = 64.8$, $SD = 0.37$, R = N/A	53%
Nimrod, 2012	218	Cross-sectional survey	Computer-variety	Participating in online communities provided joyfulness, stimulation and companionship. Online anonymity makes self-disclosure easier	$M = 64.7$, SD = N/A, $R = 55–75$	56%

(Continued)

TABLE 1 (Continued)

References	*N*	Design	ICT type	Outcome	Age	% Female
Lelkes, 2013	11,000	Cross-sectional survey	Computer-general ICT	Those who suffer from loneliness or lack of social meetings, did not appear to benefit from internet use. Social isolation was lower among internet users. Positive association between regular internet use and self-reported life satisfaction	Age = 65+	N/A
Kim et al., 2016	6,476	Cross-sectional survey	Computer-general ICT	ICT use associated with increased likelihood of women visiting with family or friends (OR = 1.6, $p = 0.002$) and going out for enjoyment (OR = 1.3, $p = 0.018$). Association exists for men but only for going out for enjoyment (OR = 1.4, $p = 0.036$)	Age = 65+	56%
Lyu and Sun, 2020	7,193	Cross-sectional survey	Computer-general ICT	Social capital plays a mediating role in the relationship between Internet use and self-rated health among the older adults	*M* = N/A, *SD* = N/A, *R* = 60–95	48.99%
Tsai et al., 2010	57	quasi-experimental	Video-Skype/Windows Live Messenger	Video conference intervention: Experimental group had significantly better emotional ($p < 0.01$) and appraisal ($p < 0.01$) social support and loneliness ($p = 0.02$, $p = 0.03$) scores 1 week and 3 months after baseline compared to those in the control group. Depressive scores significantly ($p = 0.02$) lower at 3 months for experimental as compared to control group	Exp: *M* = 74.42, *SD* = 10.18, *R* = N/A control: *M* = 78.48, *SD* = 6.75, *R* = N/A	Exp: 58.3%, control: 57.6%
Jimison et al., 2013	9	Case series	Skype and health coach	Participants reported that Skype facilitated communication with remote family members and assisted in developing fast friendships that extended to additional social activities	*M* = 73.8, *SD* = 6.7 *R* = 76–92	89%
Tsai and Tsai, 2011	90	quasi-experimental	Video-Skype/Windows Live Messenger	After 3 months of videoconferencing with family the experimental group had higher changes in appraisal and emotional social support ($p < 0.001$). Experimental group had lower mean changes in loneliness ($p < 0.001$) and depressive scores ($p < 0.001$) evident at 3, 6, 12 months compared to baseline.	Exp: *M* = 73.82, *SD* = 11.19, *R* = N/A control: *M* = 79.26, *SD* = 11.19, *R* = N/A	Exp: 55%, control: 60%
Nam, 2019	1,132	Cross-sectional survey	Social media	Social media directly and indirectly (*via* perceived social support) influenced quality of life; men use social media for social support more than women	Age: 65+	54.90%
Aarts et al., 2015	626	Cross-sectional survey	Social media- social network sites	Usage unrelated to emotional/social loneliness or mental health	*M* = 66.94, *SD* = 5.99, *R* = N/A, 60 +	50.50%
Ivan and Hebblethwaite, 2016	13	Case series	Social media-Facebook	Video chat preferred over Facebook to build relationships with grandchildren	*M* = N/A, *SD* = N/A, *R* = 60–80	100%
Larsson et al., 2013	5	Case series	Social media	Social media use identified as complimentary to daily activities, not replacement; provided a way to be a part of grandchildren's lives in a new way, increased knowledge about society, included and improved conversation. Participants worried about managing appearance on internet and privacy	*M* = N/A, *SD* = N/A, *R* = 65–85	60%
Bell et al., 2013	142	Cross-sectional survey	Social media (Facebook)	Social media users scored higher on social satisfaction and ICT confidence than non-users; no relationship with loneliness	*M* = 72, *SD* = 11, *R* = 52–92	66.90%
Pimentel et al., 2016	31	Case series	Smart phone-communication and social media apps	Participants reported that training allowed for greater socialization with family, friends and between colleagues of the course and increased independence and autonomy	Beginner class: *M* = 67, *SD* = 3.2, *R* = 58–77 advanced class: *M* = 66.8, *SD* = 3.3, *R* = 62–74	Beginner: 77.7% advanced: 61.5%
Pecino et al., 2012	165	Cross-sectional-survey	Smart phone-general	Having a mobile phone helped preserve friendships and increased independence, but not a means of social expansion	Mean = 62, *SD* = 5.46, *R* = N/A	66.7%

Exp = experimental, *M* = mean, *SD* = standard deviation, *R* = range, *N* = sample size.

observational studies involved comparing two or more groups and were cross-sectional in nature. For example, (Melenhorst et al., 2016) recruited 24 e-mail users and 24 non-users to participate in a focus group to discuss communication scenarios, while (Tsai et al., 2015) compared prototype scenario engagement among the young-old, old-old and oldest-old participants. See **Table 1** for a complete description of the characteristics of the 54 reviewed publications.

This review revealed that ICT devices were enjoyable (Straka and Clark, 2000; Nap et al., 2009; Gajadhar et al., 2010; Agmon et al., 2011; Nimrod, 2012; Chi et al., 2017); and using ICTs was associated with reduced social anxiety (Xu et al., 2016), higher wellbeing/life satisfaction (Shapira et al., 2007; Bell et al., 2013; Lelkes, 2013; Ballesteros et al., 2014; Sims et al., 2017; Nam, 2019; Quittschalle et al., 2020), improved self-efficacy (Straka and Clark, 2000; Woodward et al., 2010; Bell et al., 2013; Mitzner et al., 2019), greater self-esteem (Billipp, 2001; Bobillier Chaumon et al., 2013), and higher autonomy (Khvorostianov et al., 2011; Pecino et al., 2012; Pimentel et al., 2016; Pak et al., 2020).

There were associations between using ICTs and reduced loneliness (Shapira et al., 2007; Ballantyne et al., 2010; Tsai et al., 2010; White et al., 2010, 2016; Tsai and Tsai, 2011; Blažun et al., 2012; Cotten et al., 2013; Sims et al., 2017; Czaja et al., 2018) and social isolation (Lelkes, 2013) and depression (Shapira et al., 2007; Tsai et al., 2010; Tsai and Tsai, 2011; White et al., 2016; Czaja et al., 2018; Nam, 2019; Teo et al., 2019; Quittschalle et al., 2020). However, one study found no connection among ICTs loneliness or mental health (Aarts et al., 2015).

Generally, ICTs fostered social connections with family, friends and new acquaintances (Straka and Clark, 2000; Pfeil et al., 2009; Ballantyne et al., 2010; Khvorostianov et al., 2011; Blažun et al., 2012; Cornejo et al., 2012; Garattini et al., 2012; Nimrod, 2012; Pecino et al., 2012; Tsai et al., 2012, 2015; Winstead et al., 2012; Cotten et al., 2013; Jimison et al., 2013; Larsson et al., 2013; Arthanat et al., 2014; Huang and Hsu, 2014; Osmanovic and Pecchioni, 2015; Waycott et al., 2015; Delello and McWhorter, 2016; Ivan and Hebblethwaite, 2016; Melenhorst et al., 2016; Papa et al., 2016; Pimentel et al., 2016; Xu et al., 2016; Sims et al., 2017; Barbosa Neves et al., 2018; Czaja et al., 2018; Nimrod and Ivan, 2019; Zaine et al., 2019; Lyu and Sun, 2020). ICT use was associated with greater emotional and/or social support (Tsai et al., 2010; Woodward et al., 2010; Tsai and Tsai, 2011; Czaja et al., 2018) and social engagement (going out and hobbies) (Kim et al., 2016). They also increased leisure activities (Khvorostianov et al., 2011; Arthanat et al., 2014; Nimrod and Ivan, 2019).

Other articles reported on concerns older adults have with ICTs (e.g., managing appearance, privacy) (Nimrod, 2012; Larsson et al., 2013; Chi et al., 2017), as well as on older adult's perceived usefulness of ICT devices, and emphasized the importance of including older adults in ICT designs/interventions (Wherton and Prendergast, 2009; Papa et al., 2016).

4. Discussion

The goal of this review is to investigate the relation between modalities of using ICTs and loneliness and social connectedness among older adults. Our examination of the literature suggests that the introduction of ICTs may improve the wellbeing of older adults in three major ways:

First, in the majority of studies reviewed here, evidence indicates that ICTs are associated with a reduction in loneliness, and depression. Second, ICTs promoted social connectedness by facilitating conversations. Third, we identified a series of other factors that contribute to the above-mentioned associations including, training, self-efficacy, self-esteem, autonomy, and the design/features, or affordances, of such devices. In the following sections, we discuss specifics of research studies reviewed, to provide a finer grained picture of the contextual specifics of studies that offer evidence to support our conclusions.

4.1. ICT use is associated with decreased loneliness, and depression and increased wellbeing

Findings from the scoping review allowed us to examine the specific ICT devices that were associated with reductions in loneliness and depression along with improvements in wellbeing. Interventions involving video conferencing (Tsai et al., 2010; Tsai and Tsai, 2011), web-based computer training (i.e., internet and social-networking websites) (Shapira et al., 2007; White et al., 2010, 2016; Blažun et al., 2012; Cotten et al., 2013) and two prototypes (Ballantyne et al., 2010; Czaja et al., 2018) were associated with decreased loneliness. Video conferencing provided older nursing home residents with emotional and appraisal social support (i.e., information that is useful for self-evaluation), and users experienced reduced depressive symptoms at three (Tsai et al., 2010; Tsai and Tsai, 2011) six and 12 months (Tsai and Tsai, 2011). Similarly, users of video chat had approximately half the probability of developing depressive symptoms, compared to non-users or those who used only email (Teo et al., 2019). Since video chat provides the richest media for mimicking in-person contact, it has a fundamental benefit for increasing social and emotional connectedness, in turn reducing feelings of loneliness (Tsai and Tsai, 2011; Teo et al., 2019; Ibarra et al., 2020). Such findings highlight the importance of creating ICT opportunities that are more like interpersonal exchanges to improve older adults' wellbeing.

A quasi-experimental study noted older adults in their computer training course demonstrated decreased depression as compared to controls (Shapira et al., 2007). Cross-sectional and longitudinal survey results indicate ICT was associated with lower depression (Teo et al., 2019; Quittschalle et al., 2020). RCT designs have provided mixed findings on the effects of ICT training on loneliness and depression. An RCT prototype intervention completed individually by participants and provided easy access to resources and information sources and opportunities for engagement and communication (i.e., PRISM) was negatively correlated with depression scores (Mitzner et al., 2019). After conducting this RCT with 300 older adults, the group using PRISM, demonstrated greater perceived social support, and decreased loneliness at 6 months, but group differences disappeared at 12 months (Czaja et al., 2018). Another 12-month prototype

intervention completed individually showed increases in wellbeing, but not in depression or activities of daily living (Ballesteros et al., 2014). RCTs involving computer training (e.g., learning computer basics) provide inconsistent findings. For example, 2 weeks of group computer training resulted in a trend toward decreased depression (White et al., 2010). Another 6-month group computer training intervention found greater self-efficacy and quality of life among the computer training group as compared to control but no differences in loneliness or depression (Woodward et al., 2010). A 3-month computer training study found weekly computer training with a nurse or significant other improved self-esteem compared to the control group who received only weekly nurse visits but no computer training. Additionally, those who trained with the nurse also demonstrated reduced depression (Billipp, 2001). Findings from RCTs highlight that the effectiveness of ICT interventions may be more closely related to who is conducting the training, rather than the training duration. Group versus individual based training formats are likely to affect training efficacy (Ibarra et al., 2020; Balki et al., 2022). These factors are discussed in more depth in Section 4.3.1.

Using web-based ICTs and using them frequently was associated with greater wellbeing compared to non-web-based ICTs or not using them at all. In a large-scale qualitative study of more than 1,600 older adults in Germany, individuals using web-based ICTs reported lower levels of loneliness compared to users of non-web ICT (e.g., TV) and non-users (Pak et al., 2020). Similarly, internet users expressed having greater and more social support networks than non-users, and users reported better self-rated health-related quality of life, fewer depressive symptoms, fewer chronic medical conditions and less feelings of loneliness (Quittschalle et al., 2020). Regular internet use was also associated with a lower chance of being socially isolated among older adults aged 65 and over even after controlling for personal characteristics such as income, marital status, gender, and health conditions (Lelkes, 2013). However, in another study, a higher frequency of online engagement was associated with lower levels of loneliness but not with lower levels of perceived social isolation among older adults in assisted and independent living communities. This finding suggests that *in person contact* rather than *online contact* may impact perceptions of social isolation (or social inclusion) (Cotten et al., 2013). Social networking websites seem to be related to temporary feelings of loneliness (i.e., loneliness which is experienced at a particular time of day or time of life) because of the flexibility of online communication, which can be used at any time of the day (Ballantyne et al., 2010; Nimrod, 2012). Facebook users were found to score higher on social satisfaction and confidence with technology as compared to non-users, but no differences in feelings of loneliness existed (Bell et al., 2013). Similarly, the greater the use of social media, the better the perception of social support, which increases participants' quality-of-life (Nam, 2019). Among socially isolated older adults, ICTs that involved a closed social networking tool, such as posting photographs and messages on shared display for friends helped to facilitate social engagement and enhanced relationships between older adults and care managers (Waycott et al., 2015).

4.2. The contexts in which ICTs appear to have been helpful

The benefits of ICTs seem to be tied to strengthening pre-existing and new social connections and, promoting leisure and the fostering of intergenerational connections.

4.2.1. ICT use strengthened pre-existing and new social connections

Multiple studies demonstrate that family and friends are important motivations for participating in and/or learning about ICT use (Ballantyne et al., 2010; Anderson-Hanley et al., 2011; Arthanat et al., 2014; Tsai et al., 2015; Barbosa Neves et al., 2018). Activities involving family connections were reported as being performed more frequently than those involving general social connection, leisure, health management, shopping, finances (Arthanat et al., 2014) or even obtaining new information (Sims et al., 2017). In turn, research indicates ICTs helped strengthen communication between older adults and their family and friends (Straka and Clark, 2000; Pfeil et al., 2009; Ballantyne et al., 2010; Khvorostianov et al., 2011; Pecino et al., 2012; Cotten et al., 2013; Jimison et al., 2013; Larsson et al., 2013; Huang and Hsu, 2014; Tsai et al., 2015; Delello and McWhorter, 2016; Ivan and Hebblethwaite, 2016; Melenhorst et al., 2016; Papa et al., 2016; Pimentel et al., 2016; Barbosa Neves et al., 2017; Sims et al., 2017; Czaja et al., 2018; Zaine et al., 2019). ICTs commonly reinforced in-person meetings and complemented offline communication with family, friends and new acquaintances (Pfeil et al., 2009; Larsson et al., 2013; Lelkes, 2013). ICTs also helped older adults remain in frequent contact with distant relatives (Khvorostianov et al., 2011; Melenhorst et al., 2016). Using ICTs to strengthen connections with others in turn is shown to potentially improve older adults' sense of wellbeing by reducing loneliness and improving self-rated health (Cotten et al., 2013; Lyu and Sun, 2020).

We further investigated the types of ICTs used to facilitate social connections. For example, an ICT intervention that incorporated email, internet access, and online classrooms for social interactions made it easier to communicate with family and friends compared to a non-ICT intervention that included receiving a list of family/friends and other participant contacts to call (Czaja et al., 2018). Email frequently was used for exchanging light talk with friends and relatives (Pfeil et al., 2009). For in-depth conversations involving close personal relationships, one study identified that telephone or video chat was preferred over email or Facebook (Ivan and Hebblethwaite, 2016). Mobile phones were found to facilitate the provision of social support but they were not used extensively to maintain or enlarge older adults' social networks (Pecino et al., 2012). Video conferencing increased older adults' number of social contacts, and total online communication time with family and friends (Jimison et al., 2013). The use of an iPad-based communication app facilitated social connectedness in participants with geographically distant relatives (Barbosa Neves et al., 2017) and increased half the participants' (6/12) communication frequency with social ties. However, the use of this application did not necessarily make relationships more meaningful as it was often used for brief contact or follow-ups. Other ICT prototypes such as 'Media Parcels' (sending and receiving pictures, audio clips, videos from other participants with

the help of a facilitator to deliver the content) promoted social connection (Zaine et al., 2019).

Other ICT prototypes, not readily available to the public, hold promise. For example, one study reported the results of the use of a digital pet avatar with a voice activated cat or dog that was made available for 24/7 interaction through a live operator. Participants claimed that the device enhanced social interactions with other people as users could talk about their pet to friends and family (Chi et al., 2017). Another home-based communication system prototype encouraged peer-to-peer social engagement and offered older adults the chance to meet new people and promoted social connection online and offline (Garattini et al., 2012). Unfortunately, assessments of loneliness before and after the technology deployment were not considered.

Internet Communication and Technologies demonstrated to benefit relationships with others by reinforcing in-person meetings and internet contacts, however, they were predominantly seen as complementary, rather than supplementing in-person contacts (Lelkes, 2013). Social activities *via* social websites (i.e., Facebook, blogs, skype, MSN, 60 plus, and Stayfriends) and email were found to facilitate conversation with family, friends, and newly found acquaintances, and complemented both offline communication (Pfeil et al., 2009) and daily activities, rather than replacing them (Larsson et al., 2013). Using ICTs to connect with family and friends were found to be associated with greater life satisfaction, lower loneliness, and higher goal attainment (Sims et al., 2017). Connecting with family and meeting new people *via* internet was associated with lower levels of loneliness in residents of assisted and independent living communities (Cotten et al., 2013). Email and internet were beneficial for keeping in frequent contact with distant relatives over large geographic distances (Khvorostianov et al., 2011; Melenhorst et al., 2016). This was significantly associated with improved psychological wellbeing of older immigrants (Khvorostianov et al., 2011). However, it has been suggested that the internet is better at strengthening existing connections, rather than establishing new relationships (Cotten et al., 2013).

4.2.2. ICT use for leisure and the fostering of intergenerational connections

Internet Communication and Technologies were found to enhance leisure experiences when online activities were both meaningful and enjoyable (Nap et al., 2009; Nimrod and Ivan, 2019). Some leisure environments fostered connections between older adults and younger generations (Agmon et al., 2011; Tsai and Tsai, 2011; Bobillier Chaumon et al., 2013; Larsson et al., 2013; Arthanat et al., 2014; Osmanovic and Pecchioni, 2015; Xu et al., 2016). Playing digital games was frequently encountered in the qualitative ICT literature emanating from leisure studies, where they were described as enjoyable, relaxing, and providing opportunities for skill enhancement (Nap et al., 2009; Osmanovic and Pecchioni, 2015; Nimrod and Ivan, 2019). However, here it is important to distinguish between different cohorts within the older population: those described as the "young-old" reported having a more favorable attitude than the "old-old" for using multimedia sharing and interactive games (Tsai et al., 2012; Xu et al., 2016). Playing games that were challenging and could enhance one's skill set seems to motivate older adults to play digital games. However, negative perceptions of digital gaming exist within this population, including a fear of failure, as multiplayer games were competitive and revealed one's skill set. For these reasons, the literature indicates that older adults prefer single player games (Nap et al., 2009) or cooperative game play (Osmanovic and Pecchioni, 2015; Xu et al., 2016).

Co-playing, in several studies, may increase feelings of connectedness between players and improve their engagement (Gajadhar et al., 2010; Xu et al., 2016), as highly interactive games simulated interpersonal conversation (Xu et al., 2016). These conclusions were supported in a survey of 124 adults, which concluded that older adults enjoy solo play on casual computer games for leisure and personal challenge, and social play for connection especially intergenerationally rather than competition (De Schutter, 2010; Khalili-Mahani et al., 2020). However, in an exergaming study by Xu et al. (2016), the age of the co-player was found to have differential effects on the "young-old" and "old-old" cohorts' psychosocial wellbeing. A young-old cohort saw improvements in sociability including an interest in being around or socializing with others and a decline in social anxiousness after playing with adolescents. Players who were categorized as "old-old" only reported improved sociability from playing with another older adult. In both cases, it was not the intervention but the togetherness that produced positive effects. Both groups showed decreased loneliness scores after game play (Xu et al., 2016).

Other leisure-based ICTs, such as engaging with the websites of cultural institutions like museums or using Google Earth for sight-seeing, facilitated older adults' participation in these types of social activities and virtual environments that would have been inaccessible due to social or physical barriers. However, from the user's perspective, leisure-based ICTs have a paradoxical relation with time. While the internet made it easier to partake in some leisure activities, such as finding and listening to music, it was also described in the negative context as something that absorbed or wasted time (Nimrod and Ivan, 2019). The importance of considering the affordances of the device to enhance wellbeing through fostering intergenerational relationships are supported by a 2019 field study by Marston et al. (2019), a social media study by Khalili-Mahani et al. (2021), and a recent scoping review by Ibarra et al. (2020).

Taken together, it is clear that ICTs foster social connections in two primary ways: (1) ICT use strengthens pre-existing and new relationships, and (2) ICTs are used for leisure, which fosters social connectivity and intergenerational connections.

4.3. Additional factors contributing to the association between ICT use and wellbeing

A series of factors positively contribute to the association between ICT use and older adults' wellbeing, which include ICT training, ownership and design/features. These factors have the ability to improve social connections, autonomy and self-efficacy, and reduce loneliness, among other aspects of quality of life.

4.3.1. The association between ICT training and loneliness and social connectedness

When determining the factors that positively contribute toward the association between ICT use and older adults' wellbeing, ICT

training appears to play a critical role. Previous studies have identified that older adults who have taken computer training to learn basic computer skills (turning computers on, internet searching, and e-services) have reported reduced levels of loneliness and an increase in their social networks. For example, among older adults living in institutional care homes who face barriers to socializing because of mobility or health problems, learning ICT skills has shown to increase their social networks and reduce levels of loneliness (Blažun et al., 2012). Similarly, older adults provided with ICT training to communicate with family and finding information exhibited lower levels of loneliness. These findings were apparent in both assisted and independent living communities (Cotten et al., 2013). Such findings highlight that ICT training can have a positive contribution toward participants' social relationships making it easier to connect with family and meet new people.

Another form of ICT training can occur in groups, which creates a community of learners who may assist one another with their technology skills (Delello and McWhorter, 2016). Group ICT training formats (basic lessons, web searching, etc.) such as those by Winstead et al. (2012) and White et al. (2010, 2016) involve an instructor and/or assistant who help multiple participants. Researchers have indicated that training programs are associated with increased social networking interactions (Straka and Clark, 2000; Winstead et al., 2012), decreased loneliness (Shapira et al., 2007; White et al., 2010), reduced feelings of depression, improved satisfaction and quality of life (Shapira et al., 2007; Woodward et al., 2010), improved perceived social support (Woodward et al., 2010), and emotional state (Silva et al., 2018). However, given that ICT group training are often formed around the shared ICT experience makes it difficult to determine how much of the positive psychological effect is due to ICT use or to the group social interactions that occur during these sessions (Straka and Clark, 2000; White et al., 2010). Potential benefits from group ICT training may be related to the support provided by facilitators or family members (Billipp, 2001). Additionally, others suggest that the novelty of learning to use ICTs play a role in promoting wellbeing (Blažun et al., 2012). For example, after 6 months of ICT training there was a significant improvements in perceived social support, wellbeing and decreased feelings of loneliness. Yet these positive effects wore off at 12 months. It may be the case that the novelty of the ICT intervention disappeared after 12 months (Czaja et al., 2018). Regardless, both independent and group-based ICT training formats appear to be associated with older adults' wellbeing, at least in the short-term.

4.3.2. ICTs are positively related to self-efficacy, self-esteem, autonomy, and independence

In addition to the social benefits of ICT training, learning how to use ICTs can contribute to improvements in ICT self-efficacy (belief in ability to use ICTS), self-esteem and autonomy, by providing users with the opportunity to engage with society. More specifically, after introducing ICTs to older adults, many reported improved independence and autonomy (Straka and Clark, 2000; White et al., 2010; Bobillier Chaumon et al., 2013; Pimentel et al., 2016); self-esteem and ICT self-efficacy (Billipp, 2001; Woodward et al., 2010; Bobillier Chaumon et al., 2013; Tsai et al., 2015; Pimentel et al., 2016). It is of great importance that older adults believe in their capacity to use ICTs, a hallmark of self-efficacy, as it is a predictor for both mid-term and long-term ICT adoption and use (Czaja et al., 2006; Mitzner et al., 2019; Jokisch et al., 2021). One study identified the significance of age in relation to ICT and self-efficacy. Tsai et al. (2012) found that the oldest-old participants had a lower sense of self-efficacy when it came to multimedia sharing and interactive gaming (Tsai et al., 2012). Additionally, the type of ICT device used may strengthen feelings of independence. For example, using a mobile phone increased feelings of security and independence among older adults (Pecino et al., 2012). Additionally, survey results from older adults living in private homes and institutional settings found that in comparison to non-users or users of non-web ICTS, those who used web-based ICTs reported higher levels of autonomy (capacity to decide how to act and being accountable for actions) and lower levels of anomie (feelings related to coping with the current social standards, compatibility of one's own values to those in society and orienting oneself in fast changing society) (Pak et al., 2020). The benefits of learning how to use ICTs gave older adults a sense of belonging (Shapira et al., 2007) and an increased awareness of world events (Winstead et al., 2012; Tsai et al., 2015). This contributed to enhancing older adults' ICT competency (Bobillier Chaumon et al., 2013; Tsai et al., 2015), which provided them more opportunity to have conversations with family and friends about current events (Bobillier Chaumon et al., 2013; Larsson et al., 2013).

4.3.3. ICT design and features

Given there are many prototype studies emerging which examine the relation between ICTs and wellbeing, it is important to consider which design features or affordances of the device promote rather obstruct ICT adoption and engagement. We identified a number of prototype interventions and ICT engagement scenarios, which focused on the user interface and user experience (UI/UX) (Wherton and Prendergast, 2009; Ballantyne et al., 2010; Cornejo et al., 2012; Garattini et al., 2012; Tsai et al., 2012; Jimison et al., 2013; Huang and Hsu, 2014; Waycott et al., 2015; Papa et al., 2016; Chi et al., 2017; Czaja et al., 2018; Zaine et al., 2019). Designing ICTs with attention to the physical and cognitive needs of older adults may increase their usage and facilitate efficacy in reducing loneliness. Several studies focused on improving UI/UX by adapting the ergonomics of the ICT systems from the perspective of older users to facilitate interactions and increase use. For example, the use of EasyReach (a TV social channel with social networking opportunities) was developed for social interaction with near and distanced friends and family. While users perceived it as a way to reduce feeling of loneliness, difficulties in learning to use the system interfered with older adults' abilities to benefit from the device (Papa et al., 2016).

Managing appearance and privacy were two of the important affordances that older users identified as crucial to their desire to use ICTs (Larsson et al., 2013). Online communities that had features that allowed for anonymity and invisibility reduced social anxieties and afforded more confidence when talking to others and trying new things (Nimrod, 2012). Although ICT prototypes, such as pet avatars, were found to be beneficial in fostering social connectedness, some of their limitations included the absence of a face-to-face component, (Garattini et al., 2012) and concerns regarding the quality of the social interaction between participant

and prototype (Chi et al., 2017). Older adults frequently reported concerns about the complexity of technology, as well as the security of private information, including identity theft (Pfeil et al., 2009; Wherton and Prendergast, 2009; Garattini et al., 2012).

Internet Communication and Technologies which featured open chats, were found to have caused frustration among users. For example, frequent system users became frustrated when they received no responses or delayed responses when sending messages or calls (Garattini et al., 2012). These frequent users were women and individuals showing indications of social loneliness which suggest gender (Garattini et al., 2012; Kim et al., 2016) and levels of loneliness (Garattini et al., 2012) are factors to consider when designing ICT features and interventions. As Wherton and Prendergast (2009) have shown, it is important to be mindful of the gender inequality gap and keep ICTs simple and consistent with the needs and requirements of users to promote ICT adoption by older adults.

4.4. Challenges and limitations

A common challenge in reviewing the literature on the association between ICT interventions, loneliness and social connectedness was the heterogeneity of methodologies, statistical reporting (i.e., effect sizes), range in sample sizes across studies, and the diversity in ICT devices. For example, this review includes RCTs, cross sectional designs, quasi experiments, case series and cohort studies. Sample sizes ranged from 1 to 11,000 and there were seven different ICT categories (i.e., digital games, iPad, prototypes, computer, video, social media, and smartphone). Within each category there was heterogeneity in the features of the devices and interventions A lack of methodological consistency contributes to result inconsistency.

The diversity in this data set prohibited us from making conclusive assertions about what factors explain or obscure the association between ICTs, loneliness, and social connectedness. For instance, potential benefits from group ICT training may be to a larger extent related to the support provided by facilitators or family members than the intervention itself (Billipp, 2001). Or, novelty may have played a part in improving wellbeing, by providing new opportunities to enhance leisure, communication, and social connectedness during the experiment, but it is not clear whether such effects would remain.

Given the literature searches were performed in 2020, we did not include articles published during the COVID-19 pandemic. However, our review provides a first step in mapping the ways in which ICTs are related to loneliness and social connectedness not affected by the pandemic. This is important as ICT use/intervention studies during the pandemic would have removed features of in-person social contact, which as demonstrated in our review, can affect the association among ICT use, loneliness, and social connectedness. Future researchers may find this article useful when comparing ICT interventions pre, during and post pandemic. Final limitations of our review are that it is specific to healthy older adults and excludes those with impairments or serious health conditions. Such conditions are prevalent with aging. Therefore, future reviews should strive to include them in their research. Additionally, we did not account for possible publication biases.

5. Conclusion

5.1. Summary of findings

Prior to this review it was unknown to what extent ICTs were associated with loneliness and social connectedness. The objective was to identify the dominant themes and findings in the literature surrounding this topic and to try and uncover what other factors may be contributing to these associations. We have provided readers with a way to map out ways in which these associations may or may not exist. For example, we conclude that the majority of studies surveyed demonstrate that ICT use among older adults is associated with reduced loneliness by supplementing existing social connections, by allowing for reconnection and formation of new relationships. ICTs that provide opportunities for leisure and learning are found to be enjoyable and foster intergenerational connections, which in turn has positive effects on psychosocial wellbeing. Learning and/or training to use ICTs has a positive relation to self-efficacy, self-esteem and autonomy, and independence. As such, our findings highlight the necessity of addressing the heterogeneity of older adults' and their ICT preferences, motives, capabilities and concerns, and most importantly pre-existing social connections, to address the intertwined complexities among ICTs, loneliness, and wellbeing.

5.2. Implications for future studies

A strength of this scoping review is that it utilizes research from a range of multidisciplinary databases within the fields of Psychology, Sociology and Medicine. This extensive literature search provides an overview of the scholarly work in this field (more than 8,000 articles satisfying the initial search) and the limited number of empirical studies that satisfied our inclusion criteria (only 54 articles). The literature covered within this review encompasses both qualitative and quantitative methodologies. It is clear that a mixed methods approach provides a deep and nuanced perspective on the multiplicity of factors at play in the study of how older adults engage with ICTs and how given interventions improve wellbeing. At the same time, our review reveals the necessity of considering the context of ICT use, and the overall adoption of ICTs over the life course. Operational complexity of accounting for these variations in controlled trials underlines the difficulty of solely quantitative methodologies in establishing the health benefits of ICT interventions. Such a perspective goes beyond measuring the variations that arise from the biological factors associated with aging, as it takes seriously the psychological, social and cultural conditions that modulate the experiences of older adults in their homes or even the laboratories where some of these empirical experiments have taken place. Paying attention to these variations is a reminder of the range of motivations for the use of ICTs by older adults, as well acknowledging their preferences and their agency. Additionally, this review does not appraise the quality of evidence in terms of which ICT devices or interventions effectively reduce loneliness and improve wellbeing. As such, a systematic review focusing on this causal relation would be of great benefit

to this field of research and those designing ICTs, but a greater number of RCTs is needed to perform this review. This review can help inform future researchers to consider the importance of implementing aspects of social connection, training format, leisure, easy to use design features and affordances into their ICT designs or interventions as a way to improve wellbeing. We have provided a starting point for future mediation and moderation analyses given we have identified several contributing factors to ICT and social construct associations.

Author contributions

SH, BP, and CM identified a research question. BP and CM performed a literature search, selection, and review. BP, NK-M, and SH analyzed the data, extracted the themes, and wrote the manuscript. All authors provided feedback, reviewed 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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EDITED BY
John F. Hunter,
Chapman University,
United States

REVIEWED BY
Malinda Desjarlais,
Mount Royal University,
Canada
Kim Sawchuk,
Concordia University,
Canada

*CORRESPONDENCE
Jiayi Shi
✉ shijiayi@xjtu.edu.cn

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Online health community for change: Analysis of self-disclosure and social networks of users with depression

Jiayi Shi[1]* and Zhaowei Khoo[2]

[1]School of Foreign Studies, Xi'an Jiaotong University, Xi'an, Shaanxi, China, [2]School of Mathematical and Computer Sciences, Heriot-Watt University, Putrajaya, Malaysia

Background: A key research question with theoretical and practical implications is to investigate the various conditions by which social network sites (SNS) may either enhance or interfere with mental well-being, given the omnipresence of SNS and their dual effects on well-being.

Method/process: We study SNS' effects on well-being by accounting for users' personal (i.e., self-disclosure) and situational (i.e., social networks) attributes, using a mixed design of content analysis and social network analysis.

Result/conclusion: We compare users' within-person changes in self-disclosure and social networks in two phases (over half a year), drawing on Weibo Depression SuperTalk, an online community for depression, and find: ① Several network attributes strengthen social support, including network connectivity, global efficiency, degree centralization, hubs of communities, and reciprocal interactions. ② Users' self-disclosure attributes reflect positive changes in mental well-being and increased attachment to the community. ③ Correlations exist between users' topological and self-disclosure attributes. ④ A Poisson regression model extracts self-disclosure attributes that may affect users' received social support, including the writing length, number of active days, informal words, adverbs, negative emotion words, biological process words, and first-person singular forms.

Innovation: We combine social network analysis with content analysis, highlighting the need to understand SNS' effects on well-being by accounting for users' self-disclosure (content) and communication partners (social networks).

Implication/contribution: Authentic user data helps to avoid recall bias commonly found in self-reported data. A longitudinal within-person analysis of SNS' effects on well-being is helpful for policymakers in public health intervention, community managers for group organizations, and users in online community engagement.

KEYWORDS

online social support, self-disclosure, social network analysis, content analysis, depression, Weibo

1. Introduction

Debate continues about the effects of social network sites (SNS) on well-being. An overwhelming amount of literature has focused on the negative consequences of SNS, including (a) intensive use of SNS, which brings experiences of time displacement and overload (van der Schuur et al., 2019; Prestin and Nabi, 2020; Wang et al., 2021); (b) problematic use of SNS, which

increases levels of psychological distress, work exhaustion, and suicidal ideation and suicide attempts (McConnell et al., 2018; Froehlich et al., 2020); and (c) upward comparison and envy, led by the tendency to compare with the perfected content of others (Batenburg and Das, 2015; Spitzer et al., 2022). On the other hand, accumulating research has highlighted SNS' positive effects, including (a) online social support, which serves as a coping mechanism against negative thoughts and events (Oh et al., 2014; Bi et al., 2020); (b) reduced riskiness of self-disclosure, facilitated by SNS' publicity, broad reach, usability, and immediacy (Pan et al., 2017; Li et al., 2019; Chu et al., 2022); and (c) inspiration and enjoyment, when users reach out for social relationship maintenance (Kim and Kim, 2020; Myrick and Willoughby, 2021).

Given the omnipresence of SNS and their dual effects on well-being, a key research question with practical and theoretical importance is to investigate the various conditions by which SNS may either enhance or interfere with well-being (Ramamoorthy et al., 2021; Valkenburg et al., 2021; Hall and Liu, 2022; Parry et al., 2022). It is to understand why, how, and/or for whom SNS use is associated with well-being (Valkenburg, 2022). As pointed out by some recent reviews, this line of argument has predominantly relied on cross-sectional designs and self-reported measures of SNS use, which can be subject to recall (Hall and Liu, 2022; Parry et al., 2022; Valkenburg, 2022). Similarly, other reviews indicate that studies on SNS use tend to focus mainly on quantity (e.g., time spent, frequency of use) without much consideration of users' content or communication partners (Yoon et al., 2019; Cingel et al., 2022; Oliver, 2022).

We examine users' self-disclosure (content) and social networks (communication partners) to fill the gap. We focus on a group of engaged users who have been within an online community for half a year, thus enabling within-person observation to assess SNS' effects. Users' authentic data also helps to avoid recall bias commonly found in self-reported data (Cingel et al., 2022; Parry et al., 2022). Longitudinal within-person analyses can facilitate public health intervention as more people turn to SNS for online support (Leung et al., 2014; Yang et al., 2017; van der Schuur et al., 2019). This paper is structured as follows. We first provide the theoretical framework, followed by methods, results, and discussion.

2. Theoretical framework

This section will present our theoretical framework. We will demonstrate— between social network analysis and self-disclosure studies—a shared focus on social support embedded in interpersonal relationships, providing the basis for our mixed use of the two approaches to assess SNS' effects on well-being.

2.1. Social support and SNA

With the growing availability of online support communities, questions have been raised about their effects, calling for a more nuanced understanding of online social support. Studies have shown that online users receive emotional comfort, health-related information, belonging support, and health awareness (Oh et al., 2014; Hou et al., 2020; Liu et al., 2021; Lei et al., 2022). Users form supportive, asynchronous, and fulfilling relationships that reduce anxiety and improve life satisfaction in various conditions, such as cancer (Kim et al., 2013; Myrick et al., 2015), depression (Pan et al., 2020; Lu et al., 2021), postpartum depression (Lei et al., 2022), and HIV (Ho et al., 2017; Wang et al., 2018). On the other hand, some have indicated that passive consumption of online support can result in ineffective coping, unwanted help, negative responses, and contradicted suggestions (Batenburg and Das, 2015; Hou et al., 2020; Lin and Li, 2021).

The conflict in the literature lies in the primary focus of understanding social support as an attribute of people surrounding the individual, including the types, amount, and impact of support on the individual (Oh et al., 2014; Zhang and Yang, 2014; Wright, 2016; Liu et al., 2018; Lin and Li, 2021). As a result, these approaches have overlooked social support's relational and structural aspects. As with offline social support, emerging data have increasingly suggested that the effects of online social support are shaped and contextualized by interpersonal relationships between providers and recipients (Eysenbach et al., 2004; Gibbs et al., 2010; Myneni et al., 2016; Joglekar et al., 2018; Levonian et al., 2021). Developing interpersonal relationships is a prerequisite or cause of network structure, and both can affect feelings of social support (Lakey and Orehek, 2011; Ali et al., 2015; Hall and Liu, 2022). Online support contributes to well-being when users engage in ways that foster meaningful interpersonal connections (Reifegerste et al., 2017; Li et al., 2019; Lin and Li, 2021).

Recent developments in Social Network Analysis (SNA) enable researchers to understand how relational data works. SNA defines social networks as the structural framework within which social support is provided or not based on the ties (edges) between individuals or groups (nodes) (Cobb et al., 2010; Lin et al., 2014; Li and Xu, 2020). SNA describes social relationships in terms of contacts and connections. Relational connections enable the exchange between individuals or groups and their feelings, thoughts, and behaviors (Xu and Zhang, 2016; Lin and Li, 2021; Qu et al., 2022). Throughout these connections, individuals and groups share inherent resources, including social support (Phung et al., 2013; Zhang et al., 2017; Li and Xu, 2020; Pan et al., 2020).

In contrast to its potential with relational data, few SNA studies have looked into users' content in online communities about diseases or the characteristics of users' networks (Ramamoorthy et al., 2021). Some of the limited studies have examined social support on social network sites. Some have focused on how individuals are surrounded by relationships that affect their health behaviors, social supports, and health outcomes (Cobb et al., 2010; Yang et al., 2017; Froehlich et al., 2020; Li and Xu, 2020; Liu and Yeo, 2021). Some have examined how network structures can facilitate social support, disseminate health-related information, and increase health awareness (Joglekar et al., 2018; McConnell et al., 2018; Bi et al., 2020; Lei et al., 2022).

Publications that concentrate on SNA of online social support more frequently use static projections of networks, in which they use community detection approaches or identify groups at a specific moment in time as the means of describing the networks (Yang et al., 2017; Froehlich et al., 2020). Nevertheless, longitudinal networks are better analyzed through snapshots since networks are temporal objects whose edges and nodes change over time (Leung et al., 2014; Ramamoorthy et al., 2021; Yang et al., 2021). Online support networks develop in phases (early and late), with some users remaining engaged for a long time while others join and leave. In each phase, network-level attributes can explain group communication and support

network, including connectivity, global efficiency, average clustering coefficient, and degree centralization (Froehlich et al., 2020; Li and Xu, 2020; Yang et al., 2021); and node-level attributes can evaluate the role of individuals and their dynamic interaction, including degree and betweenness centralities (Cobb et al., 2010; Joglekar et al., 2018; Li and Xu, 2020).

SNA investigates the interpersonal communication network in disseminating information, transmitting social support, and affecting health behavior and outcome. Content produced by users in the network deserves equal attention, including, most importantly, users' self-disclosure.

2.2. Self-disclosure and social support

People nowadays increasingly disclose themselves on social network sites (SNS). The process of revealing the previously unknown to others through user-generated content is called self-disclosure (Gibbs et al., 2010). Literature on self-disclosure focuses on self-disclosure's content and impact (Huang, 2016; Chu et al., 2022).

Researchers can analyze mental health outcomes that reflect users' well-being based on self-disclosures on SNS. Several self-disclosure studies focus on detecting depression, a common and important negative indicator measured in social media and well-being literature (Balani and De Choudhury, 2015; Xu and Zhang, 2016; Leis et al., 2019; Lu et al., 2021). In that regard, well-being can be defined as a spectrum on which there is both the presence and absence of mental health. Well-being can be measured by various positive and negative indicators, such as life satisfaction or depression (Houben et al., 2015; Hall and Liu, 2022; Valkenburg, 2022). Psychological studies examine the concept of well-being in the context of specific mental disorders (e.g., depression, panic disorder, post-traumatic stress disorder) that interfere with individuals' sense of autonomy, self-esteem, and growth (Ryff, 2014; Zhang et al., 2022). A person suffering from depression may experience and express persistent sadness, physical pain, shame, negative emotions such as anger and self-loathing, a loss of interest in daily activities, and suicidal thoughts in certain circumstances (Yoon et al., 2019). Consequently, researchers have found that using first-person singular pronouns, negative emotion words, and death words are important self-disclosure attributes that help reveal depression symptoms (Rosenquist et al., 2010; Leis et al., 2019; Tadesse et al., 2019).

Another line of argument relates to the impact of self-disclosure on well-being (Luo and Hancock, 2020; Chu et al., 2022). By addressing negative emotions, self-disclosure can ease depressive moods and improve mental well-being, making it a valuable therapeutic ingredient. Individuals' ability to recover from adversity can be enhanced by sharing their stories with others. According to Pennebaker et al. (2015), participants assigned to a writing assignment of traumatic and upsetting experiences showed benefits to their immune systems. Discourse about emotionally loaded traumatic events can be a safe way to confront mental illness.

The literature, however, provides contradictory findings regarding the benefits of self-disclosure on SNS. Online communication's anonymity, publicity, wide reach, and immediacy make self-disclosure a double-edged sword. On the one hand, researchers have suggested that bloggers benefit from self-disclosure in maintaining and extending their human relations, which improves mental well-being (Lee et al., 2019; Luo and Hancock, 2020). Posting on SNS tends to reduce the perceived riskiness of self-disclosure, thus encouraging people to express themselves openly, vent negative feelings, and seek social support (Huang, 2016; Ho et al., 2017; Malloch and Taylor, 2018; De Simoni et al., 2020). On the other hand, while online communities involve the interaction of at least two subjects, these objects are typically unclear and unstable unless they have been targeted and notified. A long-term absence of objects during self-disclosure may lead to self-isolation and loneliness for some users (Gibbs et al., 2010; Luo and Hancock, 2020; Chu et al., 2022). When users feel ignored or excluded in online interpersonal interaction, they may experience cyberostracism (Zhang et al., 2022). Aside from this, when users disclose personal information (such as feelings, experiences, and thoughts), they expose themselves to cyberbullying risk since other users may have different values and cognitive preferences. Thus, users in online communities need to be able to establish a friendly semantic environment for digital communication in order to avoid negative consequences of self-disclosure, such as cyberbullying and cyberostracism (Gibbs et al., 2010; Pan et al., 2017).

Reconceptualizing self-disclosure in relational contexts may provide a valuable framework for reconciling the conflict in the literature. More recently, some researchers have recognized the critical need to study the mediation effect of social support in the self-disclosure to well-being link, highlighting the fact that self-disclosure and its associations with well-being are complicated and context-dependent (Hou et al., 2020; Chu et al., 2022; Lei et al., 2022). However, additional research on self-disclosure incorporating users' relational contexts (i.e., communication partners) is urgently needed, especially in light of online communities' rising popularity. Social deficiencies among offline social circles or limited access to like-minded individuals have made online communities especially attractive for social connection (Liu et al., 2018). For example, compared to face-to-face support networks, online health communities are frequently used by individuals whose primary social network (i.e., friends and family) has limited knowledge of their health condition (Wright, 2016; Yoon et al., 2019; Pechmann et al., 2020). The study of how users' self-disclosure content relates to social support in relational contexts has important implications for improving social connections within online communities.

Collectively, as we have synthesized in this section, social network analysis and self-disclosure studies outline a critical need to understand SNS and their effects on well-being in a network of interpersonal relations that enhance or interfere with social support. Social support on SNS is perceived, received, and achieved in a network of relationships surrounding the users, whose self-disclosure triggers partner responsiveness and group interaction.

Our research aims to assess SNS's effects on well-being by accounting for users' content (self-disclosure) and communication partners (social networks) in the online support community. We use a mixed method of social network analysis and content analysis. Based on our literature review, mixing the two approaches is based on their shared emphasis on social support embedded in interpersonal relationships. In the following sections, relevant literature will be used to explain and support the findings with regard to three research questions. We will utilize SNA to answer research question 1, a content analysis of self-disclosure to answer research question 2, and a comprehensive analysis of users' networks and self-disclosure to

answer research question 3. We will describe our analytical procedures and the results based on the following research questions:

1. How would the dynamics of network structure strengthen or hinder social support?
2. How would the changes in users' self-disclosure reflect their mental well-being?
3. How can users obtain more social support through self-disclosure?

3. Materials and methods

3.1. Data collection and methods

For the current study, we choose a social network site called the Depression Supertalk[1] in Weibo. For a longitudinal comparative analysis, we collect data during July 2021 (phase 1) and January 2022 (phase 2). To have a within-person research design, we group the overlapped users in two phases and refer to them as engaged users ($N=221$). As suggested by some research, engaged users who stay within one community tend to develop a sense of community, which refers to the degree to which an individual identifies with members within the community (Eysenbach et al., 2004; Carron-Arthur et al., 2015). We use a customized Web crawler (script written in Python) to extract engaged users' attributes, including user ID, gender, posts, in-replies, out-replies, number of likes, number of retweets, and comment users.

We construct the social network formed by the post-reply connections of the engaged users and others. We name the constructed network the Depression Supertalk Network (DSN), a multi-directed network with self-loops and multiple edges. We compute and compare the DSN in phase 1 and phase 2 to show its dynamics, drawing on a set of well-established metrics in SNA (see section 3.2). We use Anaconda Python 3.6[2] for data collection, NetworkX 2.2[3] for network analysis and visualization, and GraphPad Prism 9.3.1[4] and SPSS 27[5] for statistical analysis.

We segment and tokenize users' posts and comments for content analysis with Butter[6] and feed the data into the Chinese version dictionary of Linguistic Inquiry Word (SC-LIWC),[7] a validated and well-adopted toolkit for psychometric analysis in mental expression research (Lieberman, 2007; Pennebaker et al., 2015; Xu and Zhang, 2016; Lumontod and Robinson, 2020). LIWC classifies the input words into four categories: linguistic processes (e.g., pronouns, adverbs), psychological processes (e.g., emotions and cognitive process), personal concerns (e.g., biological concerns, death), and spoken (everyday language use). The resulting categories are standardized as the occurrence rate of corresponding categorical words in the messages. Further, these categories can be used as linguistic and psychometric indicators of depression.

3.2. Measures

We use a set of well-established network-level and node-level attributes to analyze the dynamics of the DSN (see Table 1). Network-level attributes include global efficiency, average clustering coefficient, and degree centralization; node-level attributes include in−/(out−) degree, in−/(out−) degree centrality, and betweenness centrality.

To analyze the topological position of the users, we calculate in-degree centrality, out-degree centrality, and betweenness centrality. In the DSN, a unique node in the network represents a unique user ID. An edge between two nodes represents the existence of a reply-to relationship between the two corresponding nodes. A directed arrowhead stands for the direction of the comment: an inbound link represents in-reply to the user, and an outbound link represents the user's out-reply to others. In-degree counts inbound links directed toward a node, representing the extent others contact a user. It proxies the amount of social support a user receives (Yang et al., 2017; Froehlich et al., 2020). Out-degree is the number of connections initiated by a user, which proxies the social support a user offers to others (Zhang and Yang, 2014; Li and Xu, 2020). A node's degree centrality is the fraction of nodes its edges are connected to. Betweenness centrality indicates the extent to which a node occupies an intermediary position on the shortest paths connecting other nodes and serves as a potential go-between. Depending on the betweenness score, some nodes act as a bridge for clusters, while others remain isolated within a local cluster (Froehlich et al., 2020; Yang et al., 2021).

For the view of the whole network, we analyze global efficiency, average clustering coefficient, and degree centralization. Global efficiency concerns network closeness. It calculates the average geodesic distance, i.e., the mean value of the distance between all pairs of nodes (Knoke and Yang, 2008). The average clustering coefficient is the mean of the fraction of ties among a node's contacts over the possible number of ties between them (Bi et al., 2020). Degree centralization is the overall integration or consistency of the graph (Li and Xu, 2020).

In terms of content analysis, we use LIWC as a language model to capture linguistic and psychological attributes in users' self-disclosure, quantity (duration, frequency, breadth), and quality (valence, authenticity, intention) (see Table 1).

Duration: The writing length reflects the users' self-disclosure through sharing personal thoughts, ideas, and feelings with others. It proxies users' amount of communication and activeness in involvement (Lieberman, 2007; Batenburg and Das, 2015; Pan et al., 2017). LIWC captures the writing length as word count, i.e., the mean of the number of words in a post.

Breadth: Breadth of self-disclosure related to the range of topics covered within self-disclosure. Some words provide experiential information about psychosocial experiences of depression, including first-person singular forms, biological process words, and death words (Rosenquist et al., 2010; Leis et al., 2019; Tadesse et al., 2019).

1 Depression Supertalk (Weibo Depression SuperTalk, 2022), one of the largest health communities in Weibo, founded in Sep. 2019. According to its agenda, all members have self-tested or have been clinically diagnosed with depression. The community encourages its members to discuss problems, exchange suggestions, and share support to cope with depression.

2 https://anaconda.com

3 https://networkx.github.io

4 https://www.graphpad.com

5 https://www.ibm.com

6 https://www.butter.tools

7 https://www.liwc.app/

TABLE 1 Data and variable description.

Variable[A]	Operational definition	Description
Social network data		
Post	The number of posts by a user.	The total number of posts contributed to the forum indicates members' participation in the community.
In-reply	The number of comments left for a user's post.	It proxies social support received by the user, especially information support.
Out-reply	The number of replies a user gives to others.	It proxies the amount of social support a user provides to others.
Like	The number of posts that are rated favorable by other users.	It gauges the amount of social support received by a user, especially emotional support.
In-degree	The number of inbound links directed toward a node.	It proxies to what extent others contact a user in the network. It gauges the amount of social support received by a user.
Out-degree	The number of connections initiated by a user (outbound links from a node) in his/her social network.	It proxies the social support a user offers to other members.
Betweenness-centrality	The proportion of the shortest paths between pairs of two nodes traversing through a node.	It proxies the importance of a node for the interactions of other nodes in the network.
(Out−/in-) degree centrality	A node's (out−/in-) degree centrality is the fraction of nodes its edges are connected to.	It gauges the importance of a given node in the information flow.
Global efficiency	It calculates the average geodesic distance, i.e., the mean value of the distance between all pairs of nodes.	Global efficiency is inversely related to the topological distance between nodes and proxies the information transfer efficiency of the network.
Average clustering coefficient	It is the mean of the fraction of ties among a node's contacts over the possible number of ties between them.	It quantifies the extent to which neighboring nodes are connected.
Degree centralization	Degree centralization is the overall integration or consistency of the graph.	It measures the distribution of positional advantages of nodes in the network.
Self-disclosure		
Quantity		
Breadth	1st person singular pronouns (i); death words (death); biological process (bio)[B]	Bio-words refer to primarily factual information related to health information users share, including symptoms, treatments, and embodied experiences of depression. Death words are linked to suicidal ideation and suicide attempts. First-person singular pronouns reflect self-references.
Duration	*Writing length (WC)*	Writing length represents the degree of community involvement. It proxies a desire for social support, for it denotes the intimacy and the emotional attachment the members have toward the online health community.
Frequency	Active day	Count as the number of days the users post in the community. It gauges users' self-disclosure frequency and attachment to the community.
Quality		
Valence:	Negative emotion (negemo); positive emotion (posemo); cognitive process (cogproc)	Positive and negative valences reflect the hedonic aspect of well-being. Cognitive processing words reveal the depth and complexity of users' thinking, demonstrating the eudaimonia aspects of well-being.
Authenticity	Adverb (adverb)	Adverbs emphasize the degree and extremeness. Adverbs indicate sentiment and authenticity in self-presentation.
Intention	Informal words (informal)	Informal language use emphasizes in-group membership and a commitment to group integration. It enhances support seekers' legitimacy in soliciting help.

[A]For the comparative design of this study, all variables were recomputed in both phases (July 2021 and January 2022).
[B]LIWC code in square.

Accordingly, we use the LIWC score on first-person singular forms (i-words), biological process words (bio-words), and death words. Biological process words include sub-dimensions, including body, health/illness, sexuality, and ingesting.

Frequency: Active day counts the number of days the user posts in the group. It shows users' attachment to the community. It proxies users' desire to self-present and community-involvement (Liang et al., 2019).

Valence: Psychological well-being includes psychological adjustment and negative maladjustment (Calancie et al., 2017). It conceptualizes hedonic aspects (e.g., positive and negative feelings) and eudaimonic well-being (e.g., cognitive assessment of life) (Houben et al., 2015; Oliver, 2022). LIWC captures the former as negative and positive emotion words, in which negative valence systems consist of anxiety, anger, and sadness. The latter is captured by cognitive processing words and further classified into

causation, insight, discrepancy, inhibition, tentativeness, and certainty.

Authenticity: Adverbs (e.g., very, really) often emphasize the degree and extremeness. Adverbs indicate sentiment and authenticity in self-presentation. Absolute words, such as 'always' and 'never,' are also reliable markers for diagnosing mental illness (Huang et al., 2019).

Intention: Informal language emphasizes in-group membership and a commitment to group integration (Pan et al., 2017). It also enhances support seekers' legitimacy in soliciting help. LIWC captures it as 'informal language' with five sub-dimensions: swear words, netspeak, assent, nonfluencies, and fillers.

4. Results

To facilitate the presentation and interpretation of the results, we will divide this section into three parts, each focused on a research question.

4.1. Results of social network analysis (SNA)

1. How would the dynamics of network structure strengthen or hinder social support?

We analyze engaged users' longitudinal networks in snapshots: phase 1 (July 2021) and phase 2 (January 2022). In phases 1 and 2, apart from 221 engaged users, there were 815 users and 868 users who interacted with the engaged users in the DSN, respectively.

Table 2 provides a descriptive analysis of the node-level attributes of the 221 engaged users. Engaged users' in-degree (received support) increased from phase 1 ($M = 6.30$, $SD = 11.65$) to phase 2 ($M = 7.27$, $SD = 18.30$), but this difference did not reach statistical significance, $t_{220} = -0.886$, $p = 0.38$. Conversely, a paired t-test indicated a significant difference between out-degree in phase 1 ($M = 0.96$, $SD = 0.99$) and phase 2 ($M = 0.64$, $SD = 0.91$), $t_{220} = 3.76$, $p < 0.01$. The in-degree range was larger than the out-degree in both phases, and there was more variability across the users' in-degree than out-degree. The range and variability of in-and out-degree describe whether the population is homogeneous or heterogeneous in structural positions. While the coefficient of variation was higher for in-degree than out-degree in both phases, it shows that the population was more homogeneous concerning the out-degree (offering support to others) than in-degree (receive support from others).

Table 3 presents a descriptive analysis of the network-level attributes. The DSN developed better connectivity and non-centric group interaction, evidenced by increased global efficiency, higher average clustering coefficient, and low degree centralization. Global efficiency proxies social transmission and is inversely related to the topological distance between nodes. In phase 2, the global efficiency increased from 0.20 to 0.24, indicating a closer topological distance between nodes and better network connectivity. The average clustering coefficient is a measure more weighted to the local environment of each node, as it quantifies the extent to which neighboring nodes connect (Qu et al., 2022). It measures the probability that two friends of a user are also friends. The average clustering coefficient of the DSN increased from 0.0026 to 0.0044, indicating better network connectivity in phase 2. Degree centralization shows the overall integration or consistency of the graph (Li and Xu, 2020). It measures the distribution of positional advantages of nodes. Highly centralized networks feature one or few individuals monopolizing network interactions (e.g., An extreme example resembles a star network, when all individuals connect to only one individual). The DSN featured low degree centralization (phase 1 = 0.11; phase 2 = 0.23), which suggests a low distribution of positional advantages of nodes. In other words, the low degree centralization showed that the DSN featured non-centric group interaction.

To demonstrate the dynamics of the DSN, we compute the social network structures of phase 1 (Figure 1A) and phase 2 (Figure 1B). We differentiate the engaged users as red nodes and users who interacted with the engaged users as black nodes. Users increased slightly, indicating the expansion of the DSN. The clusters of red nodes in phase 2 showed that engaged users developed a denser network. A directed arrowhead stands for the direction of the comment, with an inbound link representing in-reply to the user and an outbound link representing out-reply the user gives to another user. Inbound links (phase 1: $n = 4{,}367$; phase 2: $n = 4{,}860$) overwhelmed outbound links (phase 1: $n = 1700$; phase 2: $n = 1{,}412$) for engaged users, suggesting they received much more social support than they offered support to others. Significant correlation between in−/out-reply attributes showed reciprocal group interaction in the DSN (phase 1: $r_{219} = 0.69$, $p < 0.001$; phase 2: $r_{219} = 0.68$, $p < 0.001$). Also, fewer self-loops in phase 2 meant an overall increase in group interaction.

We use the Louvain algorithm to identify the communities in the DSN (Blondel et al., 2008). The Louvain algorithm draws on maximizing modularity. A community's modularity is measured by its density at the inner edges compared to the other edges in the network. Louvain's algorithm starts with small communities and iteratively merges them into communities with maximum modularity. There were 58 communities in phase 1 (see Figure 2A) and 50 in phase 2 (see Figure 2B). Users clustered in more extensive and denser communities. The DSN increasingly formalized solid communities and strong ties inside the communities. Smaller communities progressed into larger ones through cohesive social ties, interactions, and associations. The density of users within communities was higher in phase 2 ($M = 21.78$, $SD = 29.72$, range 1–189) than in phase 1 ($M = 17.86$, $SD = 21.08$, range 1–98). The density of users with more than 10 nodes was also higher in phase 2 ($M = 36.29$, $SD = 33.23$, range 11–189), compared with that of phase 1 ($M = 32.40$, $SD = 20.47$, range 12–98) (see Figures 2C,D).

The degree centrality means the number of edges connected to the nodes without considering the arrowhead. Nodes with a greater degree centrality remained robust and grew in size in phase 2 (see Figures 3A,B). Correlation results showed a significant correlation between in-degree and betweenness centrality (phase 1: $r_{219} = 0.95$, $p < 0.001$; phase 2: $r_{219} = 0.99$, $p < 0.001$); therefore, as betweenness increased, so would in-degree. Out-degree centrality and betweenness centrality did not consistently show significant correlation (phase 1: $r_{219} = 0.40$, $p < 0.001$; phase 2: $r_{219} = 0.11$, $p =$ NS). Therefore, actors with higher in-degree centrality values showed a higher intermediary position in the network. Moreover, 13 hubs—the most connected nodes in each community (Montes et al., 2020)—in phase 1 remained in phase 2, indicating increased influence and engagement of these users. Hubs have important structural positions in each module, often associated with group control and stability functions (Fortunato, 2010).

We present log–log plots for the in-degree and out-degree distribution of the engaged users (Figures 4A,B). Engaged users received more evenly distributed social support, and more users

TABLE 2 Descriptive analysis of node-level attributes of the engaged users (n=221), M (SD).

Node attributes	Phase	Range	M (SD)	Variance	Coefficient of variation
In-degree	1	1–112	6.30 (11.65)	135.68	184.89%
	2	1–255	7.27 (18.30)	334.76	251.66%
Out-degree	1	0–8	0.96 (0.99)	0.99	103.33%
	2	0–6	0.64 (0.91)	0.83	142.34%
Degree	1	1–114	6.22 (12.04)	144.90	193.57%
	2	1–225	7.27 (18.44)	340.06	253.65%
Betweenness centrality	1	0–0.34	0.01 (0.03)	0.001	294.18%
	2	0–0.45	0.01 (0.03)	0.001	376.97%

TABLE 3 Descriptive analysis of the network-level attributes in two phases.

Network attributes	Phase 1	Phase 2
Edges	1,316	1,551
Nodes	1,036	1,089
Global efficiency	0.20	0.24
Average clustering coefficient	0.0026	0.0044
Degree centralization	0.11	0.23
Communities	58	50

started to offer support to others: because in-degree is associated with receiving social support, and out-degree with offering support (Yang et al., 2017; Froehlich et al., 2020). Figure 4A shows fewer users with low in-degree in phase 2. Further evidence of more evenly distributed social support comes from the lack of a 'long tail' effect in the in-degree distribution in phase 2. Social support increasingly prevailed among the engaged users. In Figure 4B, the out-degree distribution shows a similar pattern, with more engaged users offering social support to others.

Still, we have found an uneven distribution of social support in the DSN. There was a characteristic power-law 'long tail' in the DSN (see Figure 5). All log–log plots were close to linear. Edges were power-law distributed, resulting in few nodes having many edges and many nodes having few edges (Knoke and Yang, 2008). Louvain community detection provides further evidence of the uneven distribution of social support. Eighteen clusters in phase 1 and 16 clusters in phase 2 had less than three nodes (with one user and one commenter, or self-loops), indicating social support scarcity for some users in the DSN. However, the power-law fit suggested more evenly distributed social support for the DSN and subnetworks of engaged users. For the DSN, the slope for in-degree power law distribution was steeper in phase 1 ($\alpha=-1.18$, $R^2=0.99$, see Figure 5A) compared to phase 2 ($\alpha=-1.13$, $R^2=0.98$, see Figure 5C). For the subnetworks of engaged users, the slope for in-degree power law distribution was steeper in phase 1 ($\alpha=-1.22$, $R^2=0.73$, see Figure 5B) compared to phase 2 ($\alpha=-1.08$, $R^2=0.92$, see Figure 5D).

4.2. Results of content analysis

2. How would the changes in users' self-disclosure reflect their mental well-being?

A descriptive analysis of self-disclosure attributes suggested a positive change in engaged users' mental well-being (see Table 4). A decrease occurred in first-person singular forms, negative emotion words, and death words between phases 1 and 2. First-person singular forms can help detect depression since self-references are more frequent among depressed people: A person experiencing physical or emotional pain tends to focus more on themselves and thus use more first-person singular forms (Rosenquist et al., 2010; Leis et al., 2019; Tadesse et al., 2019). Less use of first-person singular suggests that users might experience less thus express less personal physical or emotional pain. There was a decrease in the use of death words meaning less expression of suicidal thoughts and attempts (Lumontod and Robinson, 2020). Emotions reflect the hedonistic aspect of well-being (Houben et al., 2015). Increasing positive emotion words and decreasing negative emotion words indicated positive change related to hedonic aspects of well-being. Words that reflect cognitive processing reveal the depth and complexity of people's thinking, which reflects the eudaimonic aspects of well-being (Oliver, 2022). An increase in cognitive process words indicated positive changes related to well-being on the eudaimonic level.

Previous research has found that using first-person singular pronouns, negative emotion words, and death words are important self-disclosure attributes that help reveal depression symptoms (Rosenquist et al., 2010; Leis et al., 2019; Tadesse et al., 2019). In this sense, engaged users showed less depression symptoms. There was a significant difference in the amount of negative emotion words between phase 1 ($M=6.33$, $SD=7.54$) and phase 2 ($M=5.09$, $SD=5.22$); $t_{220}=2.26$, $p=0.03$. There was a marginally significant difference in the amount of first-person singular forms between phase 1 ($M=5.19$, $SD=5.77$) and phase 2 ($M=4.35$, $SD=4.46$); $t_{220}=1.71$, $p=0.08$. The amount of death words also decreased from phase 1 ($M=0.41$, $SD=1.40$) to phase 2 ($M=0.33$, $SD=1.58$), but this difference did not reach statistical significance. Moreover, there was a significant difference in number of active days between phase 1 ($M=2.62$, $SD=3.48$) and phase 2 ($M=4.96$, $SD=5.60$); $t_{220}=-12.82$, $p<0.001$, suggesting engaged users' increased attachment and self-disclosure frequencies in the DSN.

The DSN was overwhelmed with death words, bio-words, and negative emotion words, compared to Twitter, blogs, and expressive writing (see Table 4). The overuse suggested that self-disclosure in the DSN featured topics related to depression, including negative emotions, body-related symptoms, and suicide narration. It was consistent with the group's agenda to allow emotional venting, recovery, treatment, and social support among its members (Weibo

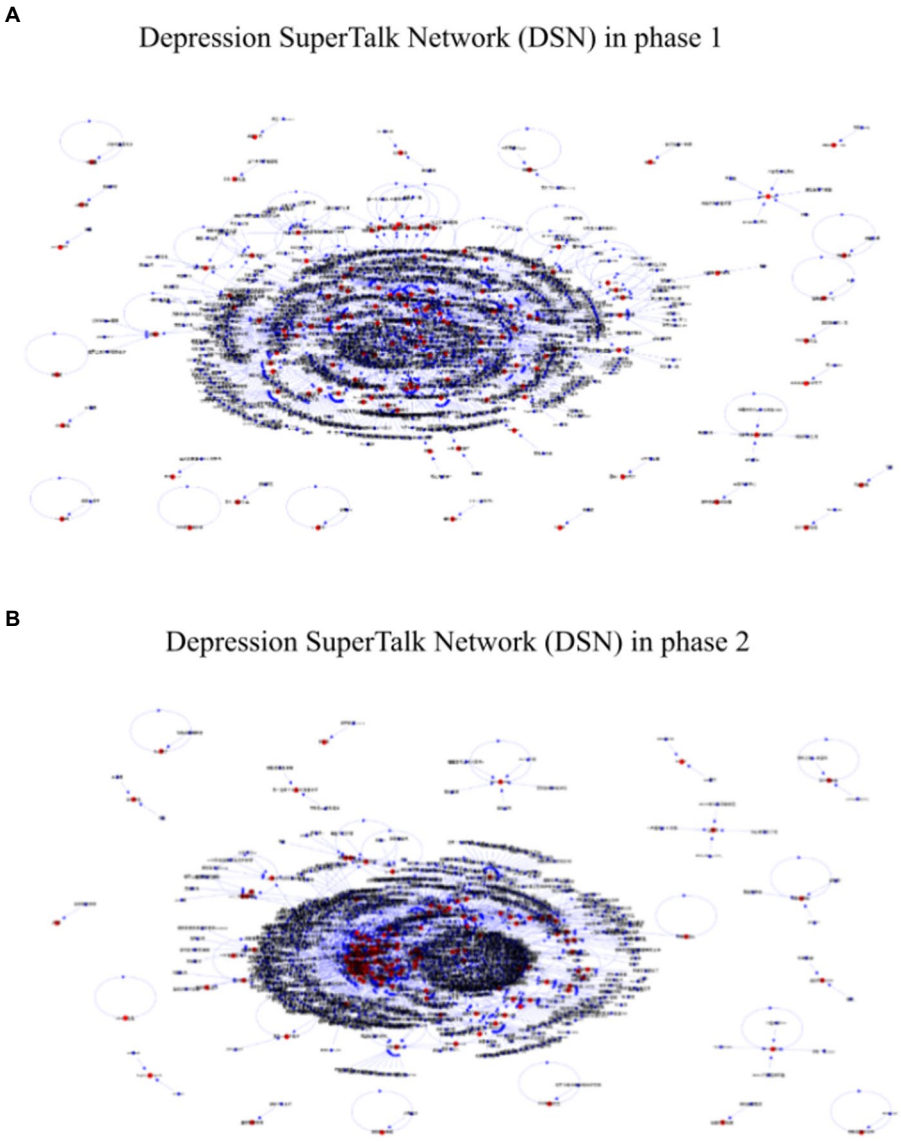

FIGURE 1
Depression SuperTalk Network (DSN) in **(A)** phase 1 (July 2021) and **(B)** phase 2 (Jan 2022). Red nodes (n=221) indicated engaged users who were in the DSN in both phases, and black nodes (n=815 in phase 1; n=868 in phase 2) indicated users who interacted with engaged users. Edges (N=1,316 in phase 1; N=1,551 in phase 2) between nodes were drawn based on reply connections. A directed arrowhead stands for the direction of the reply, with an inbound link representing in-reply to the user and an outbound link representing out-reply the user gives to another user. Note that red nodes clustered together in phase 2. There were more inbound links than outbound links for red nodes. Also, there were fewer self-loops in phase 2.

Depression SuperTalk, 2022). The DSN also used more cognitive process words than other social network sites. One possible explanation is that the DSN is primarily a support group, unlike Twitter, blogs, or expressive writing. Cognitive process words were extensively used to provide suggestions, solicit social support, and self-reflection. We will conduct further research to investigate the differences in self-disclosure between the DSN and various social networking sites.

4.3. Combining SNA with content analysis

3. How can users obtain more social support through self-disclosure?

Overall, the results of SNA indicated that engaged users formed supportive relationships featuring improved connectivity, denser communities, non-centric and reciprocal interaction, and more frequent self-disclosure. Content analysis suggested that engaged users showed positive changes in mental well-being. It might be that these engaged users benefitted from online support when they engaged in the DSN in ways that fostered supportive interpersonal connections. To further access SNS' effects on well-being, we run a correlation matrix and Poisson regression analysis with engaged users' self-disclosure and topological attributes in phase 2, after they have stayed in the community for half a year.

According to the correlation matrix, there were some correlations between topological attributes and self-disclosure attributes (see Figure 6). Significant correlations existed between the writing length

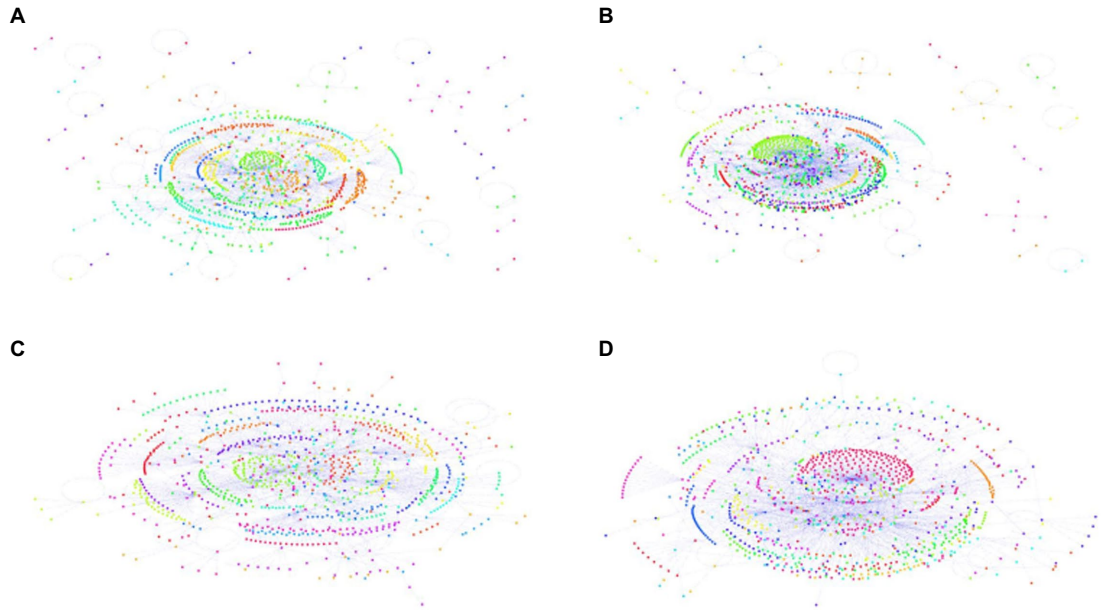

FIGURE 2
Louvain communities detection of the DSN **(A)** all communities in phase 1, **(B)** allcommunities in phase 2, **(C)** sub-communities with over 10 nodes in phase 1, **(D)** sub-communities withover 10 nodes in phase 2. The nodes in the same community calculated using the Louvain algorithmwere depicted using the same color. Note how communities were denser and appeared darker in phase 2 **(B)** than phase 1 **(A)**. Sub-communities with over 10 nodes were denser and appeared darker in phase 2 **(D)** than phase 1 **(C)**.

and topological attributes, including in-degree ($r_{219} = 0.33$, $p < 0.01$), out-degree ($r_{219} = 0.19$, $p < 0.05$), betweenness-centrality ($r_{219} = 0.31$, $p < 0.01$), and likes ($r_{219} = 0.46$, $p < 0.01$). According to the correlation, users' writing length appeared to impact their topological positions significantly.

Further evidence supporting the role of users' content in their topological positions lies in strong correlation between the self-disclosure frequency (i.e., the number of active days) and topological attributes, including in-degree ($r_{219} = 0.62$, $p < 0.01$), out-degree ($r_{219} = 0.19$, $p < 0.05$), betweenness-centrality ($r_{219} = 0.60$, $p < 0.01$), and like ($r_{219} = 0.94$, $p < 0.01$). Based on the correlations, engaged users with a greater self-disclosure frequency were more likely to receive social support, provide social support to others, hold an intermediary position in the network, and receive emotional support from others.

Topological attributes and biological process words (bio-words) correlated, suggesting the homogeneity of the DSN. A significant correlation between bio-words and in-degree ($r_{219} = 0.13$, $p = 0.01$) indicated that users were more likely to receive social support when they posted health-related messages. The correlation between bio-words and like ($r_{219} = 0.02$, $p < 0.05$) suggested that sharing health-related information increased the likelihood of receiving favorable ratings and emotional support. The association between bio-words and betweenness-centrality ($r_{219} = 0.13$, $p < 0.05$) indicated that those who disclose health-related information would have a higher intermediary position and acted as a bridge for different clusters within the network.

After demonstrating how users' self-disclosure affects their topological positions, the other side of the coin is to ask: how can users obtain more social support through self-disclosure? To answer the question, we ran a Poisson regression to predict users' received social support based on their self-disclosure attributes. The Poisson regression method analyzes counts. Log of expected (mean) counts is modeled as a linear function of predictors, constraining predicted responses to be non-negative. Estimated coefficients represent the expected change in the log of the mean for a one-unit change in the corresponding predictor. Odds ratios (ORs) are estimated by exponentiating model coefficients in the inverse of the log link. Poisson regression results are expressed as rate ratios with 95% confidence intervals. Table 5 contains a summary of the Poisson regression results.

In the final model, self-disclosure attributes associated with social support are: writing length (OR: 1.34; 95%CI: 1.27–1.41; $p < 0.001$), informal words (OR: 1.01; 95%CI: 1.00–1.02; $p = 0.01$), adverbs (OR: 0.99; 95%CI: 0.98–1.00; $p = 0.01$), negative emotion words (OR: 0.97; 95%CI: 0.96–0.98; $p < 0.01$), biological process words (OR: 1.04; 95%CI: 1.03–1.05; $p < 0.01$); first-person singular forms (OR: 1.03; 95%CI: 1.01–1.04; $p < 0.01$), and the number of active days (OR: 1.33; 95%CI: 1.04–1.70; $p = 0.02$).

The writing length is the strongest variable that influences users' social support ($p < 0.01$; $\beta = 0.29$). It reflects users' willingness to share information within the group, representing their desire for social support and emotional attachment to the community. The more information users self-disclose, the more engaged and interaction-motivated others will feel.

The number of active days is the second most significant variable affecting social support received by users ($p < 0.01$; $\beta = 0.09$). It is the number of days on which users post messages online. Those who more frequently show up and post are more likely to become acquainted, increasing their chances of receiving social support.

Biological process words ($p < 0.01$; $\beta = 0.04$) and first-person singular forms ($p < 0.01$; $\beta = 0.03$) also affect users' social support.

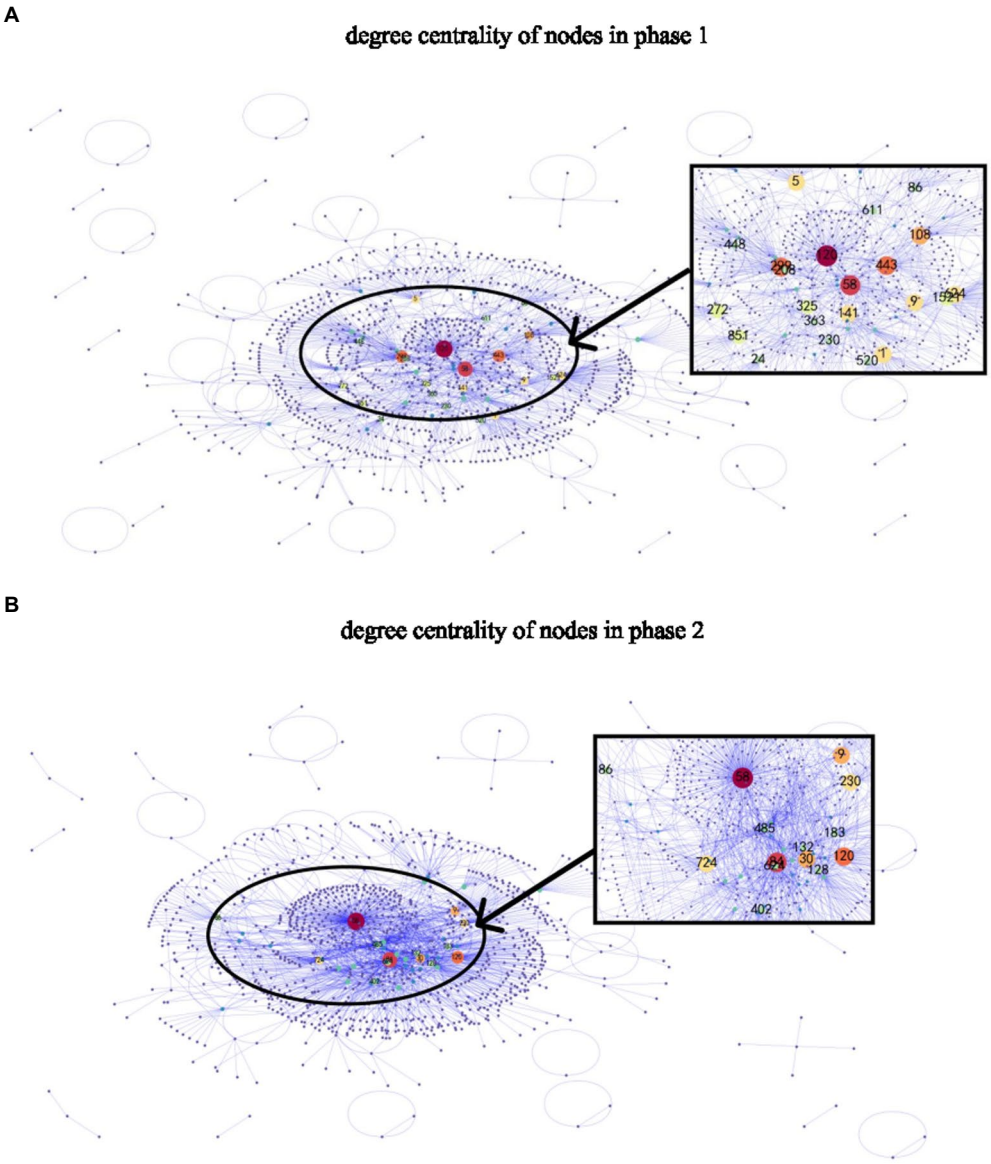

FIGURE 3
Degree centrality of nodes in **(A)** Phase 1, **(B)** Phase 2. The node size reflects degree centrality: the bigger the degree centrality value, the bigger the node size is. Users in both phases were randomly labeled. Note that nodes with big degree centrality in phase 1 remained robust and grew in size in phase 2, indicating increased influence and engagement of these users. 13 nodes remained to be hubs in both phases: 1, 9, 24, 30, 32, 58, 86, 120, 230, 383, 402, 624, 722.

Users discuss depression-related symptoms, treatments, and embodied experiences. Health-related experiences fit the group's common interests and would garner social support. People who express their concerns are likely to detail their experiences with depression in more depth, which will likely provoke others to recall similar experiences and obtain their social support.

Conversely, the use of negative emotion words ($p < 0.01$; $\beta = -0.03$) and adverbs ($p = 0.01$; $\beta = -0.01$) adversely impacts the social support received by users. The use of adverbs in expressions indicates extremeness; too much use may make others question the message's validity. Adverbs have a negative correlation with like ($r_{219} = -0.132$, $p < 0.05$, see Figure 6), indicating lower odds of receiving favorable ratings when using more adverbs.

Lastly, informal words can also affect social support received by users. Using informal words makes the users appear courteous and well-mannered, which allows them to receive more social support online.

5. Discussion

Our study aims to assess SNS' effects on well-being in light of the ongoing debate and ambiguous results (see section 2). The findings echo the need to bring in within-person analyses accounting for users' personal and situational differences. SNS' effects on well-being are not uniform or one-directional.

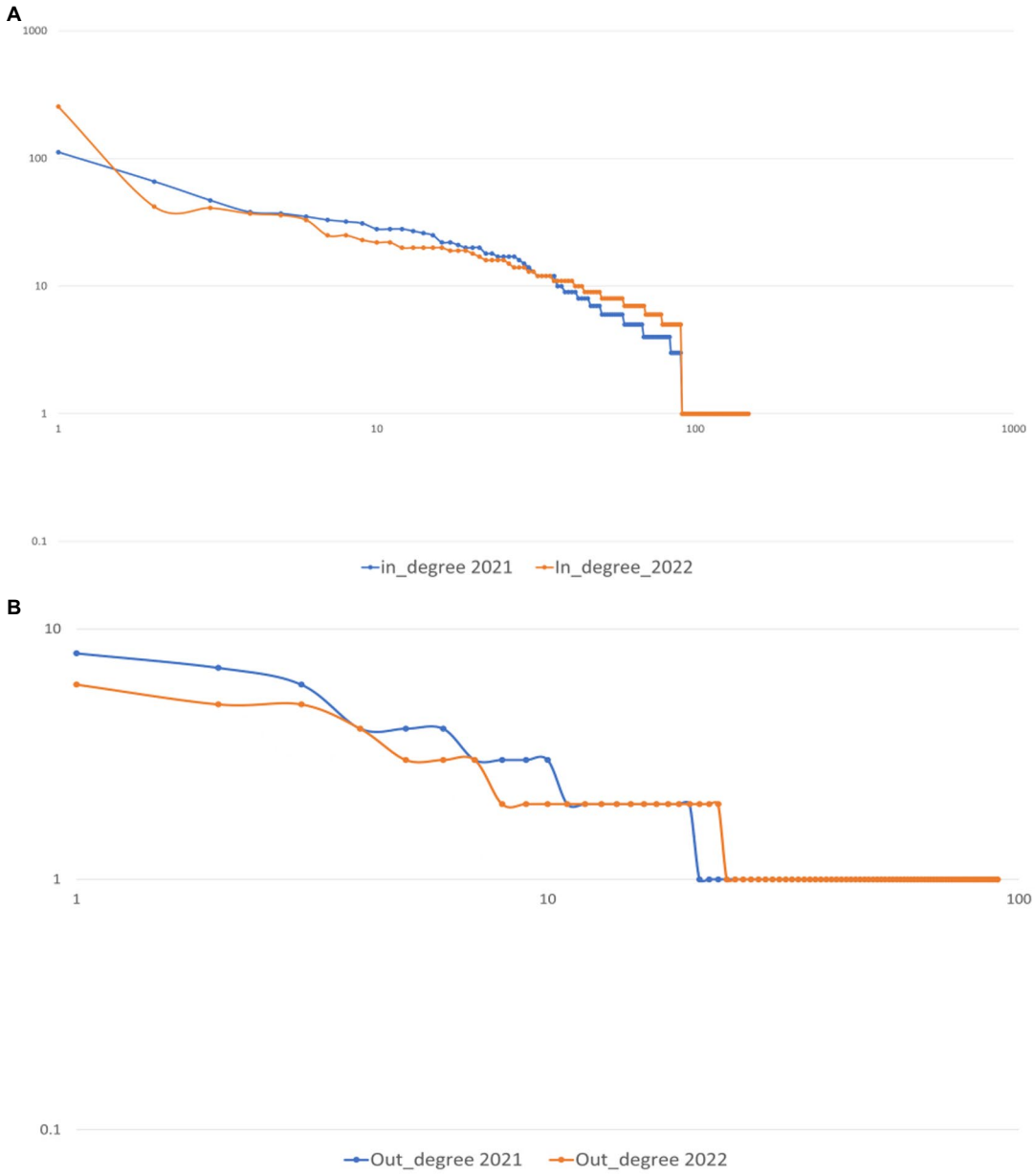

FIGURE 4
Log–log plot of the distribution of **(A)** in-degree of engaged users in both phases **(B)** out-degree of engaged users in both phases. Note in phase 2, there were fewer engaged users with low in-degree and out-degree. Compared to phase 1, there was a lack of a 'long tail' effect in the in-degree distribution in phase 2 **(A)**.

1. How would the dynamics of network structure strengthen or hinder social support?

With SNA, we have identified several network attributes strengthen social support, including network connectivity, global efficiency, degree centralization, hubs of communities, and reciprocal interactions. Network connectivity facilitates social support transmission with high global efficiency, a high average clustering coefficient, and a low degree centralization. The Louvain community detection revealed that the Depression Supertalk Network (DSN) formed stronger social ties and solid communities within communities (see Figure 2). Users clustered in more extensive and denser communities. Through social ties and interaction, smaller communities grew into larger ones. Reciprocity was also evidenced in the network, with significant correlations between in-reply and out-reply. When users post online, they are more likely to receive comments from others; and when users receive comments from others, they are more likely to respond. Log–log plots of in-and out-degree distributions (see Figure 4) showed that social support became more prevalent among engaged users: more engaged users received support and interacted with others. A less steep power-law slope of the in-degree distribution in phase 2 (see Figure 5) indicated an increasingly even distribution of social support.

Our findings are in accord with recent studies linking network attributes with social support on SNS. Individuals are surrounded by relationships that influence their health-related behaviors, social support resources, and health outcomes (Cobb et al., 2010; Phung

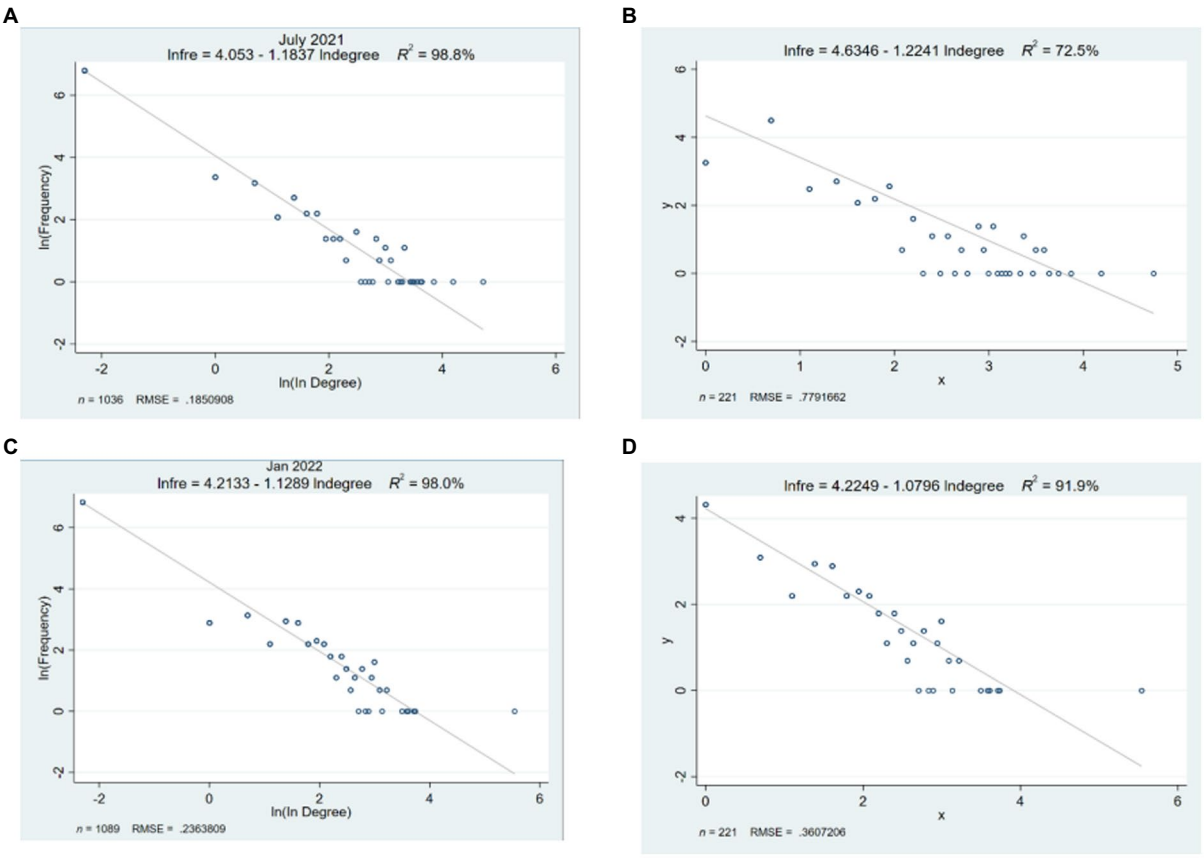

FIGURE 5
Power-law fit of cumulative degree distributions of **(A)** in-degree of the DSN (*N*=1,036, phase 1); **(B)** in-degree of the subnetworks of the engaged users (*n*=221, phase 1). Power law distribution of **(C)** in-degree of the whole DSN (*N*=1,089, phase 2); **(D)** in-degree of the subnetworks of the engaged users (*n*=221, phase 2). Power-law fit is shown as a plot of log degree (*x*-axis) by log cumulative degree distribution (*y*-axis). Left column=the DSN, right column=subnetworks of engaged users, top row=phase 1 networks, bottom row=phase 2 networks. Note for the DSN **(A)**, the slope for in-degree power law distribution was steeper in phase 1 compared to phase 2 **(C)**. For the subnetworks of engaged users, the slope for in-degree power law distribution was steeper in phase 1 **(B)** compared to phase 2 **(D)**.

TABLE 4 Descriptive analysis of self-disclosure attributes of the Depression SuperTalk Network in two phases and other social network sites.

Measures (LIWC code)	*M* (SD) phase 1	*M* (SD) phase 2		Twitter[B]	Expressive writing	Blogs
1st person singular pronouns (i)	5.19 (5.77)	4.35 (4.46)	↓	5.49	8.66	4.75
Death (death)	0.41 (1.41)	0.33 (1.58)	↓	0.15	0.12	0.19
Biological process (bio)	4.8 (5.77)	4.35 (4.46)		2.16	2.59	2.60
Positive emotion (posemo)	5.06 (6.75)	5.11 (8.89)	↑	3.66	2.57	5.48
Negative emotion (negemo)	6.33 (7.54)	5.09 (5.22)	↓	2.06	2.12	2.14
Cognitive process (cogproc)	18.54 (9.46)	19.49 (9.25)	↑	11.58	12.52	9.96
Adverb (adverb)	12.76 (8.35)	13.09 (8.06)		5.88	6.02	5.13
Informal (informal)	10.36 (8.61)	10.50 (8.06)		2.09	0.45	4.68
Active days	2.60 (3.48)	4.96 (6.00)		–[A]	–	–

[A]Data not available.
[B]The data related to Twitter, expressive writing and blogs are available in the LIWC-2015 manual, which draws on corpora containing million words as datasets, see Pennebaker et al. (2015) for details.

et al., 2013; Froehlich et al., 2020; Li and Xu, 2020; Liu and Yeo, 2021). Several network attributes are found associated with strengthening social support, including network connectivity, degree centralization, global efficiency and reciprocal interaction (Lin et al., 2014; Li and Xu, 2020; Yang et al., 2021). Researchers have demonstrated that high network connectivity helps transmit valuable information among health professionals and allocate medical resources (Li and Xu, 2020). Several studies have examined how degree centralization and global efficiency affect users' health behaviors and outcomes in online communities, illustrating the importance of non-centric and even

TABLE 5 Summary results of the Poisson regression.

Items	Coefficient	Std. Error	*z* value	*p*	OR	OR 95% CI
Ln (wc)	0.29	0.03	11.20	0.00	1.34	1.27–1.41
Informal	0.01	0.00	2.78	0.01	1.01	1.00–1.02
Adverb	−0.01	0.00	−2.64	0.01	0.99	0.98–1.00
Cogproc	0.00	0.00	0.15	0.88	1.00	0.99–1.01
Negemo	−0.03	0.01	−4.49	0.00	0.97	0.96–0.98
Posemo	−0.00	0.00	−0.04	0.97	1.00	0.99–1.01
Death	−0.01	0.02	−0.53	0.59	0.99	0.94–1.04
Bioproc	0.04	0.00	9.84	0.00	1.04	1.03–1.05
1st-person singular	0.03	0.01	4.05	0.00	1.03	1.01–1.04
Active day	0.09	0.00	22.34	0.00	1.10	1.09–1.11
Constant	0.28	0.13	2.24	0.02	1.33	1.04–1.70

Dependent Y: social support (in-degree). McFadden R2: 0.49.

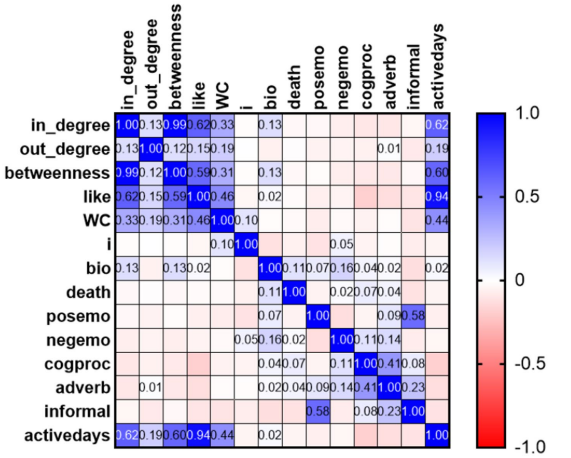

FIGURE 6
Correlation between users' self-disclosure and topological attributes.

support distribution. Meanwhile, reciprocal social support helps reduces loneliness and anxiety and improves well-being (Eysenbach et al., 2004; Malloch and Taylor, 2018; De Simoni et al., 2020).

Our finding suggests the strong impact of hubs on social support, which has not been sufficiently studied previously. Hubs, or the most connected nodes, significantly increased in degree-centrality and influence (see Figure 3). In each community, hubs were core users with prominent structural positions and played a crucial role in group control and stability. Up to now, several studies have begun to examine the importance of core users (Cobb et al., 2010; Carron-Arthur et al., 2015; Yang et al., 2017; Lin and Li, 2021). Gibbs et al. (2016) describe how certain core members are crucial to the development and sustainability of the online support community in a qualitative paper. Joglekar et al. (2018) identify users who are among the most connected in the online health support network. In the same vein, Levonian et al. (2021) find that long-term high-activity users are most vital to the sustainability of online health communities. Moving on to a better understanding of core users, Liang et al. (2019) propose to use a node-centrality analysis to identify core users and investigate the antecedents of their intention to stay active, from the perspective of social capital within enterprise-sponsored brand communities. A study by Lin and Li (2021) uses SNA and word co-occurrence network analysis to explore the characteristics of core users in tumor health communities. It finds that patients and their children were the most active groups. Based on a node-centrality analysis and the Louvain community detection method, the present study explores and proposes a different approach to identify core users. Future research is needed to investigate, using mixed designs, the mechanism of core users in online health communities, including their intentions to stay, longitudinal effects on group control and stability, and within-person differences.

The most disabling mental illness, depression is associated with low social support, especially when it has long-term adverse effects on close relationships (Kronmüller et al., 2011; Davidson et al., 2016; Lu et al., 2021). Consequently, our study contributes to the growing body of research suggesting the potential of online support groups for depression (Pan et al., 2020; Lu et al., 2021). Many easily accessible weak ties can provide support when people seek support in self-disclosure in a group-oriented environment, such as social network sites (Liu et al., 2021; Liu and Yeo, 2021). Friends and contacts in online support communities may indicate a higher level of social integration, allowing for more social support (Reifegerste et al., 2017; Hall and Liu, 2022; Parry et al., 2022). People with long-term conditions can benefit from joining online groups by being able to access social support. For those who lack or have limited access to offline support, the substitutability of offline illness work may be particularly helpful. A meta-synthesis of Allen et al. (2016) shows that social ties forged online enable individuals to engage in relevant self-management work, improve their illness experience, and address aspects of self-management that are difficult to meet offline. According to Prochnow et al. (2020), gamers who reported more site hours, more depression symptoms, and less offline support are significantly more likely to speak to other members about important life matters.

It should be noted, however, that we have also observed uneven distribution of social support among engaged users, although this was improving from phase 1 to phase 2. Several factors indicate an uneven distribution of social support, including a high number of communities with fewer than three nodes (Figure 3), a long tail effect in power-law distributions of in-degree and out-degree (Figure 4), and a power law fit of in-degree distributions (Figure 5). And in both

phases, there was a lack of offering support to others as indicated by the lack of outbound links (i.e., out-degree) for red nodes (see Figure 1), as well as low out-degree (see Table 2). The number of users who offered social support increased, but the increase was offset by the number of target users to whom they provided support. Similarly, our results also revealed that out-degree had greater variability and range than in-degree (see Table 2). Users tend to be more homogeneous for out-degree (offer support to others) than in-degree (receive support from others). In other words, users were much less likely to offer support to others than receive others' support in the community. We have found a big gap between receiving and offering support in the DSN, which confirms Hanneman and Riddle (2005) that SNS (e.g., Facebook, Twitter) tend to show more homogeneity regarding out-degree than in-degree. In the same vein, some studies have suggested that users would restrict online support to a limited number of users (Lin and Li, 2021; Lu et al., 2021; Ramamoorthy et al., 2021). The mechanism of low out-degree and its effects on SNS should be investigated in future research.

2. How would the changes in users' self-disclosure reflect their mental well-being?

We have found within-person improvement in mental well-being manifested in self-disclosure in quality (valence, authenticity, intention) and quantity attributes (breadth, duration, frequency) (see Table 4). Among engaged users, a positive change in the hedonic aspect of well-being was manifested by more positive and less negative emotions among engaged users. Their increased use of cognition process words reflected a positive change in eudaimonic aspects of well-being. They used fewer first-person singular forms—a linguistic feature associated with depression. The decrease in death words showed less expression of suicide attempts and ideation among engaged users. Based on paired t-tests, there was a significant difference in the amount of first-person singular forms used and negative emotions expressed. A significant difference was also found between phase 1 and phase 2 in number of active days, indicating increased attachment to and self-disclosure frequencies in the DSN among engaged users.

In addition, we have compared self-disclosure in the DSN with that in other social networks, such as Twitter, blogs, and expressive writing (see Table 4). Overuse of biological process words and death words showed homogeneity among the group. It satisfied the group agenda of providing a forum for depressive users to share depressive experiences and discuss health-related issues, such as treatment, cure, and suggestions (Weibo Depression SuperTalk, 2022). SNS use has been shown to reduce the perceived riskiness of self-disclosure for people suffering from diseases stigmatized by culture and society, such as depression (Huang, 2016; Pan et al., 2017; Malloch and Taylor, 2018; Li et al., 2019; Chu et al., 2022). Online communities can also facilitate more appropriate and responsive support for individuals, since they can be formed around specific stressors rather than geographical locations (Liu et al., 2018; Lei et al., 2022). Posts, comments, and likes on SNS allow users to seek social support, respond promptly to requests from others, share emotional support, and provide tangible or intangible assistance to those in need.

Our findings bolster the call for understanding self-disclosure in a relational context to resolve the conflict over how self-disclosure affects well-being. For instance, although self-contained individuals have higher levels of depression and lower psychological well-being, authentic individuals have lower levels of depression and higher psychological well-being. Numerous studies have shown these relationships depend on whether their social networks are supportive or rejective. In relational contexts with partner responsiveness and engagement, self-disclosure leads to greater well-being, but not in those that lack virtual support (McConnell et al., 2018; Hou et al., 2020; Pechmann et al., 2020).

The effectiveness of SNS on well-being has been primarily demonstrated by shorter timeframe studies (e.g., days and weeks) (Prestin and Nabi, 2020). Researchers found that humans have a person-specific equilibrium point for well-being (Weinstein, 2018). The well-being of users drops when confronted with challenges (e.g., social media-induced stress) and rises when resources are available (e.g., online social support). For instance, it has been shown that within three-week, social media use can lead to both positive and negative effects on self-esteem. The effectiveness of SNS for social support and well-being is mixed in some longitudinal studies (van der Schuur et al., 2019; Beyens et al., 2020). As we examine the DSN over half a year, we suggest that situational within-person positive changes might occur through the long-term use of online support communities. However, with limited user size, caution must be applied. Once again, the findings corroborate with other research that indicates the extent to which SNS use is related to well-being depends on how individuals use it (Hall and Liu, 2022; Oliver, 2022; Parry et al., 2022; Valkenburg, 2022).

3. How can users obtain more social support to improve mental well-being?

Previous studies have primarily focused on the quantity of SNS use rather than users' content or communication partners. Fewer studies combine users' content and communication partners. Of the limited related research, Lin et al. (2014) suggest that users with larger networks on Facebook disclose more positive emotions and that a greater need for impression management explains the relationship between network size and emotional disclosure. Xu and Zhang (2016) find some correlation between the writing length and topological properties of group members. According to Pan et al. (2017), the bridging social capital of users (measured as network betweenness) is positively related to the responses they receive. In Pan et al. (2020), users' informal language use affects the amount of social support they receive from their network. To provide richer language models and a more refined understanding of self-disclosure, we apply the Linguistic Inquiry and Word Count (LIWC-2015) to classify self-disclosure in qualitative and quantitative attributes. We have found several significant correlations between users' self-disclosure and topological positions (see Figure 6). It appears that users' self-disclosure plays a crucial role in establishing and maintaining relationships with others and forming social networks. Taking this further, we explore how users' self-disclosure provides them with more social support, aiming for more practical implications (see Table 5).

The writing length was strongly correlated with one's topological position, including in-degree, out-degree, and betweenness centrality. Similarly, the writing length largely affect one's received social support. It lends credence to studies that consider message lengths a proxy for group integration and a measure of participation. Writing length reflects users' intimacy and emotional connection to their DSN, which denotes social support (Lieberman, 2007; Batenburg and Das, 2015; Pan et al., 2017).

Biological process words correlated with betweenness ($r_{219} = 0.13$, $p = 0.05$): those who provided more health-related information would

have a higher intermediary position and acted as a bridge between clusters. Meanwhile, biological process words significantly affect users' received social support ($p < 0.01$; $\beta = 0.04$). This result occurred because homogeneity, rather than diversity, seems to be a particular attribute of the DSN. Users group together to share their common health concerns, which also fits the agenda of the DSN. Studies have shown that similar self-disclosure allows users to receive social support (Zhang et al., 2017; Malloch and Taylor, 2018; Zhang and Ahmed, 2018; Qu et al., 2022). Users are more likely to share their feelings, thoughts, and suggestions when reading a post that discloses similar health-related experiences. The perceived availability of support is more likely to increase if a person feels similar to and identifies with an online community. The similarity motivates people to seek out social connections and drives positive psychological outcomes (Malloch and Taylor, 2018; Liu et al., 2021).

The number of active days was also strongly correlated with topological attributes, making it a crucial factor in social support. Numbers of active days significantly differed between phases 1 and 2, indicating engaged users' stronger attachment to the DSN. Posting more frequently online will likely transform weak relationships into stronger ones since users become acquainted more often. People are willing to offer support to members of an online community when they identify with its members (Pan et al., 2017; Pechmann et al., 2020). The benefits of active participation also appear to extend to users (Eysenbach et al., 2004; Carron-Arthur et al., 2015; Joglekar et al., 2018). In a study conducted by Chomutare et al. (2014), using social media tools for weight loss at least once a week is strongly associated with receiving encouragement. Marengo et al. (2021) find that active members of online support communities receive more responses than those who are less active. According to Lu et al. (2021), users who spend more time online and respond to other posts are more likely to form informational support ties.

Conversely, we have found that revealing negative emotions reduces users' social support. There appears to be a consensus that expressing negative emotions will lead to more social support: human beings are particularly vulnerable to emotionally provoking content since negative emotions are open expressions of concerns and frustrations (Lieberman, 2007; Malloch and Taylor, 2018; Li et al., 2019). However, we are not alone in our view that expressing negative emotion might decrease users' received social support. High et al. (2014) suggest that people are less likely to support individuals whose Facebook profiles disclose a greater range of emotions (versus fewer emotions). Lin et al. (2014) argue that Facebook users with larger networks on Facebook disclosed more positive emotions, and a stronger need for impression management mediates the relationship between network size and emotional disclosure. Ziegele and Reinecke (2017) find users are less willing to comment on negative status updates than on positive ones, moderated by the strength of the relationship between the sender and the receiver of the status update and mediated by perceived message appropriateness and support urgency. A recent study has found that if a person discloses too much negativity on social media, they may be perceived negatively and receive less support: people tend to present the positively valanced content on social media while concealing negative emotions (Pan et al., 2020). Once again, we have demonstrated the necessity of understanding self-disclosure in relational contexts. To better understand how self-disclosure of negativity affects social support in reconciling the aforementioned conflict, future studies are needed.

5.1. Implication

The theoretical implication of our study is the use of a relational approach to understanding the effects of social network sites (SNS) on well-being by accounting for users' content (self-disclosure) and communication partners (social network). In our study design, we integrate data about the structure and composition of users' online social support networks with users' self-disclosure content (both in breadth and depth) to understand better the influence of online social support networks on health outcomes. A relational perspective on self-disclosure may provide researchers with a valuable framework for reconciling conflicting literature about the impact of self-disclosure. We demonstrate the significant role of social support in the link between self-disclosure and well-being, highlighting the importance of users' self-disclosure features as they seek and receive social support. On the one hand, social network analysis (SNA), which takes account of users' topological positions, uses network attributes to understand person-specific uses and group-based social support. We have identified users' network attributes regarding providing and receiving social support in the context of depression. On the other hand, we have analyzed users' change in mental health revealed in their self-disclosure, correlated their self-disclosure attributes with their topological positions, and anticipated how users' self-disclosure attributes trigger others' responsive social support. Self-disclosure facilitates the forming of relationships and maintains the dynamics of networks. Overall, we strengthen the need to analyze SNS' effects on well-being with a relational approach: individuals' well-being is intertwined with their relationships, surrounded by a network of relationships that influence their health outcomes and access to social support.

Our study also informs practices. As a starting point, users should pay attention to how they disclose since self-disclosure determines social support. Individuals' topological positions are correlated with their content, suggesting they are surrounded by a network of relationships that impact their health outcomes. A comprehensive analysis of user networks and self-disclosure content indicates that digital connections are triggered by deliberate decisions to communicate instead of a chance encounter, like "bumping into someone serendipitously in a hallway— with no assumption that links are bidirectional" (Churchill and Halverson, 2005, pp. 18). The results of our study suggest that biological words, writing length, informal language, and active days indicate higher levels of social support; in contrast, negative emotions and adverbs indicate the opposite. These findings suggest that shared interests, intimacy, and reciprocal connection create a friendly semantic environment for online communities (Zhang et al., 2022). Due to the positive correlation between active days and out-degree, users can extend their 'tenure' in engagement with the community that serves their needs (Balani and De Choudhury, 2015). By referencing past self-disclosures and the community's response to them, users can gain a sense of support when they visit online communities. Moreover, we have found a lack of offering social support versus receiving support in the group. To repay and exchange social support from communication partners, users can offer more social support to others. By doing so, individuals will have more trust and motivation toward the medium that mitigates self-disclosure and online support. Helping others can prevent feelings of helplessness and inadequacy and allow individuals to regain control and self-efficacy (Zhang et al., 2022).

Community organizers and web designers should cultivate intimacy and increase member reciprocity while encouraging users' authentic self-disclosure. The sociograms created from our study are useful for visualizing connections within online health communities, which shows the persuasive power of mobilizing concepts such as social networks. In another case, Morris (2005) uses social networks to derive public displays of social interactions between elderly people and their relatives and friends. People see their social interactions illustrated in these feedback displays, and their feelings of social isolation are subtly and gently refuted. Moreover, active users can observe their topological positions in the network, realizing their contribution, potential, and connections with others, enhancing their mental well-being and community intimacy. The method used in this study can also help web designers and community managers predict fluctuations in growth and dropout among users and create a more pleasant, enjoyable, and integrated experience for users. Designers and web organizers can strengthen the bond between users and the community by recognizing and rewarding continuous participation (e.g., virtual currency). As part of specific social interactions, web designers and community organizers can also consider other self-disclosure context cues such as geographical location, temperament, gender, and hobbies. Users and communities might use these contextual cues in providing and receiving social support (Yoon et al., 2019; Pechmann et al., 2020). With multimodal self-disclosure features, including emojis, pictures, audio, and videos, users can better disclose themselves, receive social support, and engage in digital communication.

Also, this study provides valuable insight for public health surveillance and psychological treatment and support, exploring how online SNS interact with face-to-face support networks to influence health outcomes. We have identified several network attributes that strengthen social support, including network connectivity, global efficiency, degree centralization, hubs of communities, and reciprocal interactions. Based on the findings, public health professionals can devise targeted interventions. The relationship between users is particularly helpful for identifying influential people and determining the network's closeness (Churchill and Halverson, 2005). The hubs of communities play an influential role in group control and stability. Placing them can facilitate the spread of accurate health information. Utilizing SNS data regarding health and well-being will enhance the future analysis of social support attributes. Psychotherapists can recognize the positive potential of online self-disclosure as a therapeutic ingredient and means of communicating with patients. With the client's permission, psychotherapists may also use online self-disclosure texts to determine health-care interventions or as part of health outcome measurements.

Increasingly ingrained in digital life, our generation and the future have a major task: to adapt to digital life and utilize the good side of technology to flourish. Since the Internet enables people to engage with others across geographical boundaries, community members can draw upon the collective experience of participants who share a common health issue in a way that is impossible in the face-to-face world. This research has shown the potential of the online community for change: we have a group of engaged users who form intimacy and provide support to each other to cope with depression related anxiety, vent negative emotions and share valuable information. A strong correlation exists between depression and social isolation (Kronmüller et al., 2011; Davidson et al., 2016; Joglekar et al., 2018). SNS users, even those experiencing severe stress, repress their disclosures, negatively affecting their ability to obtain effective support (Calancie et al., 2017; Li et al., 2019). Engaged users in our study, by shaping their selective SNS use (deliberately or not), partly created their well-being effects through individual (i.e., self-disclosure attributes) and situational factors (i.e., communication partners). Online social support may have provided users with a sense of companionship and belonging, as well as reduced their long-term anxiety and enhanced their self-efficacy in coping with uncertainty in the future (Malloch and Taylor, 2018; Lu et al., 2021; Lei et al., 2022). The widespread impact of depression on individuals has led many to turn to social media for information, connection, and guidance, making online depression communities a promising new research area. In our study, we identify self-disclosure features that shape reciprocal, non-centric networks, which could also have implications for other telecommuting scenarios, including online education, entertainment, and working.

5.2. Limitations and future studies

This study has several limitations. Firstly, this study examines only one type of social network site. Future research might examine how various SNS designs may influence self-disclosure in its quality and quantity attributes. Community managers and platform designers can develop strategies for engaging group interaction and user participation by distinguishing differences in self-disclosure across various social networking sites. Further conceptual and methodological work can also study emojis, videos, and other multimodal disclosure features affecting SNS's well-being.

Secondly, according to the official report, 80% of Weibo users are between 20 and 35, so our research might exclude adolescents and older users. Adolescents are more likely than adults to encounter negative experiences on SNS, such as cyber-victimization, sexing, and self-harm content (Beyens et al., 2020; Valkenburg et al., 2021). Adolescents' omnipresence on social networks makes parenting increasingly challenging. Among older users who use SNS, executive function is positively predicted, but it also causes some older users to feel socially displaced (Hall and Liu, 2022; Oliver, 2022). It would be interesting to examine the use of social networking sites across different age groups and media-specific parenting and caregiving (van der Schuur et al., 2019).

Thirdly, we only consider limited personal (i.e., self-disclosure) and situational attributes (i.e., communication partners) when evaluating the impact of social networks on well-being, which might limit inferences to the general population. Although suggestive, our findings are correlational. It would be helpful to develop an integrated behavior change model that incorporates a variety of personal factors (ethnicity, diagnosis, treatment history, demographics, cognitive factors, and beliefs) as well as situational factors (e.g., culture, economy, professional, community, policy) (Lin et al., 2014; Li and Xu, 2020; Wang et al., 2021; Cingel et al., 2022; Hall and Liu, 2022; Parry et al., 2022). The future can use other modeling methods, such as dynamic structural equation modeling (DSEM), to demonstrate how many participants respond to an experimental design or to test certain hypotheses (Oliver, 2022; Parry et al., 2022; Valkenburg, 2022).

6. Conclusion

Social network sites have the potential to affect users' well-being positively, but their effect is not uniform or one-directional. Our study combines individual (e.g., user self-disclosure) and situational (e.g., user social networks) factors to assess how SNS affects well-being. Three research questions guide the study and the paper. The first two show that self-disclosure is vital to establishing and maintaining relationships with others, as well as for the maintenance of networks. Our social network analysis reveals network attributes that improve social support; our content analysis reveals how self-disclosure, in its quality and quantity attributes, reflect users' mental well-being. As part of the third research question, correlation analysis and Poisson regression analysis were used to determine how users' self-disclosure attributes influence their topological positions and received social support. Users' self-disclosure and network structure play a major role in enhancing social support for mental well-being, which is relevant to interventions and surveillance in public health. It is helpful for community managers to develop strategies for building communities, policymakers to disseminate health interventions, online users to seek social support, and researchers to study the situational effects of social support on well-being.

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.

Author contributions

JS: conceptualization, methodology, investigation, project administration, writing, review, and editing. ZK: conceptualization, methodology, formal analysis, and editing. All authors have read and agreed to the published version of the 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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EDITED BY
Kostas Karpouzis,
Panteion University, Greece

REVIEWED BY
Barbara Caci,
University of Palermo, Italy
Yannis Skarpelos,
Panteion University, Greece
Nikolaos Tselios,
University of Patras, Greece

*CORRESPONDENCE
Angela Y. Lee
✉ angela8@stanford.edu

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To use or be used? The role of agency in social media use and well-being

Angela Y. Lee[1]*, Nicole B. Ellison[2] and Jeffrey T. Hancock[1]

[1]Department of Communication, Stanford University, Stanford, CA, United States, [2]School of Information, University of Michigan, Ann Arbor, MI, United States

In this paper, we develop the concept of agentic social media use: a way of engaging with social media that emphasizes having the beliefs, knowledge, and practices to use it intentionally. In comparison to instances of "mindless" social media use, people who use social media agentically do so with a purpose in mind: they leverage the affordances of social media to do things that are meaningful, useful, or satisfying for them. For example, people can use social media to intentionally build or manage their relationships, to seek out and learn new information about their interests, or to craft a positive image of themselves through the content they post. Crucially, however, there are many other valuable uses of social media that may not be considered conventionally productive but are nonetheless deliberate and useful, such as using social media intentionally to relax, unwind, and entertain themselves in an effort to modulate their emotions. To use social media agentically means to (1) hold an agentic mindset about one's relationship with social media, (2) have the knowledge and literacy to understand how to navigate social media effectively, and (3) enact practices that assert control over specific elements of social media use, such as curating content and refining algorithmic recommendation. Approaching social media use from the perspective of agency and intentionality allows us to better understand heterogeneous social media effects and to identify new ways of helping people benefit from these technologies.

KEYWORDS

well-being, social media, mindsets, psychological well-being, agency, control, social cognitive theory

Introduction

For many people, social media is integral to daily life–connecting them to a constant stream of information about their friends, their interests, and the world around them (Auxier and Anderson, 2021; Rideout et al., 2022). However, this constant connectivity (Wells et al., 2021; Abeele et al., 2022) raises important questions about the amount of control we have over our experiences with social media: Are we dependent on-or even "addicted" to-social media, or are we engaging with it on our own terms?

It is easy to find narratives that portray social media users as addicted to their devices and influenced by the pull of platforms like Instagram and TikTok. Public editorials (Petrillo, 2021; Haidt, 2022; Stabile, 2022) often emphasize the ways in which people spend more time on social media than they want to (for a review, see Sun and Zhang, 2021), or how specific features are designed to capture and ensnare user attention (Gray et al., 2018; Bail, 2021; Wells et al., 2021).

Based on these dominant narratives of social media as a powerful force that exerts control over individuals, people are often urged to reduce their exposure to social media by disconnecting (e.g., taking a "digital detox," Radtke et al., 2022) or deactivating their accounts altogether (Liao and Sundar, 2022).

However, reduction-based strategies are neither practical nor reflective of recent work on the effects of social media use on psychological well-being. Large-scale experiments show that digital detoxes do not often improve individuals' lives as theorized (Radtke et al., 2022), unless people disconnect when social media content is likely to be particularly volatile (e.g., during a contentious election cycle, Allcott et al., 2020). Instead, abstaining from social media use can even undermine well-being by removing individuals from established networks of social support, which can provide important social and emotional resources like social support and access to new opportunities (e.g., bridging social capital, Ellison et al., 2011). Indeed, new research from the pandemic era demonstrates how adolescents without social media were significantly more lonely than their digitally-connected peers (Minihan et al., 2021; Metherell et al., 2022).

Furthermore, it is increasingly evident that the amount of agency people feel that they have over social media can have powerful effects on their lives. Research on *social media mindsets* indicates that people who view social media as something they can control and use (i.e., an agentic mindset) report less depression, anxiety, and stress than those who view social media as inherently harmful and addictive (i.e., a low-agency mindset) (Lee et al., 2021). Having an agentic, positive mindset-such as viewing social media as a tool that can be used to enhance one's life-was a stronger predictor of well-being than the amount of time they spent online (Lee and Hancock, 2020). In light of these findings, deeper considerations of user agency may provide valuable insights into how to live with and benefit from social media. While it may be true that individuals hold less sway over the design of social media platforms than the corporations that run them, at the individual level there are many ways for everyday users to take control of their experiences with social media and optimize their engagement with it.

In this paper, we develop the concept of *agentic social media use*: a way of engaging with social media that emphasizes having the beliefs, knowledge, and practices to use it intentionally. In comparison to instances of "mindless" social media use, people who use social media agentically do so with a purpose in mind: they leverage the affordances of social media to do things that are meaningful, useful, or satisfying for them. For example, people can use social media to intentionally build or manage their relationships, to seek out and learn new information about their interests, or to craft a positive image of themselves through the content they post. Crucially, however, there are many other valuable uses of social media that may not be considered conventionally "productive" but are nonetheless deliberate and useful, such as using social media intentionally to relax, unwind, and entertain themselves (e.g., to modulate their emotions, Knobloch-Westerwick, 2015; Robinson and Knobloch-Westerwick, 2016). To use social media agentically means to (1) hold an agentic mindset about one's relationship with social media, (2) have the knowledge and literacy to understand how to navigate social media effectively, and (3) enact practices that assert control over specific elements of social media use, such as curating content and refining algorithmic recommendation. Approaching social media use from the perspective of agency and intentionality allows us to better understand heterogeneous social media effects and to identify new ways of helping people benefits from these technologies.

What is agency and why does it matter?

At a fundamental level, agency means "having the capacity to alter the course of events in some situation" (Cesafsky et al., 2019). When people feel they have agency, they believe they have some degree of control over the course of their own lives (Bandura, 2001) and that they can take action to get what they want or need (Moore and Fletcher, 2012).

These perceptions of agency are essential to well-being. Indeed, some of the most striking evidence of the importance of agency comes from studying its absence: people who feel they have little control over their lives tend to feel more stressed, anxious, and helpless. Indeed, one of the cognitive symptoms of depression is believing that the conditions of one's life are poor and there is little that can be done to improve it (Nolen-Hoeksema et al., 1986; Maddux and Meier, 1995; Vollmayr and Gass, 2013).

In contrast, people tend to feel more positively about themselves and more satisfied with their lives when they feel capable of taking care of themselves, whether this means feeling a sense of control over their health, relationships, or finances (Bandura, 2001; Adler, 2012; Moore and Fletcher, 2012). Indeed, perceptions of self-efficacy have long been thought to be essential to maintaining a positive self-image (Bandura, 2001), in part because these agentic beliefs are important precursors to actions that benefit the individual. For example, people with higher self-efficacy are more likely to pursue beneficial, but challenging, tasks (e.g., a new exercise routine, smoking cessation; Fletcher and Banasik, 2001; Gwaltney et al., 2009) because they believe they will succeed. Few people, after all, want to choose difficult pursuits they believe they cannot accomplish. The strength of the relationship between self-efficacy beliefs and behavioral change is such that many health interventions emphasize the need to build individuals' confidence that they will succeed as a pivotal first step toward change (Zimmerman, 2000). Indeed, a recent meta-analysis found that experimentally increasing individuals' self-efficacy was a strong predictor of individuals' health-related behaviors (Sheeran et al., 2016).

People often understand their agency relative to other forces in their lives. Even someone who generally feels in control of their life may feel less agentic in certain situations, like being in a regimented work environment that limit their choices, or in a social setting with strong norms about what is acceptable to share (e.g., the positivity bias on social media content, Schreurs and Vandenbosch, 2021). Classical research on loci of control emphasizes how beliefs about control over one's environment can influence well-being in powerful ways (Klonowicz, 2001; Mirowsky and Ross, 2007). People who view themselves as fundamentally in charge of their own lives and actions (i.e., having an internal locus of control) see themselves as capable of optimizing their experiences, such as being able to make decisions that will help them thrive by harnessing the

tools around them, whether they be digital or analog. In contrast, people who have an external locus of control feel like their lives are dictated by outside forces.

Technologies like social media can be understood as one such force. People can feel controlled by their experiences with platforms like YouTube, Instagram, and TikTok if they feel they are spending more time online than they want to or if they find themselves influenced by what they see (Lanette et al., 2018). On the other hand, people can also feel in control of their social media use and capable of using it to get what they want or need (i.e., action initiation, Moore and Fletcher, 2012). These perceptions of agency and self-efficacy (Skurka et al., 2022) may be an important determinant of whether people obtain benefits from their use, or not. In the context of media use, self-efficacy is an important determinant of technology adoption (Waddell et al., 2014) as viewing the self as capable of learning to use new devices or platforms (e.g., smartphones) is an important first step because individuals generally want to do things they believe they can be successful at. In addition to influencing individuals' beliefs about their own potential, conceptualizations about agency can also influence behavior. Indeed, thousands of interventions to date have tried to help people protect their health (Sheeran et al., 2016), well-being (O'Sullivan, 2011), and livelihoods (Shoji et al., 2016) by helping them develop a sense of agency. Considerations of agency may thus similarly improve individuals' experiences with social media.

Conceptualizing agentic social media use

What does it mean for individuals to use social media agentically? An agentic perspective of social media focuses not on the time people spend on social media, but rather the extent to which they are intentionally or unintentionally using social media to fulfill valued needs and goals. As a first step, people should feel they are in control of the ways they engage with social media, whether this means using it extensively, or not at all. Aided by a basic understanding of how social media systems work, they can then change the ways they use social media in an effort to obtain its benefits while avoiding its harms.

By centering considerations of user agency, we can focus on identifying and analyzing the psychological forces that drive behavior: asking *why* people use social media in addition to documenting *how* they use social media. The same action, like watching a video, can be driven by diverse motivations which may in turn differentially affect people's lives. For example, enjoying a video as part of an intentional ritual of unwinding after a long day may help people relax, manage their stress, and improve their mood (Johnson and Knobloch-Westerwick, 2014; Robinson and Knobloch-Westerwick, 2021). In contrast, watching the same video to procrastinate unpleasant tasks or to tune out anxious thoughts may undermine well-being by preventing people from necessary and beneficial tasks, such as managing their work lives and processing their emotions adaptively (Robinson and Knobloch-Westerwick, 2016; Reinecke et al., 2017). As in prior work on teaching individuals how to best live with and benefit from everyday forces in their lives (e.g., stress optimization theory, Jamieson et al., 2018), we can help people optimize their experiences with social media by scaffolding the belief systems, literacy, and behaviors they need to make the most effective use of these digital tools.

Our conceptualization proposes that for people to take control of their experiences with social media, they should have a mindset that orients them toward its potential uses, the literacy to understand how social media systems work, and a repertoire of practices that will help them assert control the ways they use social media. We discuss each of the following components below.

Social media mindsets

For people to optimize their experiences with social media, they need to first believe it is possible for them to harness its affordances for their own benefit. This belief system can be understood through the lens of social media mindsets, which are the core beliefs people have about the fundamental nature of social media in their lives (Lee et al., 2021). Just as individuals can have growth or fixed mindsets about the nature of their intelligence (Dweck, 2008), people hold mindsets about the amount of agency they have over their social media use (i.e., high agency vs. low agency) and the expected valence of its effects (i.e., enhancing vs. harmful). These mindsets function like a mental shortcut, offering people simple answers to difficult questions like "How will using social media generally affect me?" and "How much control do I really have over this technology?" that can help guide them toward specific ways of thinking about, responding to, and using social media (Lee and Hancock, 2023).

Having an agentic and positive mindset toward social media use appears to be particularly adaptive. Research on the relationship between social media mindsets and mental health found that mindsets can have important effects on individual well-being. In fact, people's mindsets about the role of social media in their lives were a stronger predictor of their life satisfaction and psychological distress than the amount, frequency, or intensity of their use (Lee and Hancock, 2020). Those who believed that they were in control (agency) and that social media could be beneficial to their lives (valence) not only felt better about their lives, but also reported less depression, stress, and anxiety. In contrast, people with the mindset that their social media was inherently harmful and out of their control tended to feel more psychologically distressed, in line with prior work indicating that perceiving one's own use as "problematic" can undermine mental health (Andreassen et al., 2016; Cheng et al., 2019; Cunningham et al., 2021).

Why is it important for people to have such a particular mindset toward their social media use? At a high level, mindsets guide people toward certain pathways of understanding and engaging with social media–mechanisms that have been explored in the context of appraisal effects and behavioral change (Claro et al., 2016; Crum et al., 2017; Clark et al., 2018; Yeager et al., 2019; Paakkari et al., 2021; Przybylski et al., 2021). For instance, people who see themselves as in control of their social media use tend to view instances of their social media use as meaningful and useful. As one participant described in an in-depth interview about their mindset (Lee et al., 2021), social media "is for doing things" that "[make] life easier and more colorful," whether that involves "serious" informational or social tasks like engaging with news

and maintaining friendships overseas, or simply using it to take a moment to relax in the interstitial downtime between events (Squire and Dikkers, 2012; Chess, 2018).

In contrast, people who see themselves as dependent on their social media–or subject to its influence—feel worse after they spend time on social media, whereas those with more agentic mindsets do not (Lee and Hancock, 2020). Similar results were observed in Ernala et al. (2022), where Facebook use was associated with reduced subjective well-being when people perceived their Facebook use as bad, but not when they perceived it as good. If people already hold the mindset that their social media use is not under their control, they may appraise further use as a failure to resist temptation (e.g., self-control failures, Lanette and Mazmanian, 2018; Lanette et al., 2018). This may be particularly harmful to individuals' self-esteem given the highly fragmented nature of social media use throughout the day (e.g., through push notifications and repeated phone pick-ups, Reeves et al., 2021; Brinberg et al., 2022), which may serve as a constant reminder of their perceived lack of self-control. Therefore, holding an agentic mindset that allows individuals to consider the potential ways in which they can use it for their own benefit may be an important precursor to positive experiences with social media.

Social media literacy

People can also use social media more intentionally when they understand the technical and social workings of social media platforms. Knowing more about how platforms function may be particularly important as "social media" comes to encompass an increasingly broad set of technologies, ranging from conventional feed-based platforms like Twitter to video- and game-based platforms like TikTok and Roblox (Bayer et al., 2020)–each of which presents unique affordances and challenges.

Social media literacy can improve people's ability to make informed choices about the ways they engage with social media. While everyday users may not need to understand the details of how platforms run under the hood, they can better optimize their experiences with social media if they have a working knowledge of core features (e.g., algorithmic recommendation systems) and common social dynamics on social media (e.g., self-presentation biases when presenting content) (Schreurs and Vandenbosch, 2021; Schreurs et al., 2022). Indeed, research on self-efficacy emphasizes that domain-specific knowledge is important to helping people translate a general sense of agency in their lives into action in specific facets of their life (Bandura, 2001; Mirowsky and Ross, 2007; Skurka et al., 2022). Knowing more about a particular concept–such as how social media is curated both by platforms and by people–can complement an agentic mindset in helping people assert control over their experiences with social media content.

Consider, for example, the ways in which increased literacy about content curation can support people in obtaining greater benefits from social media. It is now the norm for most platforms to use personalized algorithms to recommend content to their users (Bhandari and Bimo, 2022). Algorithm audits (Metaxa et al., 2021) and internal documents (Wells et al., 2021) indicate that feeds like the TikTok For You page and the Instagram Explore page curate content by identifying users' interests through an analysis of digital trace data, like the posts they look at, like, share, or skip. While the specifics of these processes are rarely made known to the general public—much less everyday users–knowing how these algorithm-based systems work can help people have more agency over what they see and share. For instance, research on the algorithmic crystal finds that people who understand how the algorithms reflect elements of their own identity can better shape and refine its recommendations for them by changing their own behaviors (Lee et al., 2022). Literacy can also help people manage the ways they are seen by others, through the algorithm. Research on adaptive folk theorization reveals that people with a stronger working knowledge of algorithms were better equipped to maintain their desired self-presentations (e.g., sharing certain facets with certain communities, DeVito, 2021), even in light of updates to the algorithm over time.

Literacy can also help people make intentional decisions about the ways they think about and engage with content produced by others, whether they are creators, peers, or strangers. A notable example can be seen with regards to social comparison on social media (Nesi and Prinstein, 2015; Keles et al., 2020). We know from media psychological research that self-presentations on social media are often biased toward the positive (Walther et al., 2015; Yau and Reich, 2019) as individuals strive to put their "best foot forward" and to share the highlights of their personal, professional, and romantic lives (Schreurs and Vandenbosch, 2021). Everyday users may not realize this, however, and may instead interpret these idealized self-presentations as realistic glimpses into the lives of others (Fan et al., 2019)–potentially triggering harmful processes of downwards social comparison (Chou and Edge, 2012; Frison and Eggermont, 2016; Lee, 2020). Research on the Social Media Literacy model (Schreurs and Vandenbosch, 2021) indicates that literacy may buffer against such effects. People who understand the ways in which the positivity bias of social media content distorts what they see online are protected against the adverse effects of seeing idealized content on their self-esteem (Schreurs et al., 2022). Interventions have demonstrated that teaching adolescents about these biases can improve well-being by changing how people responded to idealized social media content (Weber et al., 2022).

Practices

Using social media agentically also requires individuals to enact specific strategies to assert control over their experiences with social media. Whereas holding an agentic mindset is an important precursor to obtaining benefits from social media, and literacy can enhance individuals' ability to translate self-efficacy into action, people should also put agency into practice by changing their behavior. We define agentic practices as those where individuals modulate the ways in which they engage with social media by intentionally considering the ways in which its affordances may serve them in fulfilling valued needs and goals.

In a recent review of media use efficacy, Skurka et al. (2022) highlight how feeling capable of using media for one's own benefit is a powerful predictor of positive behavioral change. Indeed, decades of interventions on behavioral change have helped people be

healthier, spend more wisely, and live more meaningfully (Bandura, 1992; Baldwin et al., 2006; Schwarzer et al., 2008) by boosting their self-efficacy and teaching them useful practices (e.g., how to create an exercise routine, how to budget, how to maintain meaningful relationships).

In a similar vein, people can apply agentic social media use practices to learn how to obtain more benefits from their social media use. Take, for example, the ways in which people can better control their engagement with their feeds. People may feel that their feed is shaped by what is most popular overall, and therefore showing them content from interests that are not relevant to them (Eslami et al., 2016; Verduyn et al., 2022). Alternately, they may also feel that the algorithm is not dynamically keeping up with changes in their self-concept, and is instead showing them content from facets of their identity that are no longer important to them (e.g., pictures from out-of-touch friends, past partners, or old hobbies, Lee et al., 2022). A simple, yet powerful, way that people can increase their control over social media content is by making judicious use of features like the block, unfollow, and "show me less" functions (e.g., information repertoire filtration, Zhang et al., 2022). Just as people spring-clean their houses, it may be valuable for individuals to iteratively or routinely sort through their social media content to prune what is no longer useful and appreciate what brings them joy. For instance, people can remove themselves from communities they are no longer interested in or unfollow accounts that do not enhance their lives. On the other hand, people should also use existing features to positively curate their feeds by deliberately following new creators and joining new groups. Furthermore, people can manage their audience preferences by setting "close friends" lists or creating group-chats to take control of who sees their posts, and thus better manage social boundaries (Litt, 2012).

In a similar vein, people can assert control over the recommendations provided to them by personalized algorithms by using the practice of strategic refinement. Theory and research on the algorithmic crystal (Lee et al., 2022) emphasizes that individuals can shape the algorithms' model of their preferences by changing how they engage with content on the platform. Guided by the notion that their behaviors inform personalization processes (e.g., a personal engagement folk theory, DeVito et al., 2017), they can strategically increase or decrease their interaction with specific forms of content to change the algorithm's recommendations. This practice increases individuals' agency over their feeds by providing individuals a pathway to refine what they see *via* the algorithm, so that its recommendations either better align with their self-concept (e.g., learning that they enjoy specific music, fashion, humor, or views) or who they might like to be (e.g., new hobbies they want to try, new perspectives they want to consider). In one noteworthy example, a white adolescent who realized her feed was mostly other white adolescents was able to strategically refine her TikTok algorithm to show her videos from more creators of color to support more diverse artists, musicians, and activists (Lee et al., 2022). To do so, she began to watch, like, and comment messages of support on posts from BIPOC individuals. The same practice of strategically modulating engagement behaviors can similarly be applied to help individuals take a more active role in the process of curating content received through personalized algorithms.

Implications for theory and interventions

Considering agency in experiences with social media can advance theory on the differential effects of technology use on well-being. Furthermore, it can illuminate new pathways for interventions to help everyday people make the most out of these ever-present digital tools.

Understanding the extent to which individuals are using social media intentionally or unintentionally may enrich how we describe, study, and assess social media use. As increasing work confirms that social media affects people differently (Beyens et al., 2021; Pouwels et al., 2021), it is clear that using social media can both help and harm people's lives (Orben, 2020; Meier and Reinecke, 2021; Hancock et al., 2022), and that these effects cannot be explained by differences in time spent with social media alone (Przybylski et al., 2020; Parry et al., 2021). Examining the extent to which people use social media intentionally or unintentionally may help explain when social media is most enhancing. Already, research on social media mindsets indicates that people who hold more agentic mindsets experience better well-being, whereas low-agency mindsets are associated with worse well-being. Furthermore, Cunningham et al. (2021) found that the component of social media use that was most detrimental to adolescent depression was teenagers' perception of their own use as "out of their control" (i.e., problematic social media use).

Thinking about social media use in terms of its intentionality can also complement and extend existing approaches to parsing enhancing and harmful social media effects. For example, it has been commonly theorized that active social media use (e.g., posting, sharing, commenting) can improve well-being whereas passive use (e.g., browsing, watching videos) undermines it (Verduyn et al., 2015). However, new research indicates that we should go beyond examinations of type of use alone to understand heterogeneous social media effects (Valkenburg et al., 2022). For instance, eye-tracking studies like Ellison et al. (2020) find that users spend equivalent time gazing at social media content that they do and do not click on, suggesting that actions that appear "passive"–like watching a video or scrolling through a feed–may involve active thought and consideration. In fact, intentional actions that are not captured by clicks, such as calling someone after seeing a social media post, may be more powerful for relationship development and well-being than one-click "likes" or "shares."

Indeed, there are many ways for active use to be harmful (e.g., cyberbullying, Giumetti and Kowalski, 2022) and for passive use to be restorative (e.g., watching videos to relax, Cauberghe et al., 2021). Considering these two activities with an orientation around user agency highlights the fact that social media use can be a means of pursuing a goal–which can be to hurt another person (Mishna et al., 2016), or to regulate one's own emotions (et al., 2020).

Adopting an agency-centered approach can also support the development of interventions to improve individuals' experiences with social media, without necessarily requiring them to reduce their use. Indeed, research from the person-specific framework indicates that reducing social media use may be enhancing for some individuals and harmful for others (Beyens et al., 2021), and therefore may not be a useful recommendation for all (Radtke et al.,

2022). Instead, when we think about social media use from the perspective of individual agency, we can encourage individuals to develop the belief systems and behaviors to identify how best to use social media in their own lives.

For example, Lee and Hancock (2023) helped individuals develop a more agentic, positive social media mindset through a series of self-guided reflective writing exercises. The intervention scaffolded a new way of seeing social media by asking individuals to reflect on questions like "What are some ways in which you already take advantage of social media to do things that are important or useful to you?" and "What can you do differently to make the most of social media in your life?" In addition, participants also developed a personalized plan for supporting their own agentic social media use going forward by listing several ways in which they could take control of their experiences. Results showed that the intervention was successful in not only cultivating more adaptive mindsets, but also more agentic social media use. One participant in the treatment group wrote, "I have specific goals when I'm using social media… It's not controlling, it's just a tool I can use" and described how they would leverage social media in the future: "I can use social media as a support system I can go to even during difficult times like COVID-19."

An advantage of this interventional approach is that it allows individuals to develop their own plans for using social media agentically at an individual level. As the field comes to recognize the ways in which both social media use and mental health vary between, and within, individuals (Ram and Gerstorf, 2009; Valkenburg et al., 2021), interventions to improve peoples' experiences with social media should be flexible enough to account for such differences. Consider the challenge of supporting individuals in optimizing their experiences with diverse forms of social media content. While some forms of content, like extreme violence, will hurt all individuals, other kinds of content may enhance well-being for some and hurt it for others. Photos and videos of travel destinations may inspire some, but evoke envy or fear of missing out for others (van der Wal et al., 2022). Furthermore, the same person can respond to the same content in different ways at different points in time. For example, looking at photos of a romantic partner may elicit substantially different affective responses depending on the current well-being of the relationship. Providing a normative recommendation for how individuals should engage with most forms of content may thus be challenging. An agency-oriented intervention could instead support individuals in developing the beliefs, literacies, and practices they need to manage their own content streams to optimize their own well-being (e.g., by guiding individuals with reflective questions like "What kinds of social media content tend to make you feel better or worse, and why?"). By teaching individuals how to take control of their own exposure to social media content and to enact agentic practices for curating their feed, with knowledge of its underlying functionalities, we may be better able to support individuals in making the most out of their experiences with social media.

Conclusion

If social media is to be a part of our lives, we should find a way to harness its benefits and minimize its harms. Identifying the ways in which we can use social media agentically can advance theory on social media effects by introducing the intentionality of one's social media use as an important potential determinant of positive outcomes. We build on prior research to argue that people may be better able to obtain benefits from their social media use when they have an agentic mindset that empowers them to use it for valued goals, understand enough about the workings of social media to be informed users, and enact practices that allow them to exert control over their engagement with social media.

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Davide Marengo,
University of Turin,
Italy

REVIEWED BY
David Pillow,
University of Texas at San Antonio,
United States
Nurul Qomariyah,
Gunadarma University,
Indonesia

*CORRESPONDENCE
Laura Marciano
lmarciano@hsph.harvard.edu

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Social media use and adolescents' well-being: A note on flourishing

Laura Marciano[1,2]* and Kasisomayajula Viswanath[1]

[1]Harvard T. H. Chan School of Public Health, Lee Kum Sheung Center for Health and Happiness, Dana-Farber Cancer Institute, Boston, MA, United States, [2]Institute of Public Health, USI Università della Svizzera italiana, Lugano, Switzerland

Background: Several large-scale studies and reviews have reported both negative and positive associations of social media use with well-being, suggesting that the findings are more complex and need more nuanced study. Moreover, there is little or no exploration of how social media use in adolescence influences *flourishing*, a more all-encompassing construct beyond well-being, including six sub-domains (i.e., happiness, meaning and purpose, physical and mental health, character, close social relationships, and financial stability). This paper aims to fill this gap by understanding how adolescents might flourish through social media activities by fulfilling the basic needs pointed out by the Self-Determination Theory, i.e., relatedness, autonomy, and competence.

Methods: The study is drawn on cross-sectional data collected from 1,429 Swiss adolescents (58.8% females, M_{age}=15.84, SD_{age}=0.83) as part of the HappyB project in Spring 2022. Self-reported measures included the Harvard Adolescent Flourishing scale, positive and negative online social experiences, self-disclosure on social media, and social media inspiration. Control variables included, among others, self-esteem, ill-being, and personality.

Results: After applying Bonferroni's correction, results of the hierarchical regression analyses showed that positive social media experiences (β=0.112, p<0.001) and social media inspirations from others (β=0.072, p<0.001) and for others (β=0.060, p=0.003) were positively associated with flourishing. Flourishing was inversely associated with negative social media experiences (β=−0.076, p<0.001). Among covariates, self-esteem (β=0.350, p<0.001), ill-being (β=−0.252, p<0.001), perceived school environment (β=0.138, p<0.001), self-reported level of physical activity (β =0.109, p<0.001), and perceived socio-economic status (β=−0.059, p=0.001) were all related to flourishing. In contrast, gender, high school year, age, perceived stress, and personality (extraversion and neuroticism) were not.

Conclusion: Using a well-being framework to investigate social media use in adolescents is needed to go beyond the ill-being perspective. Our results align with the needs pointed out by the Self-Determination Theory. Carrying out social media activities in a way that promotes—rather than diminishes—flourishing should be included as an additional good habit influencing adolescents' development. We suggest that interventions aiming to foster adolescents' flourishing should include curricula aiming to promote a good use of social media through positive online social relationships and inspirational contents.

KEYWORDS

social media, adolescence, flourishing, self-determination theory, self-disclosure, inspiration

Introduction

In Switzerland, 99% of 12 to 19-year-olds own a smartphone, with higher prevalence rates in late adolescence (Süss et al., 2020). The most frequent activities include instant messaging and social media use (Süss et al., 2020). Compared to 2018, in 2020, Swiss adolescents spent 40 min more on their smartphones during a typical weekday (achieving a total of more than 3 h/day) and almost 2 h more during a weekend day (for a total of about 5 h/day). This was the highest level since 2010 (Süss et al., 2020), though, likely, partly due to the ongoing COVID-19 pandemic (Fernandes et al., 2020; Montag and Elhai, 2020). Indeed, due to COVID-19, increased time spent on social media was reported, together with a higher prevalence of problematic use of digital technologies, and these increments have been related to adverse health outcomes (Marciano et al., 2022a), including an increase in depressive symptoms, anxiety, and inattention problems (Marciano et al., 2022b). Several large-scale studies showed that adolescents who spend more time on screens also show lower overall well-being (Twenge and Campbell, 2019; Twenge et al., 2021), lower life satisfaction and happiness (Booker et al., 2015; Twenge et al., 2018), as well as higher levels of loneliness (Kelly et al., 2018; Twenge et al., 2021) and depression (Kelly et al., 2018; Twenge and Campbell, 2018). However, four reviews of reviews (Dickson et al., 2018; Odgers and Jensen, 2020; Orben, 2020; Valkenburg et al., 2021) highlighted small associations between digital media use and adolescents' well-being in both negative and positive directions, thus leading to mixed results and to the conclusion that *there is no uniform effect for all adolescents*. The presence of positive associations with social media use—in addition to the negative ones—also aligns with the digital Goldilocks hypothesis (Przybylski and Weinstein, 2017), according to which a moderate—"just right"—use of digital technologies would not be intrinsically harmful. In other words, when digital media use is too high, that might be at the expense of other offline activities (Camerini et al., 2020). If, on the other side, it is too low, it can deprive young people of gaining important information and connecting with peers. For example, Twenge et al. (2018) reported that, compared with no use at all, adolescents' levels of happiness were higher when digital media were used for at least a few hours a week. Similarly, digital detox would cut off young people from social connections and support, thus lowering well-being and making people crave even more to spend time online when the detox period is over (Radtke et al., 2022).

The evaluation of well-being in adolescence is particularly crucial, considering that half of the mental health disorders with long-lasting effects start in mid-adolescence (Kessler et al., 2005, 2007; Merikangas et al., 2010). A significant increase in the prevalence of adolescents' mental health problems has been reported in the past decade in the United States (Monaco, 2021) and Europe (Neufeld SAS, 2022), thus representing a great public health concern. In Switzerland, from 2012 to 2020, people treated for mental health problems increased by approximately 26% in total, with higher growth (+40%) in children and adolescents than in adults (+25%; Federal Statistical Office, 2022). This increase has been related to changes in epigenetic factors, i.e., modifiable factors deriving from the continuous and dynamic interconnection of genetic predispositions with environmental situations, with social media and screen time as one of the factors proposed to have contributed to such a growth (Monaco, 2021). Yet, more research should be conducted to explore *well*-being outcomes. Indeed, well-being is not only the absence of mental illness, but it is related to the presence of happiness, having a purpose and a sense of meaning, and good relationships (VanderWeele et al., 2020). According to the positive psychology and epidemiology perspectives, well-being is "a complex construct that concerns optimal experience and functioning" (Ryan and Deci, 2001). For some authors, well-being cannot just be defined bi-dimensionally on a continuum, but it is multifaceted, like a "garden" or an "orchestra" (Lomas and Vanderweele, 2022). Today, the concept of flourishing (Henderson and Knight, 2012; Huppert, 2013; Willen, 2021) mirrors these multi-facets by measuring a sense of growing and prospering, and it has been pointed out as a new conceptual framework for defining well-being (Huppert, 2013). Studying flourishing is becoming crucial to move from the ill-being framework (i.e., the study of psychopathological symptoms) to the science of promoting a broader notion of human well-being as an important means through which society can thrive (VanderWeele, 2017). In one review of 11 studies focusing on adolescence (Witten et al., 2019), flourishing has been conceptualized in diverse and vague ways. In particular, the presence of different assessment instruments does not fully align with the wide meaning of the construct since they often measure only one component of flourishing, like life satisfaction or meaning. In the present study, we drew on the definition by VanderWeele (2017), who refers to flourishing as "a state in which all aspects of a person's life are good" (p. 8149), thus capturing a holistic view of what it means to thrive. In particular, flourishing would include six broad domains, i.e., happiness and life satisfaction (hedonic well-being), meaning and purpose (eudaimonic well-being), physical and mental health, character and virtue, close social relationships (social well-being), and financial stability (VanderWeele et al., 2019). With the exception of financial well-being, these domains are usually viewed as ends and almost universally desired. Whereas financial stability is not an end, but it enables to preserve goods that are their own ends. Also, although not exhaustive, four pathways are associated with the domains of flourishing, i.e., family, work, education, and religious community (VanderWeele, 2017). These pathways highlight the positive role of supportive family relations and marriage, employment vs. unemployment, higher education (with possibly greater effects in the United States than European countries), and participation in religious community, respectively, on improving flourishing in the adult population. Yet, how the online environment relates to flourishing in adolescents is still largely unexplored. For example, adolescents might flourish through social media activities by fulfilling the basic needs pointed out by the Self-Determination Theory (SDT Ryan and Deci, 2000; Huppert, 2013), i.e., relatedness, autonomy, and competence. According to the STD, these needs drive human motivation and should be met for optimal development and functioning. Indeed, adolescents need to feel a sense of closeness and connectedness with others to experience emotional security and acceptance; also, they need to develop their sense of autonomy and identity by expressing themselves and making choices freely; finally, adolescents want to feel competent by showing their skills and achieving chosen goals effectively (Hui and Tsang, 2012). However, how these needs are expressed through social media activities is not clear. Also, how these activities can be related to flourishing in adolescence is still unexplored.

A recent systematic review (Gudka et al., 2023) summarized 118 studies on social media use using a framework based on flourishing dimensions. Although the focus was not on adolescents, it can be a starting point to delineate which social media activities contribute to

enhancing well-being. First, and according to the SDT's need for relatedness, studies showed that social media use augmented social support and belongingness and diminished the sense of loneliness, especially in people with specific needs and minorities. Similarly, social media fostered social capital, including both weak and strong ties, bridging and bonding capital, thus augmenting emotional support and networking value. Nevertheless, social support and enhancement of well-being offered by social media were short (Marciano et al., 2022c) and particularly useful for momentary emotional relief from stressful situations (Neubaum et al., 2014; Bayer et al., 2018). Indeed, according to the interpersonal-connection-behaviors framework (Clark et al., 2018), the quality of the social connection experienced through social media depends on the capacity of the user to build meaningful social connections or not. Similarly, the Internet-enhanced self-disclosure hypothesis and the Evolutionary mismatch model propose two opposite views through which social connections would improve vs. diminish well-being *via* the quality of online relationships (Marciano et al., 2022d). According to a study on 872 Chinese adolescents, active social media use positively influenced adolescents' flourishing, but this effect was mediated by online and offline social capital (Liu et al., 2020), thus suggesting how social capital has evolved in two forms today. Nevertheless, according to the authors, "the online environment still needs to find a foothold in offline life to influence individuals" (p. 6).

Second, according to the SDT's need for autonomy, social media use can be beneficial since it enables authentic self-expression and the process of narrative identity (McAdams, 2011), described as the internalized and meaningful story of the evolving self. Authentic self-expression and authenticity on social media lead to higher subjective well-being, including a positive mood and affect (Bailey et al., 2020). In this regard, self-disclosure on social media could facilitate building a sense of autonomy and identity development while, at the same time, maintaining close relationships with others (McLean et al., 2010). For example, narrative identities facilitate young people to build a coherent sense of themselves from the life experiences shared online (Gudka et al., 2023). Narratives are tools to develop identity by reflecting on past experiences in relation to the present and future self (Habermas and Bluck, 2000). At the same time, individual identity is socially construed, especially during the adolescent period. Indeed, a healthy identity exploration includes developing an independent sense of self, while in the context of close relationships, a process called "individuation" (McLean et al., 2010). Thus, social media might allow the integration of others' feedback in their identity formation as well as values and behaviors to create a sense of social identity (Tajfel and Turner, 2004).

Third, social media may enhance the need for competence through the exploration of one's interests. Interacting with digital tools expands existing abilities and skills (e.g., creativity through content creation; Rasheed et al., 2020). In particular, social media use fosters positive emotions through the exploration of personal interests and the discovery of new areas of learning, including topics such as cooking, sports, learning about other cultures, and being exposed to new ideas and inspirational contents (Weinstein, 2018). In other words, "interest-driven exploration" on social media refers to an active search for inspiration (Weinstein, 2018). In this regard, positive envy experienced on social media can drive inspiration through assimilation (Meier and Schäfer, 2018), i.e., when the individual focuses on how to become similar to the (upward) comparison target. By doing so, virtual communities that encourage, inspire, and share success would lead to a high sense of self-worth and accomplishment (de la Peña and Quintanilla, 2015; Meier and Schäfer, 2018; Rieger and Klimmt, 2019a). Hence, social media can be seen as a source of "daily doses" of inspiration by receiving and scrolling "eudaimonic messages," for example, through posts and memes (Rieger and Klimmt, 2019a). Interestingly, social media-based eudaimonic messages have been described as practical, i.e., they refer to situations and tasks people face daily, like motivating oneself to study for an exam or going to the gym despite being tired, thus reflecting how the presence of social media is pervasive and rooted in users' daily experiences. Also, social media-based eudaimonic content includes visual beauty and pleasantness posts thus offering short moments of contemplation and promoting mindfulness experiences (Rieger and Klimmt, 2019a,b).

Due to the paucity of literature on flourishing and social media use in adolescents, the present study aims to investigate which social media experiences are related to flourishing. In particular, guided by the developmental needs pointed out by the SDT, we included positive and negative social media experiences, self-disclosure on social media, and social media inspiration as proxies of the online fulfillment of SDT needs, to investigate how they were associated with flourishing. We aim to estimate the associations of social media activities with flourishing over and above confounding variables, including other conceptualizations of well-being (i.e., self-esteem), ill-being (e.g., psychopathological symptoms), personality (extraversion and neuroticism), perceived stress, perceived school environment, and self-reported level of physical activity, and sociodemographic factors.

Methods

Study design and sample

Data were collected from Swiss adolescents during the first wave of the longitudinal "HappyB" project,[1] carried out in Spring 2022, in canton Ticino, Italian-speaking Switzerland. Four high schools located in different regions were involved for a total of 1,662 students and 79 classes in the first and second high school years. Data were collected through an online questionnaire *via* Qualtrics during a school hour with the presence of a teacher previously trained by the research team. Students were invited to participate through a flyer distributed in classrooms, including information about the study's aim. According to the Swiss ethics guidelines, adolescent participants aged 14 and over can provide consent by themselves if the study entails minimal risks. Hence, participants gave their consent directly at the beginning of the online questionnaire. Of the initial sample, 145 participants were not present on the day of data collection or decided not to participate in the study, 28 did not complete the questionnaire, and 57 reported an invalid answer to the control question (i.e., "To check your attention, we ask you to select the number 3 from the list"). Three participants were outliers as they had z-scores > |3.5| (Iglewicz and Hoaglin, 1993) in the included variables, hence they were excluded from the analysis. The study was approved by the regional education administration and

1 https://mediaticino.usi.ch/en/happyb

by the ethics committee of USI Università della Svizzera italiana, Lugano (Switzerland).

Measures

Measures were translated from English into Italian when necessary and independently back-translated to assure linguistic validity. A complete list of items and response options is reported in Supplementary Table 1. Descriptive statistics for each included concept are summarized in Table 1. To note, measures used to investigate SDT constructs are proxies of relatedness, autonomy, and competence in the context of social media use in adolescents.

Outcome

Flourishing

It was measured using the Harvard Adolescent Flourishing Measure (ages 12–18; 48). The scale includes 12 items and response options were on a scale from 0 to 10, where higher values indicate higher levels of flourishing ($M = 7.22$, $SD = 1.47$, $\alpha = 0.840$). The following dimensions were investigated: life satisfaction and happiness (2 items), mental and physical health (2 items), meaning and purpose (2 items), character and virtue (2 items), close social relationships (2 items), and financial and material stability (2 items). The confirmatory factor analysis of the Flourishing scale showed good fit indices for the one-factor dimension ($\chi^2 = 398.387$, $df = 53$, $p < 0.001$, $CFI = 0.914$, RMSEA=. 068, $SRMR = 0.046$; see Supplementary Table 2). In particular, according to the unidimensional factor structure, the item mainly correlated to flourishing in adolescents was the experience of happiness.

Key predictors

Positive and negative social experiences on social media

Experiences elicited by social media use were measured using nine items from the Online Social Experience Measure (Kent de Grey et al., 2019). The original measure includes 20 items for positive online social experiences (OSEM+ subscale) and 20 for negative online social experiences (OSEM-subscale). We selected a subset of items from the original scale based on their factor loadings. In particular, we included five positive (e.g., "There are people who have faith in me and my abilities.," "When I feel lonely, there are several people I can talk to") and four negative online social experiences (e.g., "People have little regard for my emotions.," "I felt ignored or unimportant to others."). Answer options ranged from 1 "totally disagree" to 7 "totally agree." The items were averaged to form a single measure of positive ($M_{positive} = 5.00$, $SD_{positive} = 1.28$, $\alpha_{positive} = 0.813$) and negative ($M_{negative} = 3.55$, $SD_{negative} = 1.43$, $\alpha_{negative} = 0.802$) experiences on social media.

Self-disclosure on social media

Two items were used to measure self-disclosure on social media: "I am honest when I express something about myself "and "I express

TABLE 1 Sample characteristics (N=1,429) and variables' descriptive information.

Sample characteristics	M or n		SD or %	
Females	840		58.8	
Males	589		41.2	
First high school year	788		55.1	
Second high school year	641		44.9	
Age	15.84		0.83	
Perceived SES	2.00		0.814	
Variables	**M**	**SD**	**Median**	**Range**
Flourishing	7.22	1.47	7.49	2.17–10
Positive social media experiences	5	1.28	5.2	1–7
Negative social media experiences	3.55	1.43	3.75	1–7
Self-disclosure on social media (with close friends)	2.84	0.77	3	1–4
Self-disclosure on social media (with acquaintances or famous people)	1.93	0.75	2	1–4
Social media inspiration (from others)	5.57	2.25	5.7	0–10
Social media inspiration (for others)	4.84	2.49	5.1	0–10
Self-esteem	2.73	0.88	2.62	1–5
Ill-being	2.77	0.59	2.8	1–4
Extraversion	5.13	2.21	5.05	0–10
Neuroticism	5.36	2.63	5.32	0–10
Perceived school environment	3.16	0.718	3	1–4
Self-reported level of physical activity	6.2	2.99	7	0–10
Perceived stress	5.66	2.83	6	0–10

SES, socio-economic status.

my mood and my feelings" (Gibbs et al., 2006). The two statements were repeated for measuring two predictors: (i) self-disclosure to close friends (e.g., best friends, those you interact with every day) and (ii) self-disclosure with acquaintances or famous people (e.g., those people you know "by sight" or bloggers, Youtubers, influencers; Gibbs et al., 2006). Answer options ranged from 1 "never" to 4 "always." The two items were averaged to form a single measure of self-disclosure with close friends (M = 2.84, SD = 0.77, r = 0.376, $p < 0.001$) and self-disclosure with acquaintances or famous people (M = 1.93, SD = 0.75, r = 0.332, $p < 0.001$).

Social media inspiration

It was measured by including four items adapted from other studies looking at positive envy and inspiration (Thrash and Elliot, 2003; Lange and Crusius, 2015). The four items measured two predictors: (i) inspiration from others and (ii) being an inspiration for others. Inspiration for others included the following statement (Thrash and Elliot, 2003; Lange and Crusius, 2015): "On social media, if I notice that a person is better than me, I would try to…" followed by the following four items: ameliorate myself, focus on how to become equally successful, strive to reach the same achievements, and feel inspired. Answer options ranged from 0 "never" to 10 "always." The four items were averaged to form a single measure of inspiration from others (M = 5.57, SD = 2.25, α = 0.842). Being an inspiration for others included the following statement "On social media, if I notice that I am better at something than others, I would try to…" followed by the following four items: help others to improve, focus on how to help others to be successful in the future in the same way, strive to help others achieve the same goals, and feeling to be an inspiration for others. The four items were averaged to form a single measure of being an inspiration for others (M = 4.84, SD = 2.49, α = 0.880).

Control variables

Self-esteem

It was measured with the 10-item Rosenberg Self-esteem scale (Rosenberg, 1979; Prezza et al., 1997), with answer options ranging from 1 "completely disagree" to 4 "completely agree." The items were averaged to form a single measure of self-esteem (M = 2.73, SD = 0.59, α = 0.885).

Ill-being

It was measured with eight items adapted from the DSM-5 Self-Rated Level 1 Cross-Cutting Symptom Measure for Child Age 11–17 (Bastiaens and Galus, 2018). The list included the following symptoms experienced in the past month: somatic symptoms (1 item), inattention (2 items), sleep problems (1 item), anxiety (2 items), and depressive symptoms (2 items). Response options ranged from 1 to 5, where 1 "never (none)," 2 "rarely (slight)," 3 "several days (mild)," 4 "more than a half of days (moderate)," and 5 "almost every day (severe)." The items were averaged to form a single indicator of ill-being (M = 2.77, SD = 0.59, α = 0.859).

Personality

Personality traits included extraversion and neuroticism, and were measured with four items from the 10-item Big Five Inventory (Guido et al., 2015). Response options ranged from 0 "totally disagree" to 10 "totally agree." In particular, extraversion were measured by asking participants if they were "outgoing, sociable" and "reserved (reversed item)." The two items were averaged to form a single measure of extraversion (r = 0.352, $p < 0.001$, M = 5.13, SD = 2.21). Neuroticism was assessed by asking if they "get nervous easily" and were "relaxed, handles stress very well (reversed item)." The two items were averaged to form a single measure of neuroticism (r = 0.527, p < 0.001, M = 5.36, SD = 2.63).

Other control variables

Other control variables included gender (0 "male," 1 "female"), perceived socioeconomic status (SES) measured with the following item: "How much wealthy do you think your family is?" (from 1 "Definitely wealthy" to 5 "Definitely not wealthy"), high school year attended (0 "first year," 1 "second year"), perceived school environment with the following item "In general, do you feel comfortable in your high school?" (from 1 "Not at all" to 4 "A lot"), self-reported level of physical activity with the item "How much do you consider yourself a sporty person?" (from 0 "not at all" to 10 "very much"), and perceived stress with the item "During the last month, what was your daily stress level? (from 0 "not stressed at all" to 10 "very stressed").

Analytical plan

After checking that variables were normally distributed (skewness and kurtosis < |1|), we computed Pearson's correlations among all the included variables with the Flourishing scale. Then, we ran a hierarchical regression analysis with flourishing levels as the outcome. At each step, we added a different set of control variables and social media activities. In particular, in Model 1 we included gender, perceived SES, high school year attended, and age; in Model 2, we further added perceived school environment, self-reported level of physical activity, perceived stress, self-esteem, ill-being, and personality as control variables; in Model 3, we additional included positive and negative online social experiences, self-disclosure on social media, and social media inspiration as predictors. We controlled for multicollinearity (VIF > 5) and applied a Bonferroni's correction to interpret the results. Missing data were excluded listwise (<1.3% for all the variables). Additionally, we further explored which online social media activities were most related to flourishing with an additional regression analysis.

Results

The final analytical sample was composed of 1,429 participants (86%) attending the first (n = 788, 55.1%) and second (n = 641, 44.9%) high school year, with a mean age of 15.84 years (SD = 0.83). Around half of the sample was composed of females (n = 840, 58.8%) and most reported being wealthy or very wealthy (n = 1,070, 76.4%). Table 1 shows sample characteristics and variables' descriptive information.

Pearson's correlations showed that flourishing levels correlated with all the included variables (see Table 3). In order, flourishing positively correlated with self-esteem (r = 0.651, $p < 0.001$), extraversion (r = 0.276, $p < 0.001$), self-reported level of physical activity (r = 0.325, $p < 0.001$), perception of the school environment (r = 0.391, $p < 0.001$), positive social media experiences (r = 0.314, $p < 0.001$), self-disclosure on social media with close friends (r = 0.206,

$p < 0.001$), social media inspiration from others ($r = 0.171$ $p < 0.001$) and for others ($r = 0.167$, $p < 0.001$), and self-disclosure on social media with acquaintances and famous people ($r = 0.129$, $p < 0.001$). Conversely, flourishing negatively correlated with ill-being ($r = -0.569$, $p < 0.001$) and neuroticism ($r = -0.343$, $p < 0.001$), negative social media experiences ($r = -0.417$, $p < 0.001$), perceived stress ($r = -0.356$, $p < 0.001$), low perceived SES ($r = -0.213$, $p < 0.001$), female gender ($r = -0.189$, $p < 0.001$), attending the second high school year ($r = -0.084$, $p < 0.001$), and age ($r = -109$, $p < 0.001$; Table 2).

Results of the hierarchical regression analysis explained more than half of the variance in the Flourishing scale ($R^2 = 0.553$). After applying Bonferroni's correction ($p < 0.003$) and controlling for all covariates, the following social media activities positively predicted flourishing: positive social media experiences ($\beta = 0.112$, $p < 0.001$) and social media inspirations from others ($\beta = 0.072$, $p < 0.001$) and partially for others ($\beta = 0.060$, $p = 0.003$). Self-disclosure on social media with close friends ($\beta = 0.057$, $p = 0.005$) and with acquaintances or famous people ($\beta = -0.018$, $p = 0.365$) were not significant predictors. Conversely, flourishing levels were inversely associated with negative social media experiences ($\beta = -0.076$, $p < 0.001$). Among covariates, self-esteem ($\beta = 0.350$, $p < 0.001$), ill-being ($\beta = -0.252$, $p < 0.001$), perceived school environment ($\beta = 0.138$, $p < 0.001$), self-reported level of physical activity ($\beta = 0.109$, $p < 0.001$), and perceived SES ($\beta = -0.059$, $p = 0.001$) were all related to flourishing. Whereas gender, high school year attended, age, personality, and perceived stress showed no significant associations with the outcome.

A more details analysis using the items of social media activities influencing flourishing (i.e., positive and negative social media experiences and social media inspiration for others, see Supplementary Table 3) showed that, after applying Bonferroni's correction ($p < 0.004$), the positive social media experiences significantly and positively associated with flourishing were the possibility of having several people to talk to on social media when someone was feeling lonely ($\beta = 0.146$, $p < 0.001$), having people praising accomplishments ($\beta = 0.102$, $p < 0.001$), and having people with faith in the person and his/her abilities ($\beta = 0.118$, $p < 0.001$). Additionally, feeling inspired ($\beta = 0.111$, $p < 0.001$) was associated with higher flourishing. Conversely, feeling ignored ($\beta = -0.124$, $p < 0.001$), the presence of people with little regard for emotions (-0.064, $p < 0.001$), and feeling excluded ($\beta = -0.056$, $p < 0.001$) were negatively related to flourishing.

Discussion

In the current study, we explored social media use in adolescents using a positive well-being framework. In particular, drawing from cross-sectional data collected in a large sample of adolescents, we investigated how different social media experiences were associated with flourishing. The concept of flourishing has already been defined by VanderWeele (2017) and VanderWeele et al. (2019), but research on adolescents' flourishing is scarce, and, to our knowledge, no study has explored its relationship with different social media experiences. In this paper, we aimed to explore how adolescents' social media use influences flourishing guided by the three pathways pointed out by the SDT: augmenting or diminishing relatedness through positive or negative online social experiences, fostering autonomy through self-disclosure, and augmenting competence through inspirational contents. To control for confounding variables, we included self-esteem, ill-being, and personality (extraversion and neuroticism) as covariates and other socio-demographics and contextual factors. Results showed the following three major findings.

First, among all the social media activities, flourishing was mainly related to positive social media experiences. In particular, some positive social media experiences showed moderate and positive associations with the outcome. For example, the possibility of having several people to talk to when someone is feeling lonely was the social media experience mostly related to flourishing in adolescents. This positive association was present over and above control variables such as self-esteem, ill-being, and personality. This result is in line with a recent meta-analysis showing that good social connections are an important protective factor against ill-being in adolescence (Rueger et al., 2016), although the source of social connection changes from family to peers during the adolescent years. In general, research in diverse disciplines demonstrated that social connections are crucial for well-being and physical health (Morina et al., 2021), including stress management (Gunnar and Hostinar, 2015). Having a large network of peer relationships that are perceived as supportive acts as a safe and predictable environment improving rewarding experiences (Durlak et al., 2011) and offering an effective buffer against negative emotions (Gariépy et al., 2016). One widely explored pathway through which social connection fosters well-being is the role of social support in stressful situations (Holt-Lunstad, 2022), e.g., in a moment of loneliness. This result is crucial, considering that a study including data on 37 countries showed that loneliness rates in adolescents increased after 2012 "in conjunction with the rise of smartphone access and increased internet use, though causation cannot be proven" (Gunnar and Hostinar, 2015, p.257). Indeed, in disentangling between- vs. within-person effects, Twenge et al. (2019) found that, at the within-person level, young people using social media more often than their own average levels of use also accrued social capital and opportunities for in-person interactions, thus experiencing less loneliness. In addition to this result, relationship quality is crucial. Supportive and receptive peers promote positive affect, whereas adolescents who tend to co-ruminate on negative outcomes have protracted negative feelings (Stewart et al., 2013). Indeed, not surprisingly, in our study, negative social media experiences like feeling ignored, excluded, and interacting with people having little or no regard for participants' emotions were associated with lower levels of flourishing. Notably, the negative effects of social relations could be even worse in adolescence since the developing brain is particularly susceptible to others' behaviors and judgments (Blakemore, 2008; Somerville, 2013), and affective consequences of negative social experiences are greater in adolescents compared to adulthood (Sebastian et al., 2010). This aligns with a study on 9,107 adolescents showing that happiness was primarily and positively associated with good social connections (e.g., with family, friends, and school), and it was negatively related to bullying behaviors and discrimination (Lambert et al., 2014). Furthermore, flourishing was positively correlated with self-disclosure on social media. However, the association was not significant in the regression analysis.

TABLE 2 Correlations table of all the variables included in the regression models.

	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	13.	14.	15.	16.	17.
Flourishing	1																
Positive social media experiences	0.314**	1															
Negative social media experiences	−0.417**	−0.149**	1														
Self-disclosure on social media (with close friends)	0.206**	0.353**	−0.102**	1													
Self-disclosure on social media (with acquaintances or famous people)	0.129**	0.183**	−0.080**	0.376**	1												
Social media inspiration (from others)	0.171**	0.174**	0.025	0.128**	0.114**	1											
Social media inspiration (for others)	0.167**	0.268**	−0.032	0.169**	0.185**	0.399**	1										
Self-esteem	0.651**	0.225**	−0.482**	0.147**	0.122**	0.089**	0.063*	1									
Ill-being	−0.569**	−0.101**	0.470**	−0.052	−0.052*	0.001	0.008	−0.630**	1								
Extraversion	0.276**	0.208**	−0.204**	0.169**	0.128**	0.087**	0.099**	0.297**	−0.209**	1							
Neuroticism	−0.343**	−0.043	0.361**	−0.044	−0.066*	0.004	0.027	−0.500**	0.536**	−0.160**	1						
Perceived school environment	0.391**	0.159**	−0.241**	0.072**	0.068*	0.050	0.062*	0.332**	−0.341**	0.138**	−0.220**	1					
Self-reported level of physical activity	0.325**	0.108**	−0.136**	0.052	0.093**	0.139**	0.058*	0.300**	−0.251**	0.206**	−0.190**	0.111**	1				
Perceived stress	−0.356**	−0.017	0.311**	−0.002	−0.011	0.033	0.031	−0.479**	0.623**	−0.154**	0.588**	−0.286**	−0.119**	1			
Gender (1 = female)	−0.189**	0.046	0.208**	0.051	−0.014	−0.032	0.119**	−0.316**	0.349**	−0.093**	0.373**	−0.062*	−0.283**	0.338**	1		
Perceived SES	−0.213**	−0.095**	0.133**	−0.014	0.005	−0.027	0.003	−0.182**	0.144**	−0.088**	0.051	−0.120**	−0.147**	0.050	0.042	1	
High school year (1 = second year)	−0.084**	−0.019	0.046	0.004	0.034	−0.083**	−0.100**	−0.063*	0.120**	0.001	0.056*	−0.043	−0.035	0.101**	−0.008	0.008	1
Age	−0.109**	−0.003	0.043	−0.017	0.049	−0.033	−0.039	−0.086**	0.124**	0.009	0.055*	−0.093**	−0.073**	0.087**	−0.056*	0.104**	0.658**

*$p < 0.05$, **$p < 0.01$. SD, Self-disclosure.

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TABLE 3 Hierarchical regression results with flourishing as outcome.

	Model 1				Model 2				Model 3			
	B	(SE)	Beta	*p*	B	(SE)	Beta	*p*	B	SE	Beta	*p*
(Constant)	10.559	0.876		0.000	3.752	0.717		0.000	3.836	0.701		0.000
Gender (1 = female)	−0.566	0.077	−0.189	0.000	0.175	0.064	0.058	0.006	0.113	0.063	0.038	0.071
Perceived SES	−0.362	0.047	−0.200	0.000	−0.117	0.035	−0.064	0.001	−0.106	0.034	−0.059	0.002
High school year (1 = second year)	−0.085	0.101	−0.029	0.400	−0.054	0.074	−0.018	0.463	0.016	0.072	0.005	0.821
Age	−0.136	0.061	−0.077	0.026	0.006	0.045	0.003	0.902	−0.020	0.043	−0.011	0.641
Perceived school environment					0.328	0.042	0.160	0.000	0.283	0.040	0.138	0.000
Self-reported level of physical activity					0.061	0.010	0.123	0.000	0.054	0.010	0.109	0.000
Perceived stress					0.022	0.014	0.042	0.113	0.009	0.013	0.017	0.513
Self-esteem					1.043	0.065	0.418	0.000	0.874	0.065	0.350	0.000
Ill-being					−0.433	0.047	−0.261	0.000	−0.418	0.046	−0.252	0.000
Extraversion					0.047	0.013	0.070	0.000	0.023	0.013	0.035	0.074
Neuroticism					0.020	0.014	0.035	0.157	0.020	0.013	0.036	0.131
Positive social media experiences									0.129	0.023	0.112	0.000
Negative social media experiences									−0.079	0.022	−0.076	0.000
SD (with close friends)									0.111	0.040	0.057	0.005
SD (with acquaintances or famous people)									−0.035	0.039	−0.018	0.365
Social media inspiration (from others)									0.047	0.013	0.072	0.000
Social media inspiration (for others)									0.036	0.012	0.060	0.003
Adjusted R square	0.087**				0.515**				0.553**			

B, Unstandardized beta; SE, standard error; β, Standardized beta; *p*, value of *p*; SES, socio-economic status; SD, self-disclosure. $^{**}p < 0.01$.

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Probably, the measure of self-disclosure showed some overlaps with the construct of positive online social experiences, although there was no collinearity between the two variables. In particular, it is challenging to disentangle self-disclosure from social connection since the two are interrelated: indeed, the development of identity and autonomy happens in the context of close relationships (McLean et al., 2010).

Second, our results showed that inspiration through social media content (i.e., being inspired by others' posts and activities and being an inspiration for others) improves flourishing levels in adolescents. Positive affective outcomes, including flourishing, might be fostered by pursuing social media posts and content related to personal activities and hobbies (Meier and Schäfer, 2018). Indeed, the exploration of one's interests and the discovery of new areas of learning relieve distress and allow for spreading positive messages (Weinstein, 2018). Active posting and engaging with hedonic or inspiring social media content has improved well-being, including increasing love and compassion toward others (Janicke-Bowles et al., 2022). Also, inspiration shapes how people share: inspiring messages are more likely to be shared in new ways by the users (Xia and Wai Li, 2022). Inspirational moments on social media have also been described as gratifying (Rieger and Klimmt, 2019a), with the potential to match users' situational demands with meaning, thus giving small drives of mindfulness and psychological healing in daily life (Rieger and Klimmt, 2019a). Finally, well-being can be fostered through the assimilation of upward comparison targets through benign envy (Meier and Schäfer, 2018). For example, evocative objects of inspiration may offer new or better possibilities, thus motivating a person to take action and ameliorate oneself (Meier et al., 2020), thus contributing to different facets of well-being, like hedonic and eudaimonic, both tackled by flourishing sub-dimensions.

Third, different covariates showed moderate to strong associations with flourishing. First, self-esteem was largely and positively associated, whereas ill-being was largely and negatively associated with flourishing. This result does not surprise, considering that flourishing can be seen as the extreme of a continuum, where ill-being is the opposite side. However, well-being does not reflect the absence of ill-being (Zhao and Tay, 2022): the mid-point can be defined as a "neutral and nominal zero" (Janicke-Bowles et al., 2022, p. 3). Additionally, a good school environment (e.g., with peers and teachers) was positively associated with flourishing. This result reflects that flourishing encompasses different dimensions, including socio-ecological factors (Kim et al., 2020), and each of them should be considered in the evaluation of adolescents' well-being. In general, positive emotions during school are associated with more student engagement and adaptive coping in students (Reschly et al., 2008), and interventions based on positive psychology showed that participants improved positive emotions and increased levels of calmness and enjoyment (Laakso et al., 2022). Also, flourishing has been related to supportive school environments, students' sense of belonging to the school, and civic engagement (Fink, 2014), thus underlying the importance of considering the adolescent's environment when exploring well-being. Additionally, in line with other studies focusing on well-being outcomes such as life satisfaction, flourishing levels were related to being physically active, carrying out vigorous exercises, and participating in group sports (Proctor et al., 2009). Also, a meta-analysis reported the beneficial effects of physical activity interventions on well-being outcomes including resilience and positive mental health (Andermo et al., 2020) as well as health-related quality of life (Marker et al., 2018). Furthermore, a lower perceived SES was negatively related to flourishing. This negative association could be partly due to the fact that flourishing encompasses financial stability. Also, according to the social determinants of health, health outcomes differ by socioeconomic factors and racial and ethnic characteristics (Fernandez and Kulik, 1981; Huebner, 1991; Verme, 2011). Health inequities lead to differences in motivations, access, and engagement with communication, such as social media (Viswanath and Emmons, 2006; Kontos et al., 2007; Bekalu et al., 2019; Viswanath et al., 2021). Finally, extraversion—and not neuroticism—was related to flourishing but not in the final regression model. This result aligns with extroverts' tendency to display positivity and use social media frequently to maintain offline social contacts and create content (Amichai-Hamburger et al., 2002). On the contrary, neuroticism has been related to problematic digital media use and addictive online behaviors (Marciano et al., 2020).

To conclude, good habits encompass different dimensions of youth's well-being and can act as a "mental vaccine" enhancing brain resilience (Ekman et al., 2022). Thus, stemming from the results of our study, we suggest that, together with a range of good habits, including "healthy eating, exercising, rest and sleep, optimism, managing stress, making autonomous decisions, variety and challenge, social interactions with friends, learning new things, and repetition" (Twenge et al., 2019, p. 13), also using social media in a way that promotes rather than diminish well-being should thus be included as an additional good habit. This would further diminish the gap between public health research and public health practice (Colditz et al., 2008). Overall, these positive habits would likely influence the development of molecules crucial for good brain development and influence genes and brain plasticity, hopefully in a way that would promote positive affect and behavioral outcomes (Ekman et al., 2022).

Limitations and future directions

Some methodological limitations should be acknowledged. First, due to the cross-sectional design of our study, we cannot draw any conclusions on the causes and effects of flourishing. In this regard, we cannot exclude the reverse associations and directionality, that is, flourishing can predict a specific use of social media. Indeed, it is somewhat possible that flourishing causes productive and positive uses of social media, as well as previously shown in other studies focusing on ill-being outcomes (Marciano et al., 2022d), although the effect from ill-being to media use was stronger. Also, we included items as proxies for SDT constructs. Hence future studies should include direct measures of relatedness, autonomy, and competence that have been developed and adapt them to the social media context. Although we considered personality traits such as extraversion and neuroticism as covariates, future studies should consider all Big Five personality traits and look at differences between high vs. low levels of such traits. Additionally, we did not measure the extent of social media use. Hence, we cannot exclude that the relationship between

social media time and flourishing would be moderated by the quality and type of one's experience. Although our study makes a step forward in the discussion of positive and negative media effects, it does not completely resolve the current debate.

Although we found significant associations between adolescents' socio-contextual factors and flourishing levels, we did not include questions related to parenting or other family factors, like the quality of the parent–child relationship, which might further determine adolescents' well-being (Kim et al., 2020). Also, we measured self-reported physical activity with one item as a reliable proxy of objective levels (Scott et al., 2015). However, we suggest future studies include more reliable measures, such as the use of accelerometers and wearable devices. Although we included control variables such as self-esteem and ill-being, future studies should consider other (well-being) outcomes such as hedonic and eudaimonic well-being. Additionally, our sample might not be representative of vulnerable adolescents and minorities, hence the study results should be replicated in other cultural and contextual settings. The drop-out of participants might have been due to specific suffering conditions or reasons other than the ones listed. Furthermore, results represent a specific cohort of students (i.e., first and second high school year) and do not extend to other age groups showing different social media usages (Orben et al., 2022) or students attending different educational paths in Switzerland, like apprenticeships.

Eventually, future studies should further provide longitudinal insight into the protective and risk factors influencing flourishing. Also, they should focus more on the dose–response mechanism of social media use and well-being and disentangle between- vs. within-person dynamics, using intensive longitudinal data and investigating the temporal dynamics (e.g., how long does a positive effect of social media use last?; Marciano et al., 2022c). Furthermore, since we did not assess other variables related to a social determinant approach to health outcomes (Koh et al., 2010), additional control measures should include a more detailed evaluation of socioeconomic status. For example, further studies should focus on digital inequality, referring to how people's societal position affects their digital access, skills, and types of uses, as well as the outcomes of digital engagement, ultimately feeding back into their life chances. Although researchers examined the relationship between social media use and well-being and the role of social inequality (Buchi and Hargittai, 2022), more work should be done on flourishing. For example, Skogen et al. (2022) investigated the association between subjective SES, frequency, and daily duration of social media use and self-reported negative experiences of social media platforms in high school students in Norway. They found consistent and strong support for an association between SES and negative experiences on social media, even after adjusting for the amount of social media use. That said, flourishing is a much broader field, as mentioned above, and to better determine flourishing, over time, we might need to assess financial stability in various domains and not be limited to SES only (VanderWeele, 2017).

Conclusion

Increasing attention has been given to *ill-* instead of *well-*being indicators like flourishing (VanderWeele et al., 2020). Using well-being measures to investigate the link between social media use and well-being in adolescents is a promising tool that allows moving forward the ill-being framework. Results showed that positive online social media activities, together with the feeling of inspiration through social media, fostered flourishing, whereas negative online social media experiences showed the opposite association. These relationships were present even after controlling for covariates such as self-esteem, mental health problems, and personality. Results aligned with the SDT and suggested that specific social media activities promote well-being and, thus, should be additionally included as a good habit influencing adolescents' development. In particular, since 40 to 80% of health and wellness can be somehow attributed to social factors (Hood et al., 2016), improving social relationships might become a priority in the current public health agenda (Holt-Lunstad et al., 2017) both in the United States and globally (Holt-Lunstad, 2022). Thus, interventions aiming to foster adolescents' flourishing should include curricula aiming to improve a good use of social media through positive online relationships and the consumption of inspiring contents.

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/k6xpw.

Ethics statement

The studies involving human participants were reviewed and approved by USI Università della Svizzera italiana. Written informed consent from the 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

LM conceived the project, collected the data, provided funding, performed the statistical analysis, and wrote the first draft of the manuscript. KV wrote sections 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.2023.1092109/full#supplementary-material

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EDITED BY
John F. Hunter,
Chapman University, United States

REVIEWED BY
David Harley,
University of Brighton, United Kingdom
Sonja Heintz,
University of Plymouth, United Kingdom

*CORRESPONDENCE
Andrew Villamil
✉ Andrew.Villamil@cgu.edu

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Engaging in the good with technology: a framework for examining positive technology use

Andrew Villamil * and Saeideh Heshmati

Department of Psychology, Claremont Graduate University, Claremont, CA, United States

The focus on the negative side of technology has become a prominent factor in the understanding of the interactions between humans and technology. However, there is a positive side to technology use that has been less investigated in scientific research. Well-being researchers have determined that it is not just the absence of negative emotions or experiences, but rather the presence and frequency of positive ones that matter most. Therefore, despite the scarcity of research on the positive side of technology, the present conceptual paper focuses on how technology may be used for the *good* to produce psychological benefits (e.g., greater happiness, lower loneliness, higher peer endorsement). Based on existing literature, we posit at least three directions for good interactions with technology: (1) "seeing good" by focusing on positive visual cues through technology use; (2) "feeling good" by focusing on good feelings that arise from technology use; and (3) "doing good" by focusing on positive actions that can be enacted via technology use. Based on the synthesis of these three components, we propose a framework for technology laden engagement in the good, dubbed as, the *Engagement in the Good with Technology (EGT) Framework*. Through this framework, we explain how these three distinct aspects of seeing, feeling, and doing good can co-occur and be interrelated, and in turn potentially lead to upward spirals of positive outcomes.

KEYWORDS

positive psychology, cyberpsychology, positive technology, digital technology, digital media, smartphones, social media, virtual reality

Introduction

Most research into technology has focused on the negative aspects of technology use. Although much research finds detrimental impacts of technology use on people's psychological well-being, other studies show mixed findings. Less research has been conducted on how technology is used in a positive way that can in turn lead to positive outcomes for the person and their health and well-being. Similar to almost any other tool, there are positive and negative ways one can experience technology that can be beneficial or detrimental to them. Digital technology has experienced rapid adoption across several generational cohorts and the effects of this usage are still not fully understood. In fact, the COVID-19 pandemic alone has shifted perspectives on technology use. While younger adults are the predominant users of technology, research conducted by the AARP has demonstrated that older adults (44%) view technology positively and as a primary means of connection (Kakulla, 2021). Additionally, over 80% of adults 50 and over depend on technology to connect with family and friends through texting, emailing, video chatting, and social media. Overall, a considerable proportion of young adults and older adults' time is spent online where they are constantly

engaging with streams of information, images, sensations, and experiences that may influence their mental health, development, and well-being.

Even though technology use is becoming pervasive and more research studies are focusing on the effects of technology, there still remains a plethora of questions around the benefits that technology use might have. For instance, how can technology be used to elicit positive emotions such as joy, awe, self-transcendence, love, and/or positive values? Even less research has been conducted on understanding the mechanisms of technology that support collaborative behavior between people across different backgrounds and beliefs. How can positive actions be enacted through technology in manners that support resource building, positive discussions, or prosocial behaviors, which in turn strengthen connections and increase positive engagement? While social media presents some positive outcomes as it relates to maintaining relationships, there is a lack of concrete research into the positive uses of technology that can reduce loneliness, depression, anger, substance abuse, radicalization, hate, or anxiety. This gap requires a broader understanding of how positive mechanisms may lead to positive outcomes by engaging in the good with technology.

The complicated nature of technology use has invited scholars from disciplines such as philosophy to better understand how societies can understand the good sides of technology or, as Coeckelbergh refers to "the good society with technology" (2018). In fact, philosophers focusing on technology and its use have explored the nature of technology and determined that humans shape the tools they use. Humans decide how these tools are utilized and in turn, determine if it is used for the good or the bad—this may depend on the community and social influence on the perceptions of values toward technology (Coeckelbergh, 2018). In this dynamic relationship between humans and technology, fostering ethical considerations and promoting critical engagement with technological advancements becomes paramount. By actively recognizing and embracing our role as shapers of technology, we can collectively strive toward harnessing its potential for positive impact and shaping a future where technology serves the greater good.

Based on existing literature, there are at least three directions where good interactions with technology have been individually examined: *Seeing good, Feeling Good,* and *Doing Good*. One line of research has focused on the interactions and effects of positive visual cues through technology [i.e., seeing good (Janicke-Bowles et al., 2018); moral elevation (Haidt, 2000); memes (Myrick et al., 2022)]. Another line of research has focused on good feelings as a result of interacting with technology [i.e., "feeling good" via increases in positive affect (Diener, 1984); broaden and build theory (Fredrickson and Joiner, 2002); prosocial media (Greitemeyer, 2009); social media (Sherman et al., 2016)]. Lastly, a line of research focuses on positive actions through technology [i.e., "doing good" via acts of kindness, good deeds, etc. (Keltner, 2009; Gray, 2011a,b); prosocial spending/donations (Aknin et al., 2013; Dai and Zhang, 2019)]. This paper provides a review of existing research and presents a coherent framework that illustrates ways technology can be used for the "good." We then discuss how this framework can be used as a basis for future research in an understanding of positive usage of technology, the interplay between these factors, and psychological outcomes of these positive engagements with technology.

Engaging with technology

Overall, technology use has expanded significantly over the past decade alone. Social media accounts for a significant portion of technology use. The numbers themselves provide some details about what is occurring. For example, we know *who* is using social media (e.g., 63% of users on TikTok in the United States are adults; Statista, 2022a). However, we do not know *how* these members are using technology and the granularity of what the effects of these engagements are on the individuals. Most of the recent research on technology has demonstrated several negative outcomes from extensive technology use, such as dependency, loneliness, issues involving privacy, social comparison, hate speech, anxiety, body dysmorphia, depression, and abuse (Thomée et al., 2010; Assimakopoulos et al., 2017; Laaksonen et al., 2020; Kakulla, 2021; Sutrisna et al., 2021; Danvers, 2022; Minadeo and Pope, 2022), but engaging with technology in the real world involves a complex system of simultaneous interactions that are less understood.

Within the United States, over 95% of young adults use social media (Auxier and Anderson, 2021). On average, Americans spend over 2 h using social media per day with over 81% of adults engaging in platforms such as YouTube (Suciu, 2021), which is more time than they spend sharing meals with others (Melore, 2021). Social networks such as TikTok have over 800 million global active users per month with over 37 million users belonging to Generation Z in the United States alone, and those numbers are estimated to increase to 48.8 million Gen Z users by 2025 (Statista, 2022b). Globally, more than 60% of young adults are able to access the Internet (Cerniglia et al., 2017; Sutrisna et al., 2021). Additionally, over 59% of Instagram users check the app daily and young adults spend, on average, over three hours per day on social networking platforms (Henderson, 2020).

The rapid rate of technology adoption and usage coupled with the advancement of technology has provided significant concerns for researchers, educators, and policymakers; these concerns span from what the nature of technology is to the fact that we lack sufficient understanding of how technology is used and how it impacts people's lives in the short and long term (Pleasants et al., 2019; Krutka et al., 2022). Along with these concerns, more researchers have been focusing on understanding technology better, however, most have been focused on the negative consequences of technology use. This focus on negative outcomes may be because the strength of bad experiences is more powerful than the intensity of good ones (Baumeister et al., 2001). This occurs because the negative potency of bad experiences is much more salient than good events and heavily influences how individuals process bad experiences (Rozin and Royzman, 2001). This is especially true when individuals are using technology. The negative effects of technology are readily apparent when looking through research. For example, studies have shown negative outcomes of persuasive technology from algorithms that prioritize engagement at any cost (anger, anxiety, suicidal ideation, depression; body image negativity; Rhodes et al., 2020; 60 Minutes, 2021; Center for Humane Technology, 2021; Minadeo and Pope, 2022). The potency of negative engagement has devastating consequences on individuals across every age group (social comparison, distortions in self-perception, disconnection; addiction, social isolation/rejection, radicalization and distrust; Baumeister et al., 2001; Eisenberger et al., 2003; Kross et al., 2013; Fredrickson and Joiner, 2018; Costello et al., 2022; Wilson, 2022).

Previous research has demonstrated that when individuals endure negative experiences and emotions, the effects of these experiences in

turn reflect a series of negative downstream consequences (e.g., anger, depression, fear, fight, or flight; Fredrickson and Joiner, 2002, 2018). Immediately, the effects of these negative emotions lead to a narrowing of action repertoires (anger, fear, hate, detachment) and an inability to connect with others. It also leads to internal manifestations of negative consequences such as anxiety, depression, withdrawal from others, susceptibility to disinformation and radicalization, and an inability to build long term resources that support the organism's well-being (Fredrickson, 2003; Center for Humane Technology, 2021; Bor and Petersen, 2022; Regehr, 2022).

Algorithms used in social media, in an attempt to maintain the attention of end users, provide a constant barrage of sensations, images, videos, and other forms of outputs that effectively activate regions of the brain and influence cognitive attention and behaviors (Fogg, 2003; Godinho et al., 2017; Cohen, 2018). The regions that become highly activated and dysregulated are typically involved in responses such as addiction (ventral tegmentum), information processing (Prefrontal Cortex), or fight or flight response (limbic system) of the users who engage with these cues (Fogg, 2003; Seo et al., 2020; Center for Humane Technology, 2021). These negative experiences, elicited through highly adaptable artificial intelligence using machine learning, strategically target the neurocognitive systems and hijack the autonomic nervous system. Experts in technology refer to this advanced process as a "race to the bottom of the brainstem" [The Rubin Report (Director), 2017]. This engagement can lead to pervasive unintended consequences such as fear, anger, disgust, radicalization, hate, online bullying, alienation, and more. It is important to note that some studies have shown complex nuances, small effects, or mixed results in relation to social media use and well-being (Orben and Przybylski, 2019; Kross et al., 2020; McFarland et al., 2023). However, many investigations and reports have come to light which demonstrate how negative engagement with technology can lead to adverse consequences such as increased suicidal ideation, depression, anxiety, problematic social media use, violence, hate speech, and other consequences, including negative mental health effects in groups such as teenagers (Kavanagh et al., 2019; 60 Minutes, 2021; Castaño-Pulgarín et al., 2021; Huang, 2022; Shannon et al., 2022).

Other consequences of negative engagement with technology can include addiction, cyber bullying, and other misuses of devices that are harmful to people's health such as extensive blue light exposure, sleep dysregulation, and aggressive behaviors from exposure to disinformation, angry provocative content and messages through networks, podcasts, and fear inducing viral videos (Neumann, 2013; Erreygers et al., 2019; Kırcaburun et al., 2019). These negative experiences are not just limited to social media. Human interactions with technology are leading to severe polarization and isolation in many individuals who are not adequately prepared to interact with technology in healthy ways. What if, however, there was an approach to supporting healthy engagement with technology and using it for the good? In order to answer this question, we need to first clarify what we mean by "the good" and engagement in *the good* through technology.

Engaging with the good

Research on the *good* has expanded researchers' understanding of how humans interact and shape their daily lives across developmental standards and expectations. The field of Psychology has yet to define the term *good*, but researchers studying positive psychology have demonstrated that good feelings are an essential component to well-being (Fredrickson, 2003; Seligman, 2011). For example, experiences that elicit positive affect broaden the scope of attention which in turn lead to the building of future resources which then provide numerous positive benefits that shape positive experiences and broadening repertoires (Fredrickson and Joiner, 2002, 2018; Lyubomirsky, 2010). Other researchers have demonstrated that good actions are also an essential component to well-being (Keltner, 2009). For example, directed acts of compassion or kindness, and active cooperation with others rewards a region of the brain known as the nucleus accumbens which is densely populated with dopamine receptors, and in turn enhances positive experiences.

Therefore, in order to understand what is meant when we use the term *good*, it is important to provide an operational definition of the word that is used to describe these positive terms. The etymology of the word good is derived from Germanic Origin gudą, and from old English gōd, implying virtuous or morally uplifting context. Oxford dictionary defines good as "useful, advantageous or beneficial in effect, possessing or displaying moral virtue, showing kindness, giving pleasure; (something that is) enjoyable or satisfying" (Oxford English Dictionary, 2022). Aristotle refers to the "supreme" good as an activity of the rational soul as it relates to virtue. Virtue, for the Greeks, is equivalent to excellence (Aristotle Bartlett and Collins, 2011). Within the beliefs of Mohism, Mohists advocate a consequentialist criterion for evaluating *good* actions (Mo and Fraser, 2020). What is benevolent or right is what provides *good* consequences—specifically, it benefits people. Among benefits, doing good for others, such as donating, volunteering, caring for, or feeding others takes priority over simple hedonic enjoyment. Mohists prize the virtue of benevolence, which they regard as committing us to furthering the benefit of all the world (including ourselves).

Venot and Veldwisch (2017) present a higher-level overview of what is *good*, stating, "Connections and associations are made to something that is Good in the abstract sense, or to values assumed to be universal (though they reflect a narrow vision of progress, mostly Western and male dominated), such as equity, progress, development, and modernity" (2017). These unique interpretations and presentations of what is *good* provide context around the term, however in order to understand what is *good* from a psychological perspective it must be understood within the context of how it is being used. Therefore, for the purposes of this paper we define *good* as a mechanism or association between positive interactions with authentic beneficial effects that contribute to positive outcomes. The relationship that humans share with technology is complicated and while there are some shared associations with experiences that elicit positive outcomes, there is an essential need to understand how humans are engaging in the *good* with technology. Based on previous research, engaging with the good can be categorized into three classifications: seeing the good, feeling good, and doing good.

Seeing good

Seeing good is one way for people to engage in the good. Throughout the day, people are exposed to visual cues (events, actions and other behaviors, communication/information) that are meaningfully assessed through an intricate cognitive appraisal

process. This is especially true when using technology. Operationally, seeing good involves a positive visual-cognitive top-down process where visual stimuli influence attention, personal expectations, and perceptual information (Gilbert and Li, 2013). When an individual perceives a positive visual cue, this, in turn, influences positive affective experiences and meaningful cognitive judgments (Diener, 1984; Eid and Larsen 2008; Hanson, 2013). Research demonstrates that the downstream consequences of seeing good leads to increased motivation and the development of strategies for secure social interactions, behaviors, and relationships (Sprafkin et al., 1975; Sanders et al., 2000; Janicke-Bowles et al., 2018; Gilbert and Basran, 2019). This is further evidenced through an evolutionary lens of human adaptation, where seeing the good relates to the capacity for positive experiences through cooperation and joy (Smith, 2010; Hanson, 2013; Gilbert and Basran, 2019). It has also been associated with other perceptions, such as experiences in novelty or perceptual vastness (awe; Rudd et al., 2012) and altruistic joy (the happiness from witnessing the good fortune of others; Hanson, 2013).

Some examples of seeing good include social or prosocial perceptions or seeing good in the lives of others (Smith, 2010). Other examples include inspirational visual cues (Haidt, 2000; Janicke-Bowles et al., 2018), imagining good facts (Hanson, 2013), having access to information that contributes to positive outcomes (Graham and Nikolova, 2012; Siegel and Thomson, 2017) and other visual experiences that increase accessibility/agency or positive emotions such as happiness, gratitude, awe, positive perceptions, or positive orientations (the general tendency to care about the needs of others; Thomson and Siegel, 2013; Thornton et al., 2019). Some researchers associate seeing good as a process of "taking in" visual and cognitive experiences as a means of coping and fostering well-being in their lives and the lives of others (Hanson, 2013). Essentially, seeing good is the access to visual information that contributes to positive outcomes. This visual process is associated with early evolutionary capacities for connections and interactions through positive non-verbal cues, such as smiling (Mukherjee et al., 2018).

Recently, research into visual stimuli within digital environments have reflected similar cognitive processes through digital visual cues. Positive cues from inspirational media can lead to the broadening of attention and perception (Haidt, 2003; Janicke-Bowles et al., 2018; Mukherjee et al., 2018), and prosocial outcomes (Greitemeyer, 2009). They are associated with increased motivation, positive emotions and inference of meaning (Gilbert and Li, 2013; Myrick et al., 2022). Positive visual cues during technology use include, but are not limited to, "good" things, such as funny videos, creative visual narratives, loving scenarios, prosocial video games, awe provoking content, fun experiences, and watching people do good things for each other (Sanders et al., 2000; Salimkhan et al., 2010; Thornton et al., 2019; Myrick et al., 2022). Essentially, seeing good is the access to information that contributes to positive outcomes.

Feeling good

Feeling good is another way people engage in the good. Operationally, feeling good is associated with the presence of higher positive affective states. Positive affective states are defined as pleasant feelings that contribute to positive levels of hedonic well-being (more positive affect than negative affect; Diener and Diener, 1996; Diener and Seligman, 2002). Hedonic well-being is often defined as the process of seeking pleasure and maximizing good feelings (Waterman, 2008). A feeling is a subjective, evaluative process whose appraisal determines whether the feeling is pleasant or unpleasant (APA Dictionary of Psychology, 2022).

The appraisal process occurs through a biopsychological cascade of energy and interactivity across cognitive structures within the limbic system and prefrontal cortex (Rolls, 2005). The cognitive system integrates (subjective) information and in turn elicits good responses (Fredrickson, 2003). Feeling good increases hedonic levels and motivates humans to engage with their environments, build resources, connect emotionally, and engage with others in positive ways (i.e., approach behaviors; Diener and Diener, 1996; Belonging; Siegel, 2022). There are other mechanisms that contribute to experiences of good feelings. For example, a eudaimonic perspective (the actualization of one's potential), emphasizes that positive feelings arise through the fulfillment and engagement in meaningful activities (Ryan and Deci, 2000).

Examples of activities that often elicit good feelings include but are not limited to, spending time with friends, relaxing, meditating (Diener and Seligman, 2002; Huebner et al., 2014), or engaging in stimulating activities (Holstein et al., 1990). Stimulating activities can include engagement with music, concerts and other events (through dancing, listening, singing, etc.; Dunbar et al., 2012), or playing games (Hunter et al., 2019; Gkogkidis and Dacre, 2020). With the convenience of technology today, people are able to relax or engage in stimulating activities from the comfort of anywhere and at any time around the world with devices. Other engaging activities with technology that contribute to good feelings, include viewing and receiving "likes" on social networking posts (Sherman et al., 2016; Ellis et al., 2020) and playing video games (Guegan et al., 2020). The benefits from positive or good feelings contribute to one's quality and satisfaction with life and are correlated with an increase in people's sense of "oneness" with others (Diener, 1984, 1994; Edinger-Schons, 2020; West et al., 2021), the building of trust with acquaintances (Dunn and Schweitzer, 2005), increased resilience (Fredrickson, 2003), and other mechanisms that increase positive resources. Given that technology has become a vessel for young adults to experience biopsychosocial cascades of good feelings through digital experiences (i.e., social media, video games, blogs, podcasts, etc.; Magis-Weinberg et al., 2021; Myrick et al., 2022), provide a pivotal role in providing additional opportunities for positive outcomes (Kushlev et al., 2021). The downstream effects from feeling good during positive technology use provide increased perception of peer support (Magis-Weinberg et al., 2021), inspiration (Meier and Schafer, 2018), motivation (Janicke-Bowles et al., 2018), prosocial behavior (Kushlev et al., 2021) and can even improve how people visually perceive the world and how they behave offline (Jolij and Meurs, 2011). Feeling good during technology use, therefore, represents another domain within the trichotomy of engaging in the good with technology, and may play a significant role in positive technology use.

Doing good

Doing good is viewed as any action seeking to promote perceived positive outcomes. Actions involving directed compassion and kindness, or affiliative behaviors, are most often associated with the

construct of doing good (George and Brief, 1992; Tappin and Capraro, 2018). Affiliative behavior is an important component of doing good and is defined as a positively interpreted action that facilitates peaceful and friendly interactions (Depue and Morrone-Strupinsky, 2005). Doing good is often accompanied by the concept of doing good deeds (Gray, 2011a,b). Good deeds are correlated with proactive agency, that is, a sense that an individual is motivated to construct, contribute, or influence circumstances through their choices and actions (Ryan and Deci, 2000; Bandura, 2006; Gray, 2011a,b; Pettengill, 2020). Within this study, "doing good" is viewed as any action seeking to promote positive outcomes. There is a reciprocal relationship between doing good and positive experiences, thoughts and behaviors, particularly when humans are able to cognitively assess their perceived impact. That perceived impact is a judgment that one's actions have consequences for the welfare of others (Grant, 2007). As people do good, the impact of their actions influences their thought patterns and perceptions (Bower, 1975; Neisser, 1976; Bandura, 1989; George, 1991; Gray, 2011a,b), which reinforces the actualization of good behaviors.

Examples of doing good include but are not limited to, acts of kindness, donating, volunteering, promoting and posting positive content or comments on digital platforms (Pettengill, 2020), sharing authentic information or experiences, preparing for timely responses to crises and supporting people in need (Palen et al., 2007; Schueller et al., 2019; Hunsaker et al., 2020; Schueller and Torous, 2021; Tygielski et al., 2021), or sharing positive computer-mediated communication (Riva, 2002; Al-Zoubi and Shamma, 2021; Cavalheiro et al., 2022; Walsh et al., 2022).

Doing good leads to further perceptions of one's agency and the impact of those actions, because perceptions of actions are the means by which people make sense of experience (Smith and Ellsworth, 1985; Gray, 2011a,b; Pettengill, 2020). Through the use of technology, people are able to participate more easily in topics they are passionate about and, in some cases acting as agentic influencers, by sharing and having access to authentic information and knowledge (Goldman et al., 2008; Dahal et al., 2020). These factors increase perceptions of agency and increase quality of life as opportunities to express feedback about social interests and other areas of concern positively influence motivation and other perceptions such as satisfaction with life (George, 1991; Ryan and Deci, 2000, 2001; Wessels, 2013).

Other benefits of doing good include individual and larger social advantages, including increases in positive affect, optimism, gratitude, life satisfaction, and joviality (Alden and Trew, 2013; Pressman et al., 2015). When accounting for the recipients of good deeds, research demonstrates that there are increases in positive mood and nonverbal cues such as smiling, which enhances the supporting nature of connections with groups (Gray, 2011a,b; Pressman et al., 2015). Doing good also influences the perceived impact of good behaviors and facilitates perceptions of self-efficacy, which in turn influences human agency and further actions (Depue and Morrone-Strupinsky, 2005; Bandura, 2006; Grant, 2007; Hawkley et al., 2007). Doing good for others fosters positive perceptions by others, which also contributes to feelings of agency, and positively influences human capabilities (Gray, 2011a,b). Additionally, good deeds create secure social interactions and supportive relationships, in addition to providing experiences of personal fulfillment (Ryan and Deci, 2001; Gray, 2011a,b; Siegel, 2022). Studies on individuals suffering from high social anxiety have demonstrated that doing good consistently over time also decreases social anxiety, increases relationship satisfaction, and significantly boosts positive affect (Alden and Trew, 2013). All of these benefits increase opportunities for positive experiences for "doers" and "receivers" demonstrating several positive outcomes.

Engaging in the good with technology: a conceptual framework

Modern Technology provides opportunities for individuals to engage in the *good*. Based on the three directions of research taken on the investigation of engagement in the *good* (seeing good, feeling good, doing good) we propose a novel conceptual framework that situates these domains of engagement in the good within the context of technology use. Figure 1 reflects our Engagement in the Good with Technology (EGT) framework as a triadic model. Placed at each corner of this triangle is one of the three domains of engagement with good. We discuss these three domains in the context of technology use as reflected centrally in the model. As seen in Figure 1, all domains of engagement in the good with technology are connected with lines, depicting the interrelated nature of these domains. The underlying premise of this model is that the elements of engagement in the good with technology are dynamic–they change across time and at times co-occur–and create a system. Namely, we deem this model as a dynamic network in which all elements of the network are interrelated and change as a system: Changes in one can be highly related to changes in other elements in the network of EGT and these relationships are proposed to be bidirectional.

In graph theory (Barnes and Harary, 1983) networks demonstrate the connectivity among "actors" that can be objects, people, items or

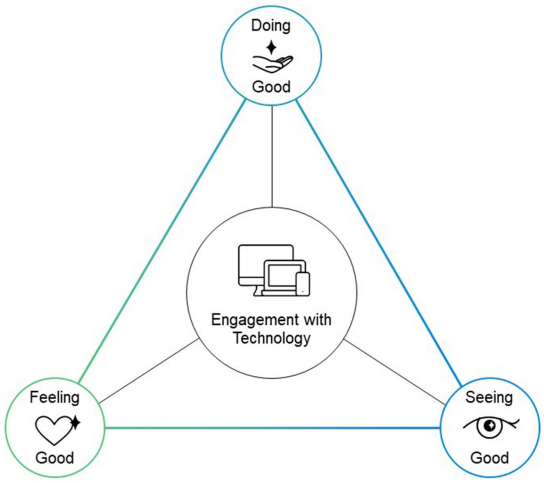

FIGURE 1
Engagement in the Good with Technology (EGT) Framework. The EGT framework reflected in this figure demonstrates three domains for engaging in the good. At each corner is a node that is influenced by positive experiences that may occur during technology use. Each domain is activated through engagement with technology as represented in the center of the figure. Depending on the type of engagement, each node can become highly activated or less activated depending on what is occurring. These changes are dynamic. Increases in one node may influence the others, inversely, decreases in one may show decreases in others and they may be bidirectional.

any other groups of elements that form a system (Wasserman and Faust, 1994). Networks are made of elements that are denoted as "nodes" connected via lines, dubbed as "edges." Edges represent the relationships among the nodes and illustrate the strength of the relationships among the nodes; these relationships can be directional or non-directional. Through a network perspective, we can examine relationships among all nodes of a network at the same time and explore changes in the configuration of a network over time and as a result of perturbations. Network analytics also provides the possibility of assessing the importance or "centrality" of each node in a network. For example, we can identify which node in the network is more strongly connected to all other nodes in the network (i.e., strength centrality) or acts as a connector among all the nodes of the network (i.e., betweenness centrality).

Approaching the EGT model as a network, the three facets of engagement in the good with technology are considered as nodes and the lines connecting them are the edges quantifying the relationship among them. Through this, we can explore the interconnectivity as well as the importance of the nodes within the network. Moreover, we can explore the EGT model in terms of the different configurations the network can take and how changes in one node of the network in different contexts can change the configurations of the network in different ways. Figure 2 demonstrates examples of the different configurations the EGT network can take.

Figure 2A demonstrates an example configuration of the EGT network where, for example, someone is seeing good by watching an act of kindness video on their smartphone. While seeing good is increasing in this triadic network, feeling good is also increasing because the video is making them feel happy. Thus, in this model, the two seeing and feeling good nodes are activated (depicted via their increase in size) but doing good is less relevant and therefore, smaller in size. While the act of seeing good has the potential to increase people's motivation to do good (Janicke-Bowles et al., 2018), in this specific example, doing good has not yet been activated.

Figure 2B on the other hand, demonstrates an example of the EGT network configuration where someone engages in doing good, for example by donating funds to charity for war refugees on their computer (increase in doing good). While doing that, the individual may encounter war images of violence occurring in the war, leading to negative feelings (decrease in feeling good). Seeing good in this case is also small and less activated due to the imagery that they are witnessing in this context.

Figure 2C depicts a third possible configuration of the EGT network. In this case, an individual could be listening to music and their favorite song comes up. They feel good and begin dancing. In this case, the individual's feeling good is heightened while their levels of Seeing good and doing good may remain the same.

Figure 2D represents another configuration where doing good and feeling good is elevated but seeing good is inactive. An example of this can be when someone uses social media to message a friend who is going through a tough time. While supporting their friend, the person feels good about being a source of support. In this case, this person has low exposure to seeing something good using their technology.

Network configurations for the EGT model are not limited to the ones presented in Figure 2, rather they represent examples of ways that this model can be adopted to quantify various scenarios of engagement with the good through technology in terms of the three domains in different life contexts. Quantifications of these configurations through network analysis can then be examined in relation to psychological outcomes of interest, further elaborated in the next section.

Applications of the EGT framework

There has been a request from researchers, educators, and policymakers to help people flourish with technology (Kushlev and Leitao, 2020; 60 Minutes, 2021; Kamenetz, 2021; Minadeo and Pope, 2022). Yet, there needs to be more research on how people engage in the good with technology. Beyond the theoretical and evidentiary support, the EGT framework provides a conceptual and theoretical grounding across three domains that can be used to explore positive technology experiences. Specifically, this model provides a dynamic and systems-level structure for understanding engagement in the good with technology. We take a network perspective toward this model where the different domains of engagement with the good via technology are assumed to be interconnected and should be examined as a whole instead of the sum of its parts.

Using the EGT Framework, future research can examine the dynamical changes in the EGT network in relation to various psychological and health outcomes. In fact, through the network perspective, we can bypass examining the individual impact of each of the domains of good technology use with mental health outcomes but rather explore the different configurations of the EGT network as a whole with outcomes of interest (see, e.g., Heshmati et al., 2021). For example, frequent use of technology to see good throughout the day (seeing good) may also stimulate good feelings in the person (feeling good) and ultimately lead to altruistic inclinations and prosocial motivation (doing good). This makes a "closed" triadic network where all three edges of the network are present (Robins, 2015); this is as opposed to an open triadic network that has at least one edge missing from the network (i.e., no connectivity or association between two nodes of the network). With this, we can examine whether a closed triadic EGT network (all three aspects of engaging in the good are adopted simultaneously and increased together) is predictive of a person's satisfaction with life as opposed to an open triadic network (only one or two aspects of engaging with the good is being adopted).

Moreover, taking a network approach toward domains of positive technology use can be helpful in informing future interventions targeted at increasing technology use for the good. Through measures of network centrality (e.g., strength, betweenness, closeness) we can quantify the importance of each of the three different domains of good in the EGT network. In other words, we can identify which node (domain of the good) in the network is most strongly connected to the rest of the network—namely, increases in that node will make it highly likely that other nodes in the network would increase as well. This particular node can then be the point of influence in this network for interventions since it is the most central and highly connected to other nodes. This would make the intervention more economical such that with increases in one part of the network, other aspects are also likely to increase.

EGT as a research tool

This Model can serve as a resource in both research and design landscapes. From a research standpoint, this model can be used to

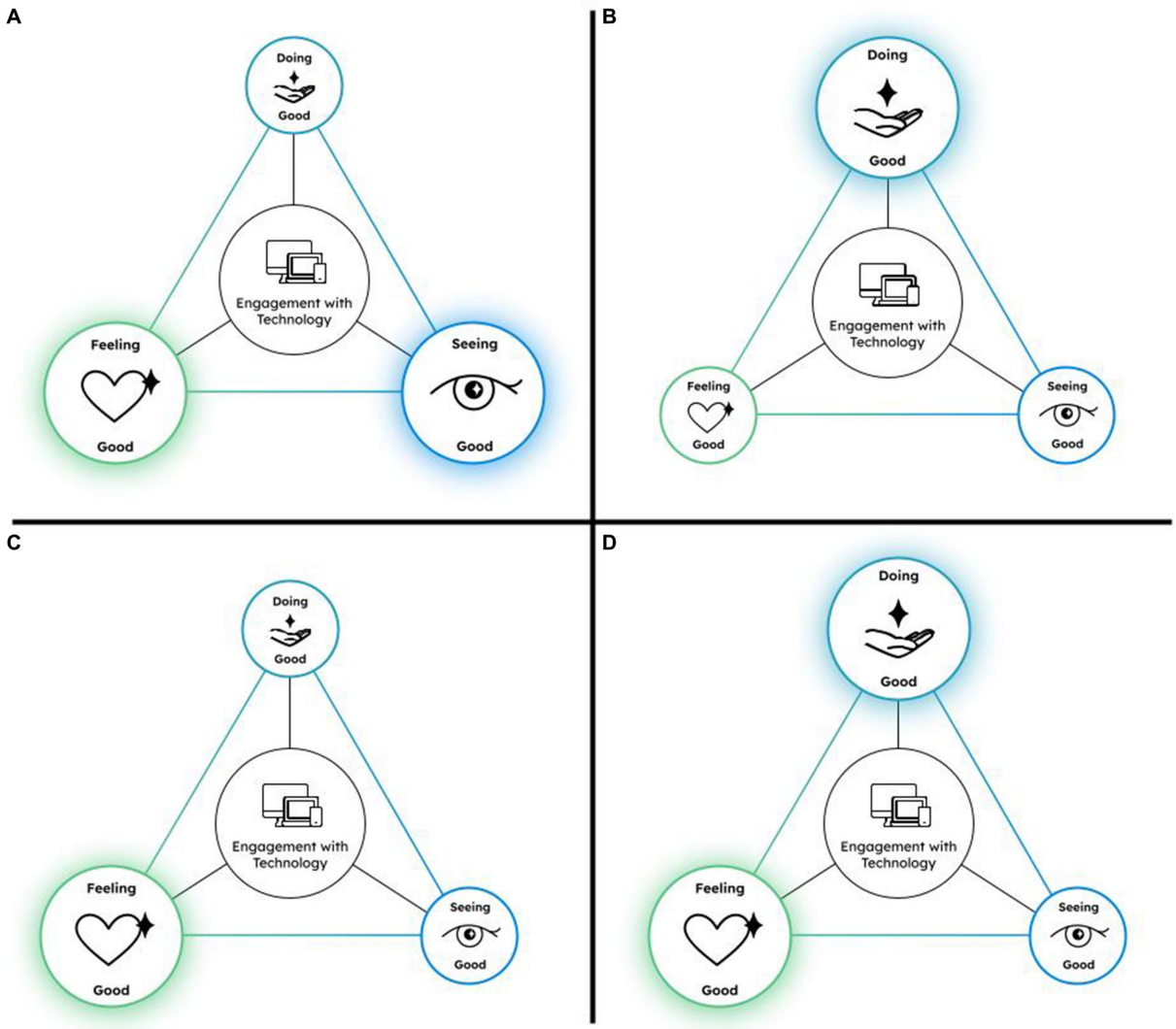

FIGURE 2
Example configurations of the EGT network model. Four different possibilities in network configurations are presented in this figure. Model **A** shows when Seeing Good and Feeling Good are increasing but Doing Good is not activated. Model **B** reflects when Doing Good is increasing and Seeing Good and Feeling Good are not activated. Model **C** demonstrates when Feeling Good is increasing but Seeing Good and Doing Good are not activated, Model **D** illustrates when Doing Good and Feeling Good are increasing, but Seeing Good is not activated.

empirically test theoretical assertions relevant to positive technology use. For example, in emotion research, a ratio of positive events to negative events has been proposed as a means of overcoming the effects of negative experiences (Fredrickson, 2009; Lyubomirsky, 2010; Rusu and Colomeischi, 2020). Even though a debate exists around the value of the ratio (Gottman and Gottman, 2015; Friedman and Brown, 2018), research continues to support the notion that it is important for humans to experience more positive experiences than negative experiences in order to flourish (Lyubomirsky, 2010; Rusu and Colomeischi, 2020). As a Research tool, people can use the EGT framework to examine the amount of positive engagement with technology in relation to negative engagement. This model could serve as a means of understanding the degree to which people are engaging in positive experiences and weighing them against negative ones. This tool could be constructive in advancing the development of measures that assess positive technology use. By providing tangible representations of technological interactions, they also serve as cornerstones for future studies, enabling a deeper exploration into the essence of technology use.

Moreover, investigative inquiries using this framework could be tailored to discern the antecedents of positive technology use, thereby shedding light on key variables that influence user interactions and outcomes. This model could also be used to develop interventions that support positive outcomes by dialing up the degree or frequencies of positive engagements and then measuring how these may impact individual responses to them. This framework can also be used to research technology users across generational cohorts. For example, we know technology use is pervasive in young adults (18–35). Therefore, it could be beneficial to know how much they use technology for good, what modes they use, and how positive technology use is related to their well-being.

Other areas that could be explored include whether these cohorts use technology for the *good* through seeing, feeling, and doing good. If so, how often are they engaging in seeing, feeling, and doing good

in their daily lives? What modes are they using to engage in these behaviors (e.g., messaging, virtual reality, gaming, social media, sharing)? Other questions that could be explored include whether people who engage in the good with technology frequently report higher subjective well-being. Or is engaging in the good through seeing, feeling, and doing via technology related to higher levels of trait altruism and prosocial behavior? These are just some of the questions that would be interesting to explore in further research using the EGT framework.

EGT as a design tool

Many researchers have urged technology designers (Technologists) to take decisive action. For example, some researchers are requesting strategies for improving positive engagement (e.g., body positivity; authentic information) with technology among populations who find it challenging to deal with exposure to sensitive content on social media platforms (Minadeo and Pope, 2022). Integrating these components into applications spanning diverse platforms and virtual experiences may yield advantageous results for end users of these platforms. Considering that one of the primary goals of technology companies is to enhance user engagement and increase corporate investments, the EGT Model offers a unique avenue for technologists. It allows them to establish protective mechanisms or procedures with algorithms that might positively affect users by boosting positive emotions, resonance, and engagement.

Take, for instance, a situation where a social media algorithm persistently recommends potentially harmful content. With the EGT Framework, it could establish safeguards where, through machine learning, the algorithm could start proposing content that typically promotes beneficial or affiliative behaviors. This might encompass exposure to uplifting videos, options to contribute to virtuous causes, and subsequently reflecting those advantageous outcomes to the user. Consider a donation scenario that also provides insights into the favorable repercussions of such an act. Should individuals integrate a direct beneficial outcome into their cognitive processes, they are enabled to not only Do Good and See Good but also to Feel Good.

Another potential function of the EGT Network lies in its capacity to foster positive engagement through the promotion of enriching learning environments. Given the overwhelming volume of information readily available today, it can be challenging for individuals to discern and comprehend genuinely helpful and authentic information. The EGT Network can counter this issue by creating positive spaces or illuminating pertinent and healthy information. This approach promotes beneficial outcomes through productive communication, such as reframing and reliance on fact-based sources. Additionally, by supporting healthy behaviors, the EGT Network could enhance users' learning abilities. For instance, when end-users seek information about healthy exercise or diet suggestions, resources designed with an EGT Framework can be particularly beneficial. Such resources can guide users to authentic information from professionals, connect them with positive and healthy support groups or mentorship opportunities, and even allow them to support others on similar journeys. Consequently, this enables users to make well-informed decisions.

Given that the frequency of interactions and the amount of time that people engage with devices is increasing exponentially, future research could benefit from a framework that reflects the dynamics of positivity-focused technology strategies across different technological landscapes such as Extended Reality (XR; Virtual Reality, Augmented Reality), gaming, metaverse environments, or more. Understanding how the EGT Network can function across interactions is an important element in supporting future applications. As evidenced, incorporating elements across different platforms could promote positive behaviors such as cooperation and mutual support or create positive learning environments for all ages.

Conclusion

Technology, as always has been the case, is only going to become further integrated into the human experience. Research has demonstrated that at times, how we use technology can reduce perceptions of agency, narrow our perceptual scope of attention, and disconnect us from one another. As we have demonstrated in this article, how we choose to use technology is ultimately the main predictor of how it impacts us. However, currently, we lack the tools required to measure and understand how we may consciously choose to engage with our technology, positively. Therefore, measuring and having instruments at our disposal that supports adaptation to technology can empower how people engage with technology in positive ways and promote human flourishing.

By considering the broad scope of how good is enacted with technology we can provide more information about the positive influences and directions of positive technology use. In view of the fact that negative technology experiences are a common occurrence for everyone, having a coherent reference point for how positive engagement occurs, may bolster support for those who need it most. Whether people are text messaging, exploring metaverses, using apps, video conferencing, using social media, or more, technology plays a vital role as an extension of the human experience. The triadic model for engaging in the good with technology (i.e., EGT framework) provides a coherent framework and important context for interactions and encourages further exploration of positive experiences with technology use. This framework further supports the exploration of research questions that have not been answered before. Examining positive interactions of technology provides an opportunity for researchers, educators, and practitioners to understand how to support and enhance well-being in populations, and determine successful methods for people to engage with technology in positive ways. This model can be used and adopted by researchers, organizations, companies, institutions as a means of understanding how to enhance positive upward spirals in people's mental health through *good* technology use.

Author contributions

AV was an overall majority of this paper, developed the theory, conceptual framework, researched, wrote the literature review of research, and proposals. SH was a valuable resource involved in discussing the framework, reviewing the work, editing and reviewing the paper, contributed expertise in her knowledge of Social Network Analysis to help inform the supporting analyses, and proposed

applications. 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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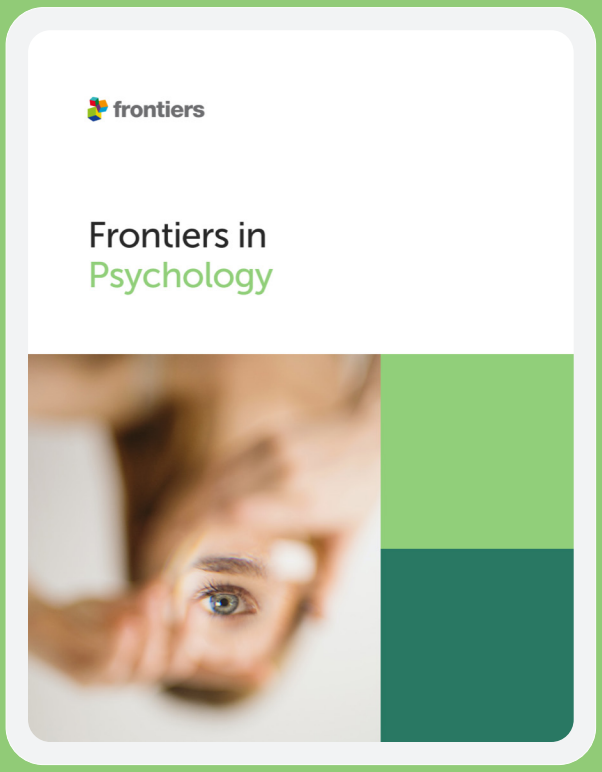

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