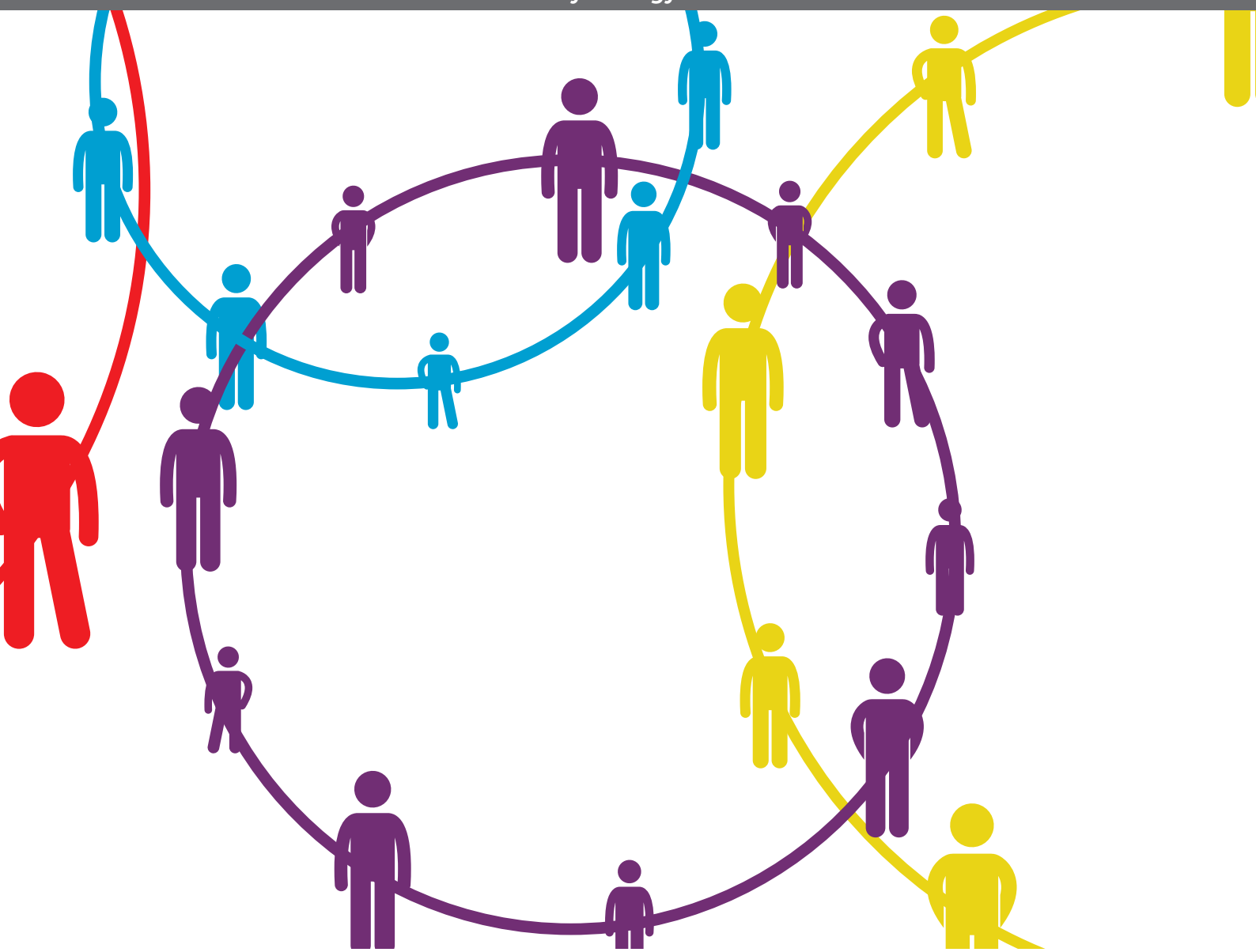
NEUROSOCIOLOGY: A NEW FIELD FOR TRANSDISCIPLINARY SOCIAL ANALYSIS

EDITED BY: Gennaro Iorio, Rosalba Morese, Rudina Rama and Vincenzo Auriemma

PUBLISHED IN: Frontiers in Sociology, Frontiers in Behavioral Neuroscience and Frontiers in Psychology



frontiers Research Topics

frontiers

ISSN 1664-8714
ISBN 978-2-88976-179-1
DOI 10.3389/978-2-88976-179-1

About Frontiers

Frontiers is more than just an open-access publisher of scholarly articles: it is a pioneering approach to the world of academia, radically improving the way scholarly research is managed. The grand vision of Frontiers is a world where all people have an equal opportunity to seek, share and generate knowledge. Frontiers provides immediate and permanent online open access to all its publications, but this alone is not enough to realize our grand goals.

Frontiers Journal Series

The Frontiers Journal Series is a multi-tier and interdisciplinary set of open-access, online journals, promising a paradigm shift from the current review, selection and dissemination processes in academic publishing. All Frontiers journals are driven by researchers for researchers; therefore, they constitute a service to the scholarly community. At the same time, the Frontiers Journal Series operates on a revolutionary invention, the tiered publishing system, initially addressing specific communities of scholars, and gradually climbing up to broader public understanding, thus serving the interests of the lay society, too.

Dedication to Quality

Each Frontiers article is a landmark of the highest quality, thanks to genuinely collaborative interactions between authors and review editors, who include some of the world's best academicians. Research must be certified by peers before entering a stream of knowledge that may eventually reach the public - and shape society; therefore, Frontiers only applies the most rigorous and unbiased reviews.
Frontiers revolutionizes research publishing by freely delivering the most outstanding research, evaluated with no bias from both the academic and social point of view. By applying the most advanced information technologies, Frontiers is catapulting scholarly publishing into a new generation.

What are Frontiers Research Topics?

Frontiers Research Topics are very popular trademarks of the Frontiers Journals Series: they are collections of at least ten articles, all centered on a particular subject. With their unique mix of varied contributions from Original Research to Review Articles, Frontiers Research Topics unify the most influential researchers, the latest key findings and historical advances in a hot research area! Find out more on how to host your own Frontiers Research Topic or contribute to one as an author by contacting the Frontiers Editorial Office: frontiersin.org/about/contact

NEUROSOCIOLOGY: A NEW FIELD FOR TRANSDISCIPLINARY SOCIAL ANALYSIS

Topic Editors:
Gennaro Iorio, University of Salerno, Italy
Rosalba Morese, University of Italian Switzerland, Switzerland
Rudina Rama, University of Tirana, Albania
Vincenzo Auriemma, University of Salerno, Italy

Citation: Iorio, G., Morese, R., Rama, R., Auriemma, V., eds. (2022). Neurosociology: A New Field for Transdisciplinary Social Analysis. Lausanne: Frontiers Media SA. doi: 10.3389/978-2-88976-179-1

Table of Contents

frontiers | Frontiers in Sociology

EDITORIAL
published: 26 April 2022
doi: 10.3389/fsoc.2022.911361

Editorial: Neurosociology: A New Field for Transdisciplinary Social Analysis

Vincenzo Auriemma[1]*, *Gennaro Iorio*[1], *Rosalba Morese*[2,3] and *Rudina Rama*[4]

[1] Department of Political and Social Study, University of Salerno, Fisciano, Italy, [2] Faculty of Communication, Culture and Society, Università della Svizzera italiana, Lugano, Switzerland, [3] Faculty of Biomedical Sciences, Università della Svizzera italiana, Lugano, Switzerland, [4] Department of Sociology, University of Tirana, Tirana, Albania

Keywords: sociology, neurosociology, transdisciplinary, empathy, social psychology

Editorial on the Research Topic

Neurosociology: A New Field for Transdisciplinary Social Analysis

INTRODUCTION

Within this research theme, it was possible to open a new transdisciplinary Frontier, within which sociology and neuroscience in general, can contribute to the improvement of social researchers and all interested scholars, expanding the different levels of analysis of the social sciences. The key concept, from the classics of sociological thought, is based on a discipline that can contain this cultural transformation initiated by the discovery of mirror neurons forward, namely neurosociology. The latter must be considered as the discipline that investigates social interactions and socialization with respect to the structures and functions of the brain. As a transformative perspective that builds on the postulates of sociology and, therefore, whose goal is not to favor one discipline over another, it falls within the trappings of a discipline that aims to investigate how the human brain influences the complicated set of forces that drive human relationships and social organization. However, the distinctiveness of this approach also warrants the analysis of neurosociology within social processes and how they influence neural function. Therefore, neurosociology is closely related to sociology underlying the socio-cultural-interactionist derivation of every behavior. The contributions collected, therefore, range from bibliographic and purely theoretical reviews, up to empirical research, the set of products, collected within this call, will allow expanding the field and, above all, open to trans-disciplinarity.

REVIEW AND OPINION CONTRIBUTIONS

The purpose of the review by Saladino et al. was to highlight, through empirical data contained within the bibliography, from the past 5 years, focusing interest on the connection between empathy and neuroscience. In this regard, the authors presented an in-depth study related to the social context involving violent criminals and psychopaths. The intent was to assume that empathy is an important to feel and understand the cognitive and emotional states of self and other people. Reflecting on this issue allowed empathy to be considered a psychological concept as well as a sociological one.

Reading Firat's text, it is possible to note that negative experiences, such as discrimination and exclusion, can influence health increasing physiological responses to stress, both physical and mental. Adding to the rich contribution provided to us is the ability to fit within the literature that

OPEN ACCESS

Edited and reviewed by:
John Offer,
Ulster University, United Kingdom

***Correspondence:**
Vincenzo Auriemma
vauriemma@unisa.it

Specialty section:
This article was submitted to Sociological Theory, a section of the journal Frontiers in Sociology

Received: *02 April 2022*
Accepted: *07 April 2022*
Published: *26 April 2022*

Citation:
Auriemma V, Iorio G, Morese R and Rama R (2022) Editorial: Neurosociology: A New Field for Transdisciplinary Social Analysis. Front. Sociol. 7:911361. doi: 10.3389/fsoc.2022.911361

until now has been lacking a sociological vision that could account for biological processes that are structurally and culturally shaped.

The study proposed by Shkurko's is characterized by the analysis of the natural effectiveness of the face-to-face medium. This idea, based on face-to-face communication, brings to the reader's attention the evolutionary mismatch hypothesis that evolved human nature is dependable on all other kinds of device-mediated communication that might cause negative interactions.

To better understand the relationship between social experiences and the brain, it is important to investigate neuroscience together with the social sciences. The other work, which arouses a lot of interest, is that proposed by Racionero-Plaza et al. who highlighted how the environment, and more specifically social experience, can influence the brain and even its genes. However, to fully understand these mechanisms, trying to understand what kinds of social interactions lead to certain outcomes in the brain, which differ from person to person and in behavior, neuroscience requires the postulates of the social sciences. This aspect allows for those inputs needed by neuroscience to enrich the meaning toward new discoveries about the brain.

A completely new aspect in this context, is the work proposed by Borbón, in fact through his considerations it is possible to begin to explore a topic of very close relevance, namely criminal abolitionism, which, in the neuroscientific context, takes the name of criminal neuroabolitionism. This new approach is based on the discoveries made in various disciplines, especially in the field of neuroscience, to provide a new perspective. In this sense, the transdisciplinary aspect that emerges is strong, and the link between sociology and social neuroscience is clear, offering several starting points for future studies: (1) on the neuropsychological effects of incarceration; (2) the contribution of neuroscience to investigate criminogenic social factors; (3) a new point of view to better understand criminal law as a mechanism of social control.

The trans-disciplinary openness of our call prompted Sipes et al. to provide us with interesting insights into the topic of adolescence, thus an issue that is increasingly embedded in everyday life, both within legislation and as an object of inquiry. The authors, in this paper, highlight the phases of neural and social development, basing themselves on and analyzing prosocial decisions, ascertaining that these are beneficial for personal and social wellbeing. A review highlighting the progress made in this field was necessary, reporting a total of 25 articles. In this regard, the authors offer predictions for testing a new model, proposing new future directions for studying prosocial behavior.

Finally, among the opinion articles, there is an interesting view regarding the COVID-19 emergency that seems to have passed its acute phase. Within the Paradisi et al. text, one can read the emergence of the role of online digital technologies. The authors describe, in a timely manner, how the increase in online social interactivity has increased its activity due to the social distancing to which we have been forced. However, it has had negative effects due to emotional and even physical isolation, as what has been missing is body language, which has always played a crucial role in face-to-face social relationships. This epochal change has affected the wellbeing of people, assuming very serious effects in the long run, affecting, above all, the population affected by specific fragilities. The goal of the authors was to encourage new constructive reflections, with the aim of increasing awareness of these topics of close relevance.

EMPIRICAL RESULTS: QUANTITATIVE DATA AND ORIGINAL RESEARCH

The section on empirical works opens with a work offered to us by Alfonso and Molano, the authors accurately present the work done by the musician John Cage, who based his art on "sound-scene-vision" experimentation within the theater, media, and art. The study is presented with different readings, one certainly regards the "innate rules of perception" and the other brings out the interesting relationship between art and neuroscience.

The aim of the study by Yang et al.'s, was to explore how the emotional expression of news in the post-truth era affects the cognitive processing of the audience. Indeed, news written with several kinds of emotional expression rather than neutral, can lead to changes in the cortical activity of the people belonging to the investigated sample, who were examined with electroencephalograms, and basing it on the method of functional brain connectivity. The results showed that emotional speech involved more cortical brain activity.

The article by Poali et al., describes qualitative research based on tears of joy, an emotional element of great prominence, and that, in the sociological and anthropological literature, is very present, for example in the ritual weeping of Ernesto de Martino. This research, consisting of semi-structured interviews, was carried out in India and Japan, processing the qualitative data extrapolated from the transcripts, through the software MAXQDA, to investigate this dimorphic emotional expression. The work is based on the hypothesis that tears of joy are not only an atypical expression due to what the authors call "super joy," but rather an emotional experience with a specific adaptive function.

Finally, concluding our review is the work of Zheltyakova et al. They present work investigating the characteristics of provocative behavior in an environment where the subject is anonymous. However, the personal behavior of the "anonymous" person during the processing of the provocative feedback remains largely unknown. The fMRI study conducted, has led to the evidence that through Taylor's aggression paradigm and, within a game that can generate "social provocation," the neural system activates, as a compensatory mechanism during social interactions, a system capable of dropping socially relevant information.

CONCLUSION

The main goal of this call, which we felt was fully met, was to highlight some of the insights that can be gleaned from a transdisciplinary exploration that can both account for the postulates of sociological thinking and adapt them to new neuroscientific paradigms. This has allowed, in this way, to avoid a drift into the two biggest reductionisms, cultural and biological, to put in evidence not to lean toward one discipline

rather than another, but that all disciplines, in a trans-disciplinary agreement, can generate a greater knowledge for each of them (e.g., Auriemma et al., 2020; Fante et al., 2022). Consequently, one should be wary of any theory that claims that our understanding of others is only a matter of biological input, as the cultural interaction aspect remains at the core of any discourse. The sciences need as much transdisciplinarity as possible in this field, maintaining personal objectives that cover the variety of skills and strategies we draw on, but, above all, contributing to a common knowledge that can place the person at the center of any scientific discourse, avoiding scientistic reductionism and allowing researchers and scholars to draw from the broadest possible sources and that we use to understand and make sense of others. To conclude, the wonderful and ambitious goal that we editors, belonging to distant disciplines, had set ourselves and that masterfully the authors of each paper have been able to satisfy, we must emphasize that today it is possible to go beyond what is directly available if we want to reach deeper levels of interpersonal understanding. Given the polysemous nature of the various notions presented in this appeal, one might naturally wonder if it would not be better to explore transdisciplinarity more thoroughly throughout the research articles.

AUTHOR CONTRIBUTIONS

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

REFERENCES

Auriemma, V., Iorio, G., Roberti, G., and Morese, R. (2020). Cyberbullying and empathy in the age of hyperconnection: an interdisciplinary approach. *Front. Sociol.* 5, 551881. doi: 10.3389/fsoc.2020.551881

Fante, C., Palermo, S., Auriemma, V., Morese, R. (2022). *Social Inclusion and Exclusion: How Evolution Changes Our Relational and Social Brain*. London: IntechOpen.

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: All claims expressed in this article are solely those of the authors and do not necessarily represent those of their affiliated organizations, or those of the publisher, the editors and the reviewers. Any product that may be evaluated in this article, or claim that may be made by its manufacturer, is not guaranteed or endorsed by the publisher.

frontiers in Sociology

HYPOTHESIS AND THEORY
published: 11 June 2021
doi: 10.3389/fsoc.2021.695042

A Neurosociological Theory of Culturally and Structurally Situated Cognition and Ethno-Racial Stress

Rengin B. Firat *

Department of Sociology, University of California, Riverside, CA, United States

A longstanding body of literature reveals that experiences of discrimination and exclusion lead to health disadvantages by increasing physiological stress responses both in the body and the brain. However, a sociological view that takes into account structurally and culturally shaped biological processes is missing from the literature. Building on recent literature from the sociology of morality and values and the dual process model of culture, this paper proposes and provides preliminary evidence for an applied theory of culturally situated moral cognition as a coping mechanism with ethno-racial stress. I focus on values as they help cope with ethnicity and race related stress such as discrimination. Using functional neuroimaging data, I offer evidence that values operate through both explicit (controlled and conscious) processes recruiting brain regions like the dorsal prefrontal cortex, and implicit (automatic and non-conscious) processes recruiting regions like the ventromedial prefrontal cortex, to help cope with exclusion and discrimination.

Keywords: neurosociology, ethno-racial stress, values, culture, coping, fMRI, agentic, communal

OPEN ACCESS

Edited by:
Vincenzo Auriemma, University of Salerno, Italy

Reviewed by:
Raquel Andrade Weiss, Federal University of Rio Grande do Sul, Brazil
Jörg Niewöhner, Humboldt University of Berlin, Germany

***Correspondence:**
Rengin B. Firat
rbfirat@ucr.edu

Specialty section:
This article was submitted to Sociological Theory, a section of the journal Frontiers in Sociology

Received: *14 April 2021*
Accepted: *02 June 2021*
Published: *11 June 2021*

Citation:
Firat RB (2021) A Neurosociological Theory of Culturally and Structurally Situated Cognition and Ethno-Racial Stress. Front. Sociol. 6:695042. doi: 10.3389/fsoc.2021.695042

INTRODUCTION

A longstanding body of literature reveals that experiences of discrimination lead to health disadvantages by increasing physiological stress responses such as blood pressure, cardiovascular reactivity and heart rate (Brondolo et al., 2003; Pascoe and Smart Richman, 2009). However, not all marginalized people are affected the same way from the negative effects of discrimination and social exclusion (Hughes et al., 2014; Nazroo, 2003). Psychologists have focused on various personality factors like self-efficacy or vigilant coping as protectors from stressors and stigma (Bandura, 1998; McAuley, 1992); yet a sociological view that takes into account structurally and culturally shaped biological processes is missing from the literature. This paper seeks to fill this gap by proposing a new, neurosociological theory of structurally and culturally situated moral cognition (Firat and McPherson, 2010; Firat and Hitlin, 2012) and the ways this moral cognition moderates the relationship between ethno-racial stressors and stress responses in the body and the brain.

This paper argues that cognitive sociology and the newer research area "neurosociology" have the potential to add the literature on health disparities by linking micro and macro foundations and detailing the ways our minds and bodies reproduce social structure and inequalities (Cerulo, 2002; Cerulo, 2014; Franks, 2010; Ignatow, 2007; Lizardo, 2014; TenHouten, 1997). This neurosociological approach distinguishes itself from a "sociology of neuroscience" framework, which takes more of the role of a critique of neuroscientific empirical work alongside other developments in science and technology (von Scheve, 2011). While the critiques and examinations of the knowledge and practices in neurosciences form a new, growing body of scholarship called "critical neuroscience" and are

abundant (e.g., Bruder, 2019; Choudhury et al., 2009; Schleim, 2014; Slaby, 2010), a complementary neurosociological approach incorporating neurological and biological processes into sociological theorizing and empirical work is largely missing from the literature (von Scheve, 2011). The rudimentary connections between morality and human evolution and neuroanatomy were broadly made elsewhere (Turner, 2014). This paper attempts to contribute to these efforts towards an integrated, transdisciplinary science of morality (Firat and McPherson, 2010; Firat and Hiltin, 2012; Jeffries, 2014) by offering a specific neurosociological theory of moral cognition as it relates to inter-ethnic stress.

Building on a growing body of recent literature on moral and cognitive sociology (e.g., Hitlin and Vaisey, 2010, Hitlin and Vaisey, 2013; Vaisey, 2008) and the long standing theoretical tradition of Social Structure and Personality (Pearlin, 1989; Thoits, 2006), in this paper, I argue that morality and values provide "an internal moral compass" (Hitlin and Piliavin, 2004: 362) for coping with discrimination. While previous research has looked at the ways values influence a variety of behaviors and attitudes including political behavior, pro-environmental and prosocial behavior (Barnea and Schwartz, 1998; Schultz and Zelezny, 1998; Schwartz, 2010), much less research has been concerned with behavioral effects of morality and values, especially within the health context.

Drawing from recent literature from the sociology of morality and values and the dual process model of culture and moral cognition (Miles et al., 2019; Vaisey, 2008), I propose and empirically illustrate an applied neurosociological theory of culturally situated moral cognition as a coping mechanism with ethno-racial stress. I focus on values as internalized bits of culture that motivate behavior in line with moral worldviews and help cope with ethnicity related stress such as discrimination (e.g., Firat 2016). This is not to say that culture is a fixed and uniform object shared homogenously by all members of groups; this cultural essentialist view is criticized by many (Grillo, 2003; Modood, 1998; Wikan, 1999). Rather, I view culture and morality as cognition or "schema" through which macro level institutions and structures are manifested (Hitlin, 2014) with different degrees and variations depending on individuals positions in the society as well as personal and inter-personal experiences (Firat and McPherson, 2010). This is more akin to the culture as "patterned practice" view offered by Roepstorff et al. (2010), whereby brain activity generated during experimental tasks can reveal patterns of social interaction.

Furthermore, as put forward by recent theorizing in sociology of morality (Vaisey, 2008; Miles et al., 2019), this paper proposes that these different cultural manifestations and patterned practices operate through both explicit (controlled and conscious) and implicit (automatic and non-conscious) processes. The implicit mechanisms through which values moderate ethnicity related stress are largely unknown due to methodological limitations of traditional survey and interview techniques. This paper addresses this limitation by incorporating neuroscientific functional Magnetic Resonance Imaging methods to capture the subtle mental and bodily dimensions of the relationship between values and ethno-racial stress.

ETHNO-RACIAL HEALTH DISPARITIES

A large body of literature has focused on the effects of living in ethnically and racially diverse societies. This research suggests that while many civil rights have been extended to ethnic/racial minorities and communities are getting increasingly diverse, ethnic diversity is linked to detrimental individual and community outcomes such as decreased social trust and civic life (Putnam 2007). Furthermore, several studies show that ethnic/racial diversity has important connections with health outcomes, especially for minorities. Members of ethnic and racial minority communities show poorer subjective and objective outcomes of well-being and health. For example, African Americans report lower levels of subjective well-being (Thoits and Hewitt 2001), show increased obesity rates (Flegal et al., 2012), hypertension prevalence (Egan et al., 2010) and even higher mortality rates (Geronimus et al., 1996; Kohcanek et al., 2004) than their White counterparts in the US. There is a higher prevalence of mental health problems (e.g., depression, anxiety) among immigrants and refugees in the United States and other Western nations (Fox et al., 2001; Pumariega et al., 2005; Storch and Poutska 2000).

Disparities in socio-economic status are proposed as a fundamental cause of health inequalities as lack of access to resources is linked to various diseases and higher mortality rates (Phelan, Link, and Tehranifar 2010; Phelan and Link 2013) and thus help explain ethnic/racial health disparities (Braveman et al., 2010; Nazroo and Williams 2006; Nazroo, 2003). However, there are important inter-personal mechanisms like stigma and discrimination that account for an significant portion of the effects of socio-economic status on racial/ethnic health outcomes (Hatzenbuehler, Phelan, and Link 2013; Morales et al., 2002; Mays et al., 2007; Paradies 2006; Williams et al., 1997). Research has shown that experiences of discrimination diminishes physical and mental health (Pascoe and Smart Richman, 2009; Williams and Mohammed 2009; Williams et al., 2003). Racist and discriminatory encounters are correlated with anxiety and depression and substance use (e.g., alcohol and tobacco) among African Americans (Brown et al., 2000; Landrine and Klonoff 1996; Sanders-Phillips et al., 2014).

One mechanism through which discrimination and stigma influence negative health outcomes is by heightening stress responses including blood pressure, heart rate and cardiovascular reactivity during interactions with members of different racial and ethnic group members (Brondolo et al., 2003; Clark, 2000; Harrell et al., 2003; Williams, 2012). Previous research has shown that ethno-racial/racial encounters increase stress and anxiety through cortisol changes and cardiovascular reactivity (Mendes and Koslov, 2013) as well as activation in brain regions related to feeling physical pain, i.e. dorsal anterior cingulate cortex (dACC) (Eisenberger, 2003; Eisenberger and Lieberman, 2004). Cumulative exposure to negative ethno-racial interactions and discrimination over time overload the body's allostatic load—capacity to react and adjust to challenges and stress through physiological responses such as blood pressure, cortisol activity and cardiac output (McEwen and Stellar 1993; McEwen 1998; 2000; 2004; 2005). Allostatic load

and cumulative stress have detrimental impact on health especially in members of minority communities who are exposed to repeated negative life events.

However, despite evident disparities in health, some ethnic minority groups have better health than others. For example, Hispanics in the United States have better health status than Whites despite having lower socio-economic status, lack of access to health care resources and experiences of discrimination (Morales et al., 2002). A White ethnic group, Jewish Americans, rated their health lower than non-Jewish White Americans (Pearson and Geronimus 2011). White Americans report higher rates of depression than African Americans (Breslau et al., 2006; Dunlop et al., 2003; LaVeist et al., 2014). Moreover, minority status predicts eudemonic well-being—having a purpose and meaning in life (Ryff et al., 2003). Similarly, both first and second generation Turkish immigrants in Germany have lower mortality rates than (almost half of) their German counterparts, a phenomenon not entirely explained by neither selection (healthier migrants flowing into the host country) nor attrition (less health migrants leaving the host country) effects (Razum et al., 1998). I suggest that some of these contradictory patterns can be reconciled by looking into neurosociology of cultural cognitive coping styles and values, which provides a more refined framework that takes into account inter-individual as well as inter-group variables of social experiences.

VALUES AND THEIR DUAL IMPLICIT/ EXPLICIT MECHANISMS

Sociologists of culture and morality have been increasingly paying attention to values as core components of moral culture binding people and motivating behavior (e.g., Longest et al., 2013; Vaisey and Miles 2014; Wuthnow 2008). At the societal level, values are aggregate world views shaped historically by political, cultural and socio-economic conditions (Inglehart 2015; Inglehart and Welzel 2005). At the individual level, values are internalized versions of these broader worldviews; they are relatively stable over the course of one's life and serve as abstract, cognitive systems directing behavior towards desirable goals in line with their moral viewpoints (Hitlin 2003; 2008; Howard and Renfrow 2006; Rokeach 1973; Schwartz, 1992; 1994). Values are more abstract than attitudes; they transcend beyond situations and events (Rokeach 1973). Contours of values are formed in childhood (and might shift slightly throughout life) based on various cultural and social structural positions people hold (Kohn 1989; Kohn and Schooler 1982; Longest et al., 2013). Studying values not only provide an understanding of cultural differences between social groups (Lamont 1992; 2000), they also provide insights into inter-personal differences as they influence information processing at the individual level (Dehue, McClintock, and Liebrand 1993; McClintock and Liebrand 1988).

While all humans share certain values to some extent (see Turner 2014 for an evolutionary account of human morality), the rank ordering of the values vary depending on various cultural and structural factors. For example, according to one of the most established and sociologically most adopted (e.g., Hitlin 2003; Vaisey and Miles 2014; Firat 2016; Firat et al., 2018) theories of values, Schwartz values theory (Schwartz, 1992; 1994; Schwartz and Bilsky 1987), there are ten basic, general value orientations that have evolved in response to basic conditions of human existence including coordinated social interaction and survival and well-being of the groups (Schwartz, 1992). These ten value orientations, while measured separately, can ultimately be grouped under four general dimensions: self-transcendence (universalism and benevolence), self-enhancement (power, and achievement), openness to change (stimulation, self-direction and hedonism) and conservation (security, traditionalism and conformity) dimension (Bardi and Schwartz, 2003; Schwartz and Bardi 2001; Schwartz and Boehnke 2004). In line with earlier theorizing and research (Firat et al., 2017), these values can be organized under two moral domains: agentic vs communal. These broader conceptions are also in line with the collectivistic vs individualistic value distinctions in cross-cultural psychological research (Hofstede 2001; Markus and Kitayama 1991; Triandis 2001); yet carry a broader meaning without stigmatizing one or the other dimension.

Behavioral correlates of agentic values (such as self-enhancement or openness) usually hinge on taking charge and direction, influencing others behavior and opinions (Bardi and Schwartz, 2003) but also taking generative, intentional action such as environmentally responsible consumption (Urien and Kilbourne, 2011). Being open and eager to new experiences, ideas and adventures (Bardi and Schwartz, 2003; Schwartz, 1992) guide behavior in the direction of social change such as political activism or individual change such as adapting to new media technologies (Besley, 2008; Firat, 2014). Agentic values contribute to the capacities for responding to the environment in novel ways by bringing one's attention to previously ignored approaches to problem solving, adopting new behavioral strategies and enhancing effectiveness of existing strategies (Firat et al., 2017). Based on sociological theorizing, the motivation for agency provides people with an "imaginative recomposition and critical judgment" to "reframe their relationships to existing constraints" (Emirbayer and Mische 1998:1010; see also Sewell and William 1992). Research suggests that agentic orientations contribute to the flourishing of human health by providing capacities to formulate adaptive strategies during difficult situations and eventually help change habits and choices towards healthier outcomes (Bandura, 1998, Bandura, 2004, Bandura, 2005; Welzel and Inglehart, 2010). Thus, they likely contribute to the flourishing of human health, especially in the face of negative life events, by providing capacities to formulate adaptive strategies and eventually help change habits and choices towards healthier outcomes (Bandura, 1998, Bandura, 2005; Welzel and Inglehart, 2010). I argue that this adaptive reimagination and reframing—or the agentic value orientation-is an explicit, conscious effort because it relies on secondary reflection on the initial imagination or thoughts, thus slower cognition.

Communal values (self-transcendence vs. self-enhancement dimension) revolve around cultivating prosocial concern and interest for the welfare of others and the overall community

over self or power related advantage. From an evolutionary point of view, the capacities for altruism, empathy and reciprocity and the associated emotional states provided an evolutionary advantage and added to the adaptive fitness of humans by maneuvering complex social organizations (Turner, 2014). People who are higher on communal value orientation, for example, have higher levels of generalized trust (Vyrost, Kentos, and Fedakova 2007) and more inclined to take environmental and other pro-social action (Karp 1996; Schwartz, 2010). Communal values are aligned with humans need and motivation to build coalitions (Kurzban, Tooby, and Cosmides 2001; Cosmides, Tooby, and Kurzban 2003). This evolved capacity, I argue, operates mostly through implicit mechanisms (while might also be readily available for consciousness) as detecting coalitions (or friends vs rivals) and building a sense of coalitional security and safety (see Boyer, Firat, and van Leeuwen 2015) and potentially rely on automatic categorization and identification of social groups (see also Tajfel 1978, 1982; Tajfel and Turner 1979, 1986; see Abrams and Hogg 2004). Thus, a communal value orientation, and its attitude correspondence in strong sense of coalitions, will act fast through automatic processes to shield people from the stressful effects of inter-group interaction.

The implicit vs. explicit mechanisms of communal or agentic values (or any other values whatsoever) have not been investigated so far, leaving an important gap in identifying the mechanisms for coping with ethno-racial stress, which this paper addresses.

VALUES AS COPING MECHANISMS WITH ETHNO-RACIAL STRESS

This paper proposes that culture provides cognitive buffering resources for ethno-racial stress through two value mechanisms: one attenuating felt social pain via communal values and another providing more active and adaptive strategies to these difficult situations through agentic values (see also Bandura, 1998; Bandura, 2005). The limited literature on the moderating role of values on ethnicity related stress also supports these arguments. Mostly based on the cross-cultural theory of values distinguishing between collectivistic vs individualistic values (e.g., Hofstede 2001; Markus and Kitayama 1991; Triandis 2001), research focusing on communalistic values like collectivism among Asians and familism and respect for elderly among Mexican Americans found that these values dampened the negative effects of exclusion and discrimination (Berkel et al., 2010; Delgado et al., 2011; Iwamoto and Liu 2010; Yeh et al., 2006). Studies found that collectivistic individuals did not respond as intensely to social exclusion, helping recovery from ostracism (Pfundmair et al., 2015; Ren et al., 2013). For example, Mexican American values such as familism and respect for elderly foster a disposition for prosociality that serve as emotional support in response to race-related negative life events like discrimination (Brittian et al., 2013; Knight, Cota, and Bernal 1993; Knight and Carlo 2012). This view also fits with cross-cultural research that identified self-transcendence (and openness) as so-called healthy values that facilitate positive mental health (Cohen and Shamai 2010; Jensen and Bergin 1998; Sortheix and Lonnqvist 2014). Living up to cultural values and norms also reduce stress indicators like arterial blood pressure among the darker skinned people (i.e., Blacks in Southern US and Brazil) (Dressler and Bindon, 2000; Dressler et al., 2005).

The protective role of agentic values against the negative effects of ethno-racial interactions is also supported by some literature that mainly focused on psychological constructs such as self-esteem or vigilant coping. While these constructs are not value orientations, they are aligned with agentic orientation's core dimensions such as being able to take charge and manipulate one's surroundings; and, thus offer some insights into how agentic values might help cope with stress. Accordingly, research shows that self-esteem protects people from negative social threats and stress (Rector and Roger 1996; 1997) through a vigilant coping style that seeks new, instrumental information and provides active and problem focused solutions in the face of ethno-racial stress and discrimination (Rector and Roger 1996; Tynes et al., 2012). For example, African American adolescents with higher self-esteem showed lower anxiety when faced with online discrimination than those with lower self-esteem (Tynes et al., 2012). Furthermore, vigilant coping style diminished negative mental health outcomes among Korean immigrants in Toronto (Noh and Kaspar 2003) and African Americans (LaVeist et al., 2014). Attribution theory in psychology also offers some evidence suggesting that attributions about the causality and controllability of stigma and discrimination moderate well-being (Crocker and Major 1989; Schmitt and Branscombe 2002). Research directly focusing on values also supports these findings with cross-cultural survey data by demonstrating that openness to change value orientation enhances well-being (Bobowik et al., 2011; Cohen and Shamai 2010; Georgellis, Tsitsianis, and Yin 2009; Sagiv and Schwartz 2000).

In summary, the literature on the social psychological processes of exclusion and inter-group contact have identified two important, seemingly juxtaposed, cultural cognitive resources: communal vs. agentic values (e.g., Sagiv and Schwartz 1995; 1998). I suggest that these seemingly contradictory results can be reconciled through a dual cultural coping mechanism: 1) an implicit motivational coping attenuating felt social pain via communal values and 2) another explicit coping mechanism providing more active and adaptive strategies to these difficult situations through agentic values (see also Bandura 1998; Bandura, 2005).

PROPOSED THEORY: NEURAL DISSOCIATION OF THE CORRELATES OF COMMUNALISTIC VS AGENTIC VALUES

In the proposed framework here, 1) communal values provide a sense of coherence and community that serve as collective resources promoting positive adjustment and resilience, while 2) agentic values contribute to being able to respond to the

environment in novel ways by paying attention to previously ignored approaches to problem solving and enhancing effectiveness of coping. While the effects of these value systems on neurological responses to ethno-racial stress have not been directly researched so far, several other studies that focused on similar moderators or potential behavioral manifestations of these values have found evidence in this direction. For example, cross-ethnic/racial friendships reduced stress hormone reactivity in participants who were implicitly prejudiced or highly concerned of out-group rejection (Page-Gould et al., 2008), predicted faster recovery from stress-related respiratory and hormonal reactivity (Page-Gould et al., 2010), and these positive effects were carried on to interactions with novel other-ethnicity members (Page-Gould et al., 2010). Similarly, several factors such as secure attachment style (DeWall et al., 2011), essentialist beliefs about groups, perceptions of discrimination (Masten, Telzer, and Eisenberger 2011), essentialist beliefs about groups (Bernstein et al., 2010), racial group membership and implicit bias (Krill and Platek 2009) were also found to be moderating neural responses to social exclusion and inter-racial contact. Therefore, I expect communal and agentic values to reduce sympathetic ("fight" or "flight") stress responses such as respiration, heart rate and skin conductance and increase parasympathetic responses that prepare the body to return to the homeostatic state like increasing heart rate variability through recruiting different brain regions for explicit and implicit coping.

Sympathetic and parasympathetic nervous systems are both components of the autonomic nervous system, which regulates the automatic and mostly non-conscious activity of the body. While sympathetic nervous system responds to stressful or physically arousing situations (aka "fight or flight" response) by increasing skin perspiration, respiration and heart rate, parasympathetic nervous system calms the body down or is involved in regular/ordinary activity such as slowing heart rate and respiration. These responses are down or up regulated (through feedback loops) by the central nervous system activity in the brain.

Relying on a functional dissociation in the human prefrontal cortex (see Firat, 2019; also Lieberman 2007), this paper proposes that the ventromedial prefrontal cortex (vmPFC) and the dorsolateral prefrontal cortex (dlPFC) delineate between the implicit and explicit value based coping. The vmPFC, medially placed in the frontal region of the prefrontal cortex, is reciprocally connected to sensory cortices and limbic structures and is an important center for motivation and emotional regulation, especially for moral emotions (Anderson et al., 2006; Berridge and Kringelbach, 2008; Damasio, 1994; et al., 1996; Price 1999). The vmPFC regulates moral decisions by allowing more subtle motivational and emotional factors to be weighted in judgments (Adolphs, 2009; Damasio, 1994; Greene, 2001; Greene and Haidt 2002; Mitchell, Banaji, and Macrae 2005; Moll et al., 2001). Adults with vmPFC damage fail to show autonomic responses to socially meaningful stimuli (Damasio, 1990), and fail to avoid disadvantageous choices (Bechara, Tranel, and Damasio 2000). Moreover, vmPFC is involved in inter-group processes such that it is more active in response to viewing members of in-groups (such as racial or social class in-groups) compared to stigmatized others (Harris and Fiske, 2006; Firat et al., 2017).

The dlPFC is the center for executive, top down functioning and goal directed behavior with connections to the temporal and parietal cortices to receive visual, somatosensory, and auditory information and the motor areas of the brain to coordinate movement (Firat and Hilton, 2000; Miller and Cohen, 2001; Miller and Cohen, 2019). For example, dlPFC plays a crucial role in working memory and multi-tasking (D'esposito et al., 1995; Cohen et al., 1997; Courtney et al., 1998). Patients who have damage to their dlPFC show inability to plan ahead and generate hypotheses, have trouble in flexibility tasks demanding flexibly shifting sets or changing tasks, have poor verbal fluency, and poor organizational and constructional strategies in learning new tasks (Milner 1963; Benton 1968; Jones-Gotman and Milner 1977; Stuss and Benson 1984; Waxman 2016). Moreover, some studies also suggest that the dlPFC has a role in a cognitive control mechanisms inhibiting racial bias (Stanley et al., 2008).

Based on this functional dissociation between the vmPFC and the dlPFC, I argue that we can identify the dissociable mechanisms for cultural coping strategies in response to ethno-racial stress in the human brain as 1) increased activation in the ventromedial prefrontal cortex (the brain region associated with moral intuitions and in-group identity, see Firat et al., 2017; 2019) when people adopt communal value based coping and 2) increased activation in the dorsolateral prefrontal cortex (brain region involved in top-down inhibition and executive control, e.g., Koechlin et al., 2003; MacDonald, 2000) when people employ agentic value based coping. I expect that both of these mechanisms will decrease psychophysiological stress responses (heart rate, heart rate variability, respiration and skin conductance) and thus potentially reduce allostatic load (McEwen and Stellar 1993).

In sum, as also illustrated in **Figure 1**, this paper proposes two value based coping styles: 1) an implicit motivational coping mechanism attenuating felt social pain via communal values, associated with ventromedial prefrontal cortex (vmPFC) activity and 2) another explicit coping mechanism providing more active and adaptive strategies to these difficult situations through agentic values, underlined by dorsolateral prefrontal cortex (dlPFC) activity. Again, this is not to say that individuals identifying with different groups will uniformly express the same coping styles and to the same extent; but rather, the argument I propose is that available patterns of practice shape the ways human brains respond to social or non-social environments, enabling people to co-create shared experiences (Roepstorff et al., 2010; Ma et al., 2014).

AN EMPIRICAL ILLUSTRATION

In this section of the paper, I provide an empirical illustration of the dual process model of value coping mechanisms with some data from a functional Magnetic Resonance experiment that measured responses to social exclusion in seventeen Black and eleven White subjects while they were primed with agentic or communal values (for more details see **Supplementary Table S1**).

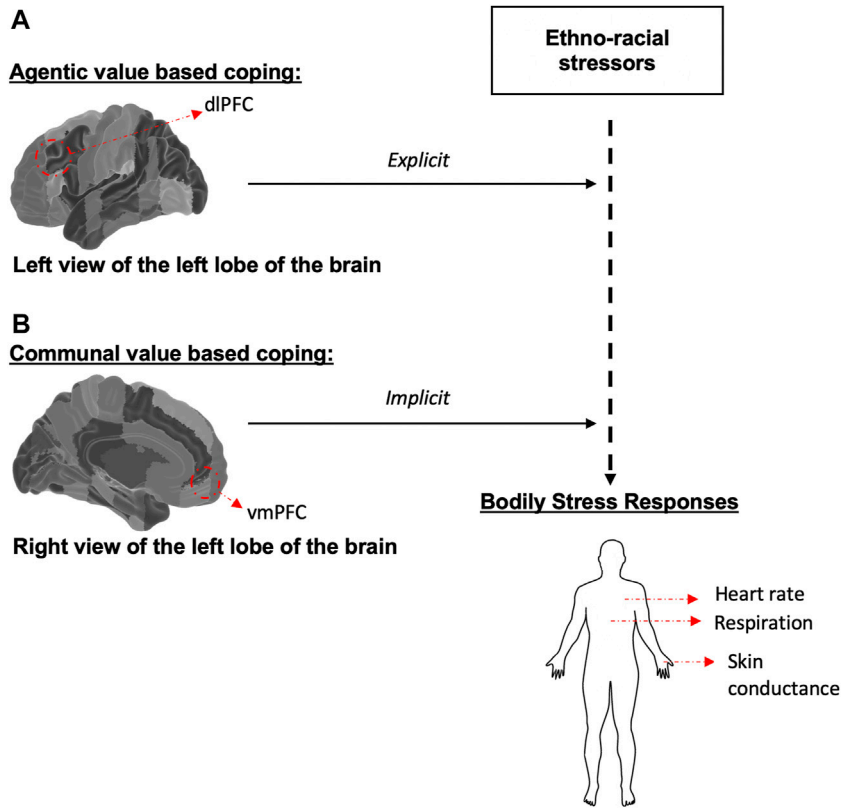


FIGURE 1 | Illustration of the dual processes of value based coping. The brain atlases adapted from the Harvard-Oxford atlas developed at the Center for Morphometric Analysis (CMA), and distributed with the FMRIB Software Library (FSL) (Bakker et al., 2015), 3D Surface View (Majka et al., 2012).

Similar to the previous neurological research on social exclusion (e.g., Eisenberger et al., 2003; Kawomoto et al., 2012; Kumar et al., 2009; Masten et al., 2011; Sebastian et al., 2010), the experimental task measured neural activity inside an fMRI scanner while participants were playing a virtual ball tossing game (Cyberball) with two other players. All imaging data were obtained with a 3-tesla MRI scanner (Research Trio 3T).

Cyberball is an online or offline (pre-programmed) ball tossing game between two or more players represented with animated gifs (see attached Cyberball example pic) and has been widely used for research on ostracism, social exclusion, or rejection (Williams 2006; et al., 2012). As in previous Cyberball studies, participants were told prior to scanning that we were interested in "mental visualization" ability (to avoid the topic of social interaction), and that they would play a game of catch over the internet with two other players. They were instructed to imagine the experience as real as possible. In this game, social exclusion was simulated with inclusion or exclusion from the game with ball tosses. There were a total of three runs (agentic vs. communalistic vs. control). At the beginning of each run, the participants read a short paragraph describing three almost identical stories describing a trip to the city, beach or the countryside with equal number of pronouns and gave their answer on a screen with a finger key response. This cultural priming procedure, also referred to as the "pronoun circling task" has been shown to effectively prime agentic (individualistic) or communalistic (collectivistic) values in a number of previous behavioral as well as fMRI studies (Gardner et al., 1999; Harada et al., 2010; Oyserman, Coon, and Kemmelmeier, 2002; Oyserman and Lee, 2007). All priming conditions contained identical stories, except for the following target phrases: I, my, me for individualism; we, our, us for collectivism; and they, their, theirs as a control/comparison condition (see attached **Supplementary Table S1** for details).

After the value priming, there were a total of 12 blocks in each run (six each of inclusion and exclusion). In the inclusion condition, the participants were over-included (50% ball possession) in order for them to register systematic differences between the inclusion and exclusion conditions and for the exclusion condition they were partially or completely excluded (16% or 0% ball possession). Each block lasted 24 s, followed by a fixation cross (16 s) (see **Figure 2**). The order of inclusion and exclusion blocks were pseudorandomized with the constraint that the same block type was never presented more than twice in a row. Each block began with an instruction screen (3 s) telling participants to "Get ready to throw the ball". Participants chose which of the other players to throw the ball to using a right index or middle finger key press response. Participants also marked

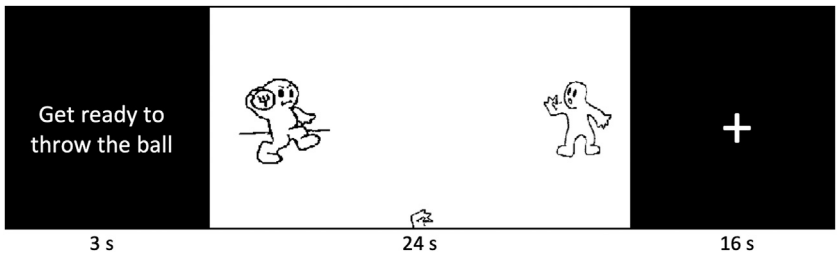


FIGURE 2 | Cyberball paradigm.

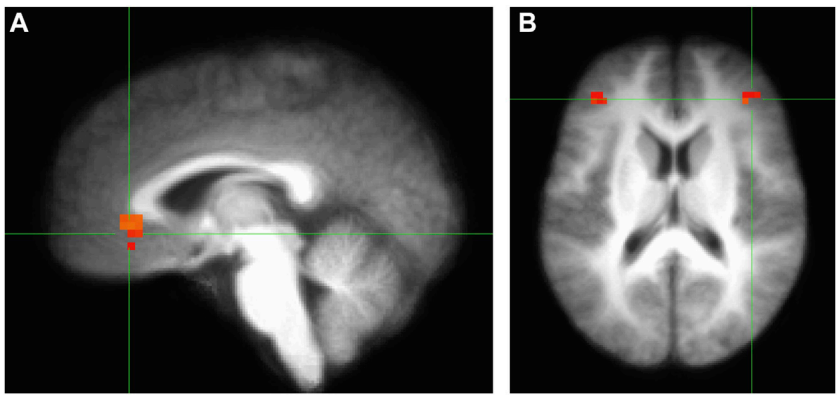


FIGURE 3 | Increased activation of the vmPFC **(A)** and the dlPFC in conditions of interest. vmPFC cluster size = 21 MNI coordinates = 2, –32, –3 dlPFC left cluster size = 13 MNI coordinates = 36, –37, 19. dlPFC right cluster size = 9 MNI coordinates = –39, –30, 29 Uncorrected p = 0.01, corrected p = 0.05.

each time one of the other players received the ball with a key press response in order to ensure that participants made motor responses during both inclusion and exclusion blocks and pay attention to the game. This cyberball paradigm is adapted from previous fMRI studies (see Sebastian et al., 2010; Kumar et al., 2009).

Data were first analyzed as individual level data and then combined into group level analyses on individual statistics. Data analysis presented here includes region of interest analyses (ROI) (for vmPFC and dlPFC brain regions) using AFNI (Analysis for Functional Neuroimaging) software. For each functional run, data were preprocessed to remove sources of noise and artifact. Data were corrected for differences in acquisition time between slices for each whole-brain volume, realigned within and across runs to correct for head movement, and co-registered with each participant's anatomical data. Normalized data were then spatially smoothed. Then, a deconvolution analysis was used to extract a hemodynamic response function for each subject. The effects of the conditions were modeled by box-car regressors convolved with the hemodynamic response function for 24 s for blocks of each trial type. Motion correction parameters were included as nuisance covariates and TRs with motion derivatives exceeding the Euclidian norm of 0.4 mm were censored in deconvolution analysis. Group-level analyses on the hemodynamic response estimates from individual statistics were conducted with a three way (race x inclusion/exclusion x values) Multi-Variate Modeling Approach (AFNI's 3DMVM command) that applied ROI masks for dlPFC and vmPFC.

In **Figure 3** present results from the contrasts of some main conditions of interest as they relate to the key arguments proposed by the theory outlined here: 1) communalistic values will recruit an implicit neural system including vmPFC activation and 2) agentic values will recruit an explicit neural system including dlPFC activation. I would like to emphasize that the results shown on **Figure 3** are correlations (as most fMRI data are), focuses on ROI analysis (rather than whole brain) and do not include various main effects or different contrasts. In other words, these results are presented to demonstrate that a neurosociological approach is a viable one to study racial differences in values and coping and not as full-fledged results to draw empirical generalizations from. However, nonetheless these results depict a very interesting picture that is for the most part supportive of the theory proposed here. As brain activity is usually observed in relation to various tasks, I present here the contrasts between specific conditions to be able to isolate the activation in response to the conditions of interest that are not shared by other conditions. Accordingly, as can be seen on **Figure 3**, Panel **A**, there is greater vmPFC activation during communalism (vs other) and exclusion (vs inclusion) contrasts and greater dlPFC activation in agentic (vs communalistic) and

exclusion (vs inclusion) contrasts in Black (vs White) respondents. This empirical illustration provides preliminary evidence for two potential mechanisms, one implicit and the other explicit, for the ways values might help racial minorities cope with the effects of social exclusion. These contrasts do not necessarily indicate that White respondents in the sample did not show similar responses. It simply meant that for Black respondents the findings were stronger. This makes sense given the context and history of United States race relations where marginalization, oppression and systemic exclusion of Black folk are hardened into the social fabric, causing a stress and anxiety overload.

FUTURE DIRECTIONS/CONCLUSION

This paper seeks to advance current understandings of cultural and cognitive sociology and the dual process models through uncovering the ways in which values can attenuate responses to social exclusion through influencing implicit and explicit neurological processes. Recent research on dual process models has rejuvenated the interest on methodologies that go beyond traditional ethnography or survey methods to capture implicit and automatic cognitive and emotive processes of culture (e.g., Miles et al., 2019; Vaisey 2009). Social behavior and attitudes are especially complex and challenging to measure directly in the context of inter-racial or ethnic relationships (Pager and Shepherd 2008). Survey or interview responses might not only accurately reflect individuals' beliefs due to social desirability but also might technically not be able to capture subtle and fast bodily reactions to social cues. The neurosociological methodologies proposed in this paper have the unique capacity to measure both fast and automatic and slow and controlled, thus avoiding social desirability issues. With this study, we are getting one step closer to a proper understanding of how culture shapes individual behavior implicitly and explicitly, detailing how distal social forces shape human mind and behavior.

As structurally and culturally shaped dispositions (Longest et al., 2013), values are well-situated for operationalizing the concept of cultural coping by embedding individuals in groups, organizations and broader cultural settings (Firat et al., 2018; Firat and McPherson, 2010). Building on previous research demonstrating that values moderate the negative effects of discrimination on well-being (Firat, 2017), I proposed and provided preliminary evidence that value orientations operate both through implicit/automatic (communal values) and explicit/controlled (agentic) values. The brain region related to automatic and emotional evaluations and processing (i.e., the vmPFC) was activated in Blacks in response to exclusion in communalistic conditions, whereas activation in the brain region most commonly associated with executive control and top-down processing (i.e., dlPFC) was related to agentic conditions during exclusion. Understanding the role of cultural values in stress responses is important in identifying a key contextual factor shaping individual responses, a mechanism often ignored by both psychologists and sociologists because it requires a thorough integration of macro and micro processes. By focusing on this macro-micro link with a neurosociological approach, this project makes a novel contribution to the body of knowledge on the effects of ethno-racial contact on stress. The mechanisms proposed in this paper are scalable to larger groups, other cultures, and identities in an increasingly diverse global society.

Future research applying this theoretical paradigm will have the capacity to identify ways for reducing ethno-racial disparities of stress and health. If the theory proposed here is further supported and augmented by empirical work, additional studies can identify specific value based intervention strategies for coping with stress in members of ethno-racial minority groups. While shared experiences of (interpersonal and institutional) discrimination and systematic social exclusion situate members of ethno-racial minority groups into oppressed and marginalized positions in the social hierarchy, values might serve as cultural, collective resources that can help improve resilience in the face of stressors. In this framework, values act as "a key cognitive capacity that can act as a mental resource for communities of color" (Firat, 2020: 77). If research can demonstrate culturally relevant implicit and explicit value strategies (for example through framing or messages) effective in buffering ethno-racial stress, these strategies could be adapted for protecting and promoting the health of members of vulnerable communities.

In conclusion, this paper has important implications for identifying the biomarkers for coping styles in response to ethnicity related stress by focusing on a sociological mechanism that operates both at the individual and macro level: value orientations. Previous research has focused on personal backgrounds such as previous racial contact or cross-ethnic friendships or psychological attributions such as self-esteem; but, no research has explored the macro societal and cultural dimensions underlying coping strategies at the micro level. The logical next step in this research paradigm would be to connect these neurological mechanisms with physiological stress responses to demonstrate the culture-brain-stress link. Responses to social interactions including ethno-racial interactions are bodily and cognitive phenomena; they are experienced and enacted through our bodies and our brains. Traditional experimental techniques like behavioral responses or survey methods are indirect ways of measuring these cognitive and bodily processes. Coupling brain imaging data with physiological data would be a spearheading attempt in linking biological mechanisms of ethno-racial relations to sociological understandings. Hopefully, this paper was able to offer a neurosociological research framework for future research seeking to expand our understandings of stress mechanism and response to social exclusion as they relate to value based coping strategies.

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 Georgia Tech University Office of Research Integrity. The patients/participants provided their written informed consent to participate in this study.

AUTHOR CONTRIBUTIONS

The author confirms being the sole contributor of this work and has approved it for publication.

FUNDING

University Research Services Administration (URSA) Georgia State University: funded fMRI scan costs.

SUPPLEMENTARY MATERIAL

The Supplementary Material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fsoc.2021.695042/full#supplementary-material

REFERENCES

Adolphs, R. (2009). The Social Brain: Neural Basis of Social Knowledge. *Annu. Rev. Psychol.* 60 (1), 693–716. doi:10.1146/annurev.psych.60.110707.163514

Anderson, S. W., Barrash, J., Bechara, A., and Tranel, D. (2006). Impairments of Emotion and Real-World Complex Behavior Following Childhood- or Adult-Onset Damage to Ventromedial Prefrontal Cortex. *J. Int. Neuropsychol. Soc.* 12 (2), 224–235. doi:10.1017/S1355617706060346

Bandura, A. (2004). Health Promotion by Social Cognitive Means. *Health Educ. Behav.* 31 (2), 143–164. doi:10.1177/1090198104263660

Bandura, A. (1998). Health Promotion from the Perspective of Social Cognitive Theory. *Psychol. Health* 13 (4), 623–649. doi:10.1080/08870449808407422

Bandura, A. (2005). The Primacy of Self-Regulation in Health Promotion. *Appl. Psychol.* 54 (2), 245–254. doi:10.1111/j.1464-0597.2005.00208.x

Bardi, A., and Schwartz, S. H. (2003). Values and Behavior: Strength and Structure of Relations. *Pers Soc. Psychol. Bull.* 29 (10), 1207–1220. doi:10.1177/0146167203254602

Barnea, M. F., and Schwartz, S. H. (1998). Values and Voting. *Polit. Psychol.* 19 (1), 17–40. doi:10.1111/0162-895X.00090

Berridge, K. C., and Kringelbach, M. L. (2008). Affective Neuroscience of Pleasure: Reward in Humans and Animals. *Psychopharmacology* 199 (3), 457–480. doi:10.1007/s00213-008-1099-6

Besley, J. C. (2008). Media Use and Human Values. *Journalism Mass Commun. Q.* 85 (2), 311–330. doi:10.1177/107769900808500206

Brondolo, E., Rieppi, R., Kelly, K. P., and Gerin, W. (2003). Perceived Racism and Blood Pressure: A Review of the Literature and Conceptual and Methodological Critique. *Ann. Behav. Med.* 25 (1), 55–65. doi:10.1207/S15324796ABM2501_08

Bruder, Johannes. (2019). Cognitive Code: Post-Anthropocentric Intelligence And the Infrastructural Brain. *Montreal ; Kingston ; London* . Chicago: McGill-Queen's University Press.

Cerulo, K. A. (2002). in *Culture in Mind: Toward a Sociology of Culture and Cognition* (New York: Routledge).

Cerulo, K. A. (2014). Continuing the Story: Maximizing the Intersections of Cognitive Science and Sociology. *Sociol. Forum* 29 (4), 1012–1019. doi:10.1111/socf.12135

Choudhury, S., Nagel, S. K., and Slaby, J. (2009). Critical Neuroscience: Linking Neuroscience and Society through Critical Practice. *BioSocieties* 4 (1), 61–77. doi:10.1017/S1745855209006437

Clark, R. (2000). Perceptions of Interethnic Group Racism Predict Increased Vascular Reactivity to a Laboratory Challenge in College Women. *Ann. Behav. Med.* 22 (3), 214–222. doi:10.1007/BF02895116

Damasio, A. (1990). Individuals with Sociopathic Behavior Caused by Frontal Damage Fail to Respond Autonomically to Social Stimuli. *Behav. Brain Res.* 41 (2), 81–94. doi:10.1016/0166-4328(90)90144-4

Damasio, Antonio. R. (1994). *Descartes' Error: Emotion, Reason, and the Human Brain*. New York: Putnam.

Dressler, W. W., Balieiro, M. C., Ribeiro, R. P., and Ernesto Dos Santos, J. (2005). Cultural Consonance and Arterial Blood Pressure in Urban Brazil. *Soc. Sci. Med.* 61 (3), 527–540. doi:10.1016/j.socscimed.2004.12.013

Dressler, W. W., and Bindon, J. R. (2000). The Health Consequences of Cultural Consonance: Cultural Dimensions of Lifestyle, Social Support, and Arterial Blood Pressure in an African American Community. *Am. Anthropologist* 102 (2), 244–260. doi:10.1525/aa.2000.102.2.244

Eisenberger, N. I. (2003). Does Rejection Hurt? an FMRI Study of Social Exclusion. *Science* 302 (5643), 290–292. doi:10.1126/science.1089134

Eisenberger, N. I., and Lieberman, M. D. (2004). Why Rejection Hurts: A Common Neural Alarm System for Physical and Social Pain. *Trends Cogn. Sci.* 8 (7), 294–300. doi:10.1016/j.tics.2004.05.010

Firat, R. B. (2020). COVID-19, Agency, and Communities of Color. *Contexts* 19 (4), 77–79. doi:10.1177/1536504220977945

Firat, R. B. (2017). Discrimination and Well-Being: The Moderating Effects of Agentic Value Orientations. *Soc. Indic Res.* 134 (1), 167–194. doi:10.1007/s11205-016-1425-z

Firat, R. B., Hitlin, S., Magnotta, V., and Tranel, D. (2017). Putting Race in Context: Social Class Modulates Processing of Race in the Ventromedial Prefrontal Cortex and Amygdala. *Soc. Cogn. Affective Neurosci.* 12 (8), 1314–1324. doi:10.1093/scan/nsx052

Firat, R. B., Kwon, H. W., and Hitlin, S. (2018). A Novel Measure of Moral Boundaries: Testing Perceived In-Group/Out-Group Value Differences in a Midwestern Sample. *Socius* 4, 237802311881874. doi:10.1177/2378023118818741

Firat, R. B. (2014). Media Usage and Civic Life: The Role of Values. *J. Soc. Polit. Psych.* 2 (1), 117–142. doi:10.5964/jspp.v2i1.113

Firat, R. B. (2019). Opening the "Black Box": Functions of the Frontal Lobes and Their Implications for Sociology. *Front. Sociol.* 4, 3. doi:10.3389/fsoc.2019.00003

Firat, Rengin., and Hitlin, Steven. (2012). ""Morally Bonded and Bounded: A Sociological Introduction to Neurology." Pp. 165–99," in *Biosociology and Neurosociology, Advances in Group Processes*. Editors W. Kalkhoff, S. R. Thye, and E. J. Lawler (Bingley, United Kingdom: Emerald).

Firat, R., and McPherson, C. M. (2010). "Toward an Integrated Science of Morality," in *Handbook of the Sociology of Morality*. Editors S. Hitlin and S. Vaisey. (New York, NY: Springer), 361–384. doi:10.1007/978-1-4419-6896-8_19

Franks, David. D. (2010). *Neurosociology: The Nexus between Neuroscience and Social Psychology* 1. New York, NY: Aufl Springer.

Greene, J. D. (2001). An FMRI Investigation of Emotional Engagement in Moral Judgment. *Science* 293 (5537), 2105–2108. doi:10.1126/science.1062872

Grillo, R. D. (2003). Cultural Essentialism and Cultural Anxiety. *Anthropological Theor.* 3 (2), 157–173. doi:10.1177/1463499603003002002

Harrell, J. P., Hall, S., and Taliaferro, J. (2003). Physiological Responses to Racism and Discrimination: An Assessment of the Evidence. *Am. J. Public Health* 93 (2), 243–248. doi:10.2105/AJPH.93.2.243

Harris, L. T., and Fiske, S. T. (2006). Dehumanizing the Lowest of the Low. *Psychol. Sci.* 17 (10), 847–853. doi:10.1111/j.1467-9280.2006.01793.x

Hitlin, S., and Piliavin, J. A. (2004). Values: Reviving a Dormant Concept. *Annu. Rev. Sociol.* 30 (1), 359–393. doi:10.1146/annurev.soc.30.012703.110640

Hitlin, Steven. (2014). ""Social Psychological Ingredients for a Sociology of Morality." Pp. 195–217," in *The Palgrave Handbook of Altruism, Morality, and Social Solidarity*. Editor V. Jeffries (New York: Palgrave Macmillan US).

Hitlin, S., and Vaisey, S. (2013). The New Sociology of Morality. *Annu. Rev. Sociol.* 39 (1), 51–68. doi:10.1146/annurev-soc-071312-145628

Hughes, M., Kiecolt, K. J., and Keith, V. M. (2014). How Racial Identity Moderates the Impact of Financial Stress on Mental Health Among African Americans. *Soc. Ment. Health* 4 (1), 38–54. doi:10.1177/2156869313509635

Ignatow, G. (2007). Theories of Embodied Knowledge: New Directions for Cultural and Cognitive Sociology?. *J. Theor. Soc. Behav.* 37 (2), 115–135. doi:10.1111/j.1468-5914.2007.00328.x

Jeffries, Vincent. (Editors) (2014). *The Palgrave Handbook of Altruism, Morality, and Social Solidarity: Formulating a Field of Study*, (New York: Palgrave Macmillan US).

Lizardo, O. (2014). Beyond the Comtean Schema: The Sociology of Culture and Cognition versus Cognitive Social Science. *Sociol. Forum* 29 (4), 983–989. doi:10.1111/socf.12130

Longest, K. C., Hitlin, S., and Vaisey, S. (2013). Position and Disposition: The Contextual Development of Human Values. *Social Forces* 91 (4), 1499–1528. doi:10.1093/sf/sot045

Ma, Y., Bang, D., Wang, C., Allen, M., Frith, C., Roepstorff, A., et al. (2014). Sociocultural Patterning of Neural Activity during Self-Reflection. *Soc. Cogn. Affective Neurosci.* 9 (1), 73–80. doi:10.1093/scan/nss103

MacDonald, A. W. (2000). Dissociating the Role of the Dorsolateral Prefrontal and Anterior Cingulate Cortex in Cognitive Control. *Science* 288 (5472), 1835–1838. doi:10.1126/science.288.5472.1835

McAuley, E. (1992). The Role of Efficacy Cognitions in the Prediction of Exercise Behavior in Middle-Aged Adults. *J. Behav. Med.* 15 (1), 65–88. doi:10.1007/BF00848378

Mendes, W. B., and Koslov, K. (2013). Brittle Smiles: Positive Biases toward Stigmatized and Outgroup Targets. *J. Exp. Psychol. Gen.* 142 (3), 923–933. doi:10.1037/a0029663

Miles, A., Charron-Chénier, R., and Schleifer, C. (2019). Measuring Automatic Cognition: Advancing Dual-Process Research in Sociology. *Am. Sociol. Rev.* 84 (2), 308–333. doi:10.1177/0003122419832497

Miller, E. K., and Cohen, J. D. (2001). An Integrative Theory of Prefrontal Cortex Function. *Annu. Rev. Neurosci.* 24 (1), 167–202. doi:10.1146/annurev.neuro.24.1.167

Modood, T. (1998). Anti-Essentialism, Multiculturalism and the 'Recognition' of Religious Groups. *J. Polit. Philos.* 6 (4), 378–399. doi:10.1111/1467-9760.00060

Nazroo, J. Y. (2003). The Structuring of Ethnic Inequalities in Health: Economic Position, Racial Discrimination, and Racism. *Am. J. Public Health* 93 (2), 277–284. doi:10.2105/AJPH.93.2.277

Pascoe, E. A., and Smart Richman., L. (2009). Perceived Discrimination and Health: A Meta-Analytic Review. *Psychol. Bull.* 135 (4), 531–554. doi:10.1037/a0016059

Pearlin, L. I. (1989). The Sociological Study of Stress. *J. Health Soc. Behav.* 30 (3), 241. doi:10.2307/2136956

Razum, O., Zeeb, H., Akgun, H. S., and Yilmaz, S. (1998). Low Overall Mortality of Turkish Residents in Germany Persists and Extends into a Second Generation: Merely a Healthy Migrant Effect?*. *Trop. Med. Int. Health* 3 (4), 297–303. doi:10.1046/j.1365-3156.1998.00233.x

Roepstorff, A., Niewöhner, J., and Beck, S. (2010). Enculturing Brains through Patterned Practices. *Neural Networks* 23 (8–9), 1051–1059. doi:10.1016/j.neunet.2010.08.002

Schleim, S. (2014). Critical Neuroscienceâ€"or Critical Science? A Perspective on the Perceived Normative Significance of Neuroscience. *Front. Hum. Neurosci.* 8. doi:10.3389/fnhum.2014.00336

Schultz, P. W., and Zelezny, L. C. (1998). Values and Proenvironmental Behavior. *J. Cross-Cultural Psychol.* 29 (4), 540–558. doi:10.1177/0022022198294003

Schwartz, Shalom. H. (1992). "Universals in the Content and Structure of Values: Theoretical Advances and Empirical Tests in 20 Countries.," in *1–65. Advances in Experimental Social Psychology*. Editor M. P. Zanna (Academic Press), 25.

Schwartz, S. H. (2010). "Basic Values: How They Motivate and Inhibit Prosocial Behavior," in *–41 in Prosocial Motives, Emotions, and Behavior: The Better Angels of Our Nature* (Washington, DC: American Psychological Association), 221–241. doi:10.1037/12061-012

Slaby, J. (2010). Steps towards a Critical Neuroscience. *Phenom Cogn. Sci.* 9 (3), 397–416. doi:10.1007/s11097-010-9170-2

Stanley, D., Phelps, E., and Banaji, M. (2008). The Neural Basis of Implicit Attitudes. *Curr. Dir. Psychol. Sci.* 17 (2), 164–170. doi:10.1111/j.1467-8721.2008.00568.x

Steven. Hitlin, and Stephen. Vaisey (2010). in *Handbook of the Sociology of Morality* (New York: Springer).

TenHouten, W. (1997). Neurosociology. *J. Soc. Evol. Syst.* 20 (1), 7–37. doi:10.1016/S1061-7361(97)90027-8

Thoits, P. A. (2006). Personal Agency in the Stress Process. *J. Health Soc. Behav.* 47 (4), 309–323. doi:10.1177/002214650604700401

Turner, Jonathan. H. (2014). ""The Evolution of Affect, Sociality, Altruism, and Conscience in Humans." Pp. 275–301," in *The Palgrave Handbook of Altruism, Morality, and Social Solidarity*. Editor V. Jeffries (New York: Palgrave Macmillan US).

Urien, B., and Kilbourne, W. (2011). Generativity and Self-Enhancement Values in Eco-Friendly Behavioral Intentions and Environmentally Responsible Consumption Behavior. *Psychol. Marketing* 28 (1), 69–90. doi:10.1002/mar.20381

Vaisey, S. (2008). Socrates, Skinner, and Aristotle: Three Ways of Thinking about Culture in Action1. *Sociological Forum* 23 (3), 603–613. doi:10.1111/j.1573-7861.2008.00079.x

von Scheve, C. (2011). ""Sociology of Neuroscience or Neurosociology?" Pp. 255–78," in *Advances in Medical Sociology*. Editors M. Pickersgill and I. Van Keulen (Bingley: Emerald Group Publishing Limited).

Welzel, C., and Inglehart, R. (2010). Agency, Values, and Well-Being: A Human Development Model. *Soc. Indic Res.* 97 (1), 43–63. doi:10.1007/s11205-009-9557-z

Wikan, U. (1999). Culture: A New Concept of Race. *Soc. Anth.* 7 (1), 57–64. doi:10.1017/S096402829900004X

Williams, D. R. (2012). Miles to Go before We Sleep. *J. Health Soc. Behav.* 53 (3), 279–295. doi:10.1177/0022146512455804

Conflict of Interest: The author declares that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

frontiers in Psychology

REVIEW
published: 28 July 2021
doi: 10.3389/fpsyg.2021.694212

Neuroscience, Empathy, and Violent Crime in an Incarcerated Population: A Narrative Review

Valeria Saladino[1], Hannah Lin[2], Elisa Zamparelli[3] and Valeria Verrastro[4]*

[1] Department of Human Sciences, Society and Health, University of Cassino and Southern Lazio, Cassino, Italy, [2] Department of Biological Sciences, Columbia University, New York, NY, United States, [3] Institute for the Study of Psychotherapies, Rome, Italy, [4] Department of Medical and Surgical Sciences, University "Magna Graecia" of Catanzaro, Catanzaro, Italy

Empathy is a fundamental construct that allows individuals to perceive and understand the cognitive and emotional state of others. Empathy is not only a psychological and sociological concept; it also heavily impacts our daily lives by affecting our decisions and actions. Empathy is connected to and involves specific parts of the brain which, if damaged or of reduced volume, can lead to actions that are morally unjust, aggressive, or simply denoting a lack of understanding and sensitivity. The literature affirms that the low level of empathy, guilt, embarrassment, and moral reasoning displayed by violent and psychopathic criminals is strongly associated with empathy-linked brain regions that are smaller in size or less developed. The aim of this review is to show empirical data over the last 5 years on the connection between empathy and neuroscience among violent and psychopathic offenders, reflecting on future research on the topic.

Keywords: empathy, deviance, violent crimes, neuroscience, psychopathy (PSY)

OPEN ACCESS

Edited by:
Vincenzo Auriemma, University of Salerno, Italy

Reviewed by:
Jason Roach, University of Huddersfield, United Kingdom
Stefano Ruberto, University of Turin, Italy

****Correspondence:***
Valeria Saladino
v.saladino@unicas.it

Specialty section:
This article was submitted to Cognitive Science, a section of the journal Frontiers in Psychology

Received: *12 April 2021*
Accepted: *30 June 2021*
Published: *28 July 2021*

Citation:
Saladino V, Lin H, Zamparelli E and Verrastro V (2021) Neuroscience, Empathy, and Violent Crime in an Incarcerated Population: A Narrative Review. Front. Psychol. 12:694212. doi: 10.3389/fpsyg.2021.694212

EMPATHY AND NEUROSCIENCE

Definition of Empathy

The construct of empathy does not have a universally recognized definition, as previous studies have focused on philosophical and behavioral aspects (Batson, 2009; Bernhardt and Singer, 2012). Lately, research has focused on identifying the underlying neural network processes. Neuroscience has made an important contribution to understanding the neural basis of empathy. A recent definition states that the empathic process occurs when the observation or imagination of affective states of others induces shared feelings in the observer and involves various components such as affective sharing, self-awareness, and self-other differentiation (Singer and Lamm, 2009). Empathy contributes to the development of positive social interactions and helps us to understand and react to others' behaviors.

Abbreviations: AI, anterior insula; aMCC, anterior medial cingulate cortex; ASN, autonomic nervous system; BLA, basolateral amygdala; CD, conduct-disordered; CMA, centromedial amygdala; CU, callous-unemotional; dlPFC, dorsolateral prefrontal cortex; dmPFC, dorsomedial prefrontal cortex; EEG, electroencephalogram; EQ, empathy quotient; fMRI, functional magnetic resonance imaging; FTD, frontotemporal dementia; HD, Huntington's disease; HPA, hypothalamic-pituitary-adrenal axis; IPC, inferior parietal cortex; IQ, intelligence quotient; MCC, middle cingulate cortex; mPFC, medial prefrontal cortex; MRI, magnetic resonance imaging; NAcc, nucleus accumbens; OFC, orbitofrontal cortex; pACC, posterior anterior; PCC, posterior cingulate cortex; PCL-R, Psychopathy Checklist-Revised; PET, positron emission tomography; PFC, prefrontal cortex; PPTM, Psychopathic Personality Traits Model; STS, superior temporal sulcus; ToM, theory of mind; TPJ, temporoparietal junction; vmPFC, ventromedial prefrontal cortex.

However, empathy is not automatic or obligatory. Indeed, our reaction to others' feelings derive from a series of factors such as the situation, the empathizer, beliefs, and goals compared with emotions of others. For instance, the suffering of strangers might not affect us because we are not motivated or interested to be involved in their feelings; however, if we attend to the suffering of friends or family, empathy activation changes. An example is a reaction to the cry of a child; some people might get annoyed, others might put themselves in the shoes of the embarrassed parent, still others might put themselves in the shoes of the suffering child, and our empathic activation changes whether that child is our grandson or a stranger.

This wide range of reactions depends on intrapersonal and situational characteristics. Also, our capacity to understand others' feelings is not necessarily connected with a prosocial attitude. Empathy must be regulated. Excessive empathy or lack of empathy denotes an inability of individuals to adapt to situations. Compared to animals, humans have greater cognitive abilities. For example, humans can process the emotional states of others using the theory of mind (ToM) (Stone, 2006), as defined by the developmental psychology. This evolutionary aspect could lead to extraordinary prosocial actions, such as caring for individuals of different species, and to the worst actions, like violence and dehumanization. There are some individuals, such as those who commit violent crimes and those with psychopathy who often have empathy deficits. Thus, a better understanding of the component of empathy and its neurodevelopment is needed.

Evolution and Types of Empathy

According to developmental and social psychology, empathy is the affective response derived from the understanding of others' feelings. First, empathy manifestations occur during childhood among infants (6-months-old), who prefer altruistic characters rather than not- cooperative ones (Hamlin et al., 2007). Children of 18–25 months tend to sympathize with others in the absence of emotional stimuli, experimenting with some form of affective perspective-taking (Vaish et al., 2009). Moreover, prosocial behaviors emerge at 12 months, a period in which children can care for people who need help (Warneken and Tomasello, 2009).

From a clinical and neurobiological point of view, empathy can be differentiated into affective empathy and cognitive empathy (Saladino et al., 2020a). Affective empathy is defined as the ability to understand and share the emotional experiences of others through an autonomic response, while cognitive empathy is defined as the ability to understand and share the point of view of others, allowing inferences on mental or emotional states (Cox et al., 2011). Affective empathy is involuntary, and it develops early than the cognitive empathy. It relates to the somato-sensorimotor response, such as the feeling of distress experiment by children when another child is crying (Dondi et al., 1999). The cognitive component of empathy is related to the ToM (the ability to interpret the mental state of others, their thoughts, and beliefs), the executive function of attention, memory, and self-regulation. Both ToM and self-regulation are associated with the functioning of the prefrontal cortex (medial and dorsolateral regions) and of the subcortical limbic structures (Zelazo et al., 2008). The prefrontal cortex continues to develop during adolescence and adulthood. This area of the brain is also responsible for controlling one's emotions and actions (Diamond, 2002).

Empathy involves several areas of the brain that are not limited to the cortex but also include the autonomic nervous system (ASN), the hypothalamic-pituitary-adrenal axis (HPA), and the endocrine system, associated with the regulation of emotional and bodily states. According to the components of both cognitive and affective empathy, scientists (Decety and Jackson, 2004; Decety, 2005, 2007; Decety and Meyer, 2008) identified two models of processing empathy: a bottom-up model associated with the affective component and a top-down model linked to the cognitive component. The bottom-up processing is mediated by the amygdala, hypothalamus, and orbitofrontal cortex (OFC) for the affective arousal; top-down processing is associated with the anterior insula (AI), medial prefrontal cortex mPFC, and ventromedial prefrontal cortex (vmPFC) for emotion awareness, and OFC, mPFC, and dorsolateral prefrontal cortex (dlPFC) for emotion regulation, control of emotion and motivation. Both processing models are connected and influenced by the ASN and the endocrine system (Decety, 2011).

Empathic Circuit and Core Network of Empathy

The research on neural substrates that are involved in the empathy circuit was guided by the hypothesis which states that there is a shared network of regions involved in both the empathic experience and the first-person affective experience (Gallese and Goldman, 1998; Preston and de Waal, 2002). Mostly, neuroimaging studies on empathy have been focused on the perception of pain. Data from two meta-analyses on the topic showed the involvement of some specific brain areas, such as the AI, the posterior-anterior (pACC), and the anterior medial cingulate cortex (aMCC). These regions are implicated in several functions, such as pain processing, evaluation and perception of emotions, and interoceptive awareness (Kober et al., 2008; Craig, 2009; Duerden and Albanese, 2011; Lindquist et al., 2012).

In supporting the shared-networks hypothesis, recent studies with fMRI have shown that pACC and aMCC are associated with both observing and feeling pain and relate with the AI, which integrates the cognitive and affective information of the personal perception of pain (Allman et al., 2010; Shackman et al., 2011). Altogether, these areas contribute to the integration of the information to the global emotional state, leading to a modulation of behavioral response, which is part of the empathic response (Singer and Lamm, 2009). Other evidence of the involvement of the AI in empathy shared networks derived from a study in participants with alexithymia. Among these people, the AI is less activated when they try to understand their own emotions and when they are empathizing with others' pain (Silani et al., 2008; Bird et al., 2010). Empathic response and the associated core network can occur through a stimulus-response or perception-based condition, in which the subject

is exposed to the presence of a concrete visual stimulus and reacts through empathic activation, or through an inference-based condition, in which individuals are exposed to abstract cues and are influenced by their perspective-taking skill and their previous experiences in attributing emotional states of others (Amodio and Frith, 2006; Frith and Frith, 2006). The activation of the core empathic-related networks in the inference-based condition is associated with ToM and mentalization's networks, characterized by the vmPF, the superior temporal sulcus (STS), the temporoparietal junction (TPJ), the posterior cingulate cortex (PCC). The perception-based condition is related to action observation areas, as dorsolateral (dlPFC) and dorsomedial (dmPFC), and the inferior parietal cortex (IPC). The reciprocal interaction between these two routes of empathy allows for a complete representation of others' emotional states (Danziger et al., 2009; Zaki et al., 2009).

As mentioned before, empathic activation is modulated by individual and contextual characteristics. Beliefs and the personal interpretation of the context influence the empathy process and the activation of the empathic core network. For instance, scientific evidence found less activation in AI when individuals witnessed the suffering of others if the subject of empathy had committed actions considered amoral by the empathizer or was perceived as part of the outgroup (Molenberghs et al., 2016; Molenberghs and Louis, 2018). The reduction in the AI area is also associated with increased activation of ventral striatum/nucleus accumbens (NAcc), linked to reward and desire for revenge (de Quervain et al., 2004; Cohen et al., 2009; Takahashi et al., 2009). Thus, empathy can be solicited through AI activation, associated with help, understanding, and prosocial behaviors, and counteracted by the activation of the NAcc and the antagonistic motivational system. Moreover, according to some research on the topic, the individual can generate and control empathic responses. When the empathizer takes the perspective of friends or family, there is increased activation of the AI and midcingulate areas, associated with higher empathic response. When the empathizer takes the perspective of a stranger, there is a decreased connection between the AI and TPJ.

Thus, the individual can increase or decrease their empathic response, using perspective-taking as a strategy based on personal engagement with the subject of empathy.

Brain Lesions and Empathy

Considering the number of areas involved in the empathic process, it is necessary to consider several disorders derived from brain lesions or dysfunctional development. Moreover, as emphasized by cited studies on the affective and cognitive components of empathy, a person could have an issue related to affective empathy but not to cognitive empathy, such as in psychopathy, schizophrenia, depersonalization, and narcissistic personality disorder (Kumari et al., 2009; Schiffer et al., 2017; Nascivera et al., 2019). Meanwhile, autism spectrum disorder, for instance, is characterized by a deficit in cognitive empathy and not in affective empathy (Baron-Cohen, 2011; Fan et al., 2014; Saladino et al., 2020d).

Studies on brain injury have provided neurobiological information related to the dissociation between affective empathy and cognitive empathy. Specifically, bilateral damage to the amygdala can compromise affective empathy (Hurlemann et al., 2010). The amygdala, together with the hypothalamus, hippocampus, and OFC, are fundamental for affective arousal and automatic discrimination of a stimulus. The reciprocal interaction between the amygdala, OFC, and STS leads to the processing of affective signals. Damage in the mPFC, associated with emotion awareness, can compromise cognitive empathy (Shamay-Tsoory et al., 2009). Emotive understanding can overlap with ToM and mentalization and is also associated with AI and vmPFC, which, together with mPFC, integrate cognitive and emotional understanding, creating a balanced condition represented throughout the PFC.

Findings on degenerative neurological diseases support this distinction between the affective and cognitive components of empathy. Snowden et al. (2003) and Nathani et al. (2020) analyzed the empathy process among patients with Huntington's disease (HD) and frontotemporal dementia (FTD), both associated with social cognitive deficits. They found the same poor empathy conditions but patients with HD reported more affective empathy deficits, while FTD patients reported cognitive empathy issues. These results can be attributed to a deficit in the ToM for FTD and a deficit in interpreting social situations for HD.

Also, Adolphs et al. (2000) studied the role of the somatosensory cortex in emotion processing. They found that damage in the right somatosensory cortex can compromise the capacity to recognize facial expressions. In fact, during the processing of facial expressions, we rely on the representations of the somatosensory cortex. However, there are conflicting opinions about mutual influence between the first-person experience of emotion and recognition of the same emotions in others. Data from a study on patients with bilateral facial paralysis found that they reported no deficit in emotion recognition, even if they did not express facial emotions (Keillor et al., 2002).

In a review on brain-imaging studies among violent offenders over the last 10 years (Bogerts et al., 2018) authors found deviations in structure and deficit in function among PFC, OFC, AI, as well as in temporolimbic structures such as amygdala, hippocampus, and parahippocampus, areas important in both affective and cognitive empathy, and in control of impulsive and aggressive behaviors (especially hypothalamus and limbic system).

Finally, clinical evidence showed that damage in PFC can provoke a deficit in empathy and interpersonal behaviors. Studies on patients with neurological lesions reported reduced empathy, especially if the damage involved the right hemisphere and the ventromedial region. Also, patients who have lesions in medial/cingulate PFC have a deficit in social interactions and emotional interpretation. These patients present a sense of apathy, poor concentration, and interest in the environment. These results suggest a key role of PFC in the empathy process and perspective-taking skills (Shamay-Tsoory et al., 2003, 2005).

Empathy is important in managing behaviors and understanding the emotional states of others. The association between empathic deficit, neuroscience, violent crime, and

psychopathic personality has therefore received increasing attention from the scientific community.

PSYCHOPATHY AND ZERO DEGREES OF EMPATHY

The Construct of Psychopathy

Psychopathy has been conceptualized according to several definitions and characteristics: sometimes as an antecedent of violence and crime, other times as a hereditary and biological condition that affects social and empathetic skills. Despite the large number of conceptualizations, theories, and research on the subject, psychopathy remains a concept to be investigated (Skeem et al., 2011). Psychopathy was identified as a mental disorder characterized by antisocial and morally reprehensible behavior and the commission of crimes with no apparent sense of guilt, shame, or remorse. Psychopaths exhibit a generalized lack of empathy with both family members and strangers, which does not allow them to differentiate emotional stimuli from impulses. This mechanism leads these subjects to equate love and sexual excitement, sadness, frustration, anger, and irritability. The concepts of psychopathy and antisocial personality are connected; specifically, antisocial personality represents the attempt to transpose psychopathy on a more operational and concrete level. Psychopathy can be considered the malignant form of antisocial personality because the behaviors of psychopaths are predatory, programmed, destructive, indifferent to the consequences, and without remorse (Fornari, 2012).

Psychopaths are divided into two categories: passive and aggressive. Passive psychopaths are parasitic toward others and exploit them. Often, they may have trouble with the law but manage not to suffer serious consequences and punishments. Psychopaths of this type mostly commit what are referred to as "white-collar crimes," i.e., economic crimes that do not involve the use of threats and physical violence. Aggressive psychopaths, on the other hand, commit serious crimes; especially those who are characterized by sexual sadism can commit serial murders of a sexual nature and, at the basis of their crimes, there seems to be the need for continuous stimulation provided by sexual arousal. The two main traits that distinguish psychopathic behavior are the inability to feel a normal degree of empathy and affection toward other people and the repeated implementation of antisocial behaviors.

A further classification of psychopathy is that of primary and secondary. The first one is characterized by self-overestimation, the tendency to use violence as a tool or means to reach a goal, pathological lying, superficial charm, lack of emotions, low levels of empathy and remorse, manipulative attitudes, low levels of stress or anxiety. Primary psychopathy does not necessarily involve the commission of crimes. Secondary psychopathy is more related to crime and deviance, with tendencies toward impulsivity and delinquency. This type does not necessarily refer to an emotional or empathic deficit, unlike primary psychopathy. Thus, the subject could develop empathy or an attachment toward someone, but morality, irresponsibility, and violence are distinctive elements in relating to others. In this case, we are faced with subjects with marked impulsiveness and a tendency to violence, linked to the aggression or anger of the subject.

According to Caretti and Craparo (2010), psychopathy is a deviant developmental disorder, characterized by a condition of instinctual aggression and the inability to have a mutual relationship. In this disorder, the emotional and behavioral elements are emptied of human feeling. The psychopathic personality includes four areas (Glenn et al., 2009): (a) interpersonal area (manipulation, pathological lying, high self-esteem); (b) affective area (absence of remorse, numbness, lack of empathy); (c) lifestyle area (search for strong feelings, impulsiveness, selfishness); and (d) antisocial area (poor behavioral control, delinquency, and violence). The element that characterizes the psychopathic personality seems to be the low level of empathy that results in the inability to identify with others and in the almost total indifference to the harmful consequences of one's violent or criminal actions (Lavazza and Sammicheli, 2012). This is a condition that tends to persist for the whole lifespan. These characteristics are revealed from the early years of childhood and manifest themselves in both genders, although males seem to be more prone to aggressive attitudes. One of the most accredited theories about psychopathy and its relationship with empathy is that this disorder derives from an empathic deficit and dysfunction of the responses of sensitivity and social identification. These characteristics can lead to violent and aggressive attitudes (Harris et al., 2001). Although the use of violence and impulsivity appears to be a prerogative of psychopathy, as shown by several media cases such as those of Ted Bundy, John Wayne Gacy, and Dennis Rader, many of them are organized, have "cold blood" in social relations, have a high capacity of decision-making, and are not violent or impulsive. Thus, some psychopaths could show ability in planning and organizing a crime (Lilienfeld and Arkowitz, 2007).

Robert Hare (1991) studied and classified the concept of psychopathy, stating that psychopathy has a hereditary predisposition (Hare, 1999). In order to scientifically evaluate the disorder, Hare structured a questionnaire called the Psychopathy Checklist-Revised (PCL-R) (Hare, 2003). PCL-R provides a reliable assessment of the psychopathy construct in a wide range of settings and for clinical and research purposes, but its elective application is in the assessment of psychopathy in criminals and forensic psychiatric patients. The tool is administered mainly by psychologists and psychiatrists, but its results are also used by all professionals working in the judicial, penitentiary, and forensic fields who find themselves evaluating and comparing psychiatric expertise in the field of criminal proceedings. The PCL-R consists of 20 items to which a score (0, 1, 2) must be attributed after the file review and the interview. The items are divided into 4 components which converge into 2 factors: Factor 1. Interpersonal / Affective: Describes the interpersonal and affective traits of social interaction, investigating the selfish, callous and remorseless use of others. It is divided into Interpersonal (Component 1) and Affective (Component 2); Factor 2. Social deviance: investigates the unstable and antisocial lifestyle, mainly regarding aspects of impulsiveness, irresponsibility, lack of scruples, and measures aspects related

to criminal behavior. It is divided into the Lifestyle components (Component 3) and Antisocial (Component 4). By administering the questionnaire to the US prison population, researchers found that an elevate percentage of prisoners reached or exceeded the threshold level for the diagnosis of psychopathy (Ibidem; Lavazza and Sammicheli, 2012). These results were confirmed by further studies which showed how psychopathy is widespread especially among the prison population (Coid et al., 2009; León-Mayer et al., 2015).

Psychopathy, Empathy, and Neuroscience

Many studies have collected data with the aim of investigating the link between psychopathy, neuroscience, and empathy.

Gregory et al. (2012) investigated differences in structural gray matter by comparing a group of violent offenders with antisocial disorder and psychopathy, violent offenders with antisocial disorder, and healthy non-offenders. Gray matter has a role in empathic processing, moral judgment, and prosocial behaviors. Results from structural magnetic resonance imaging and volumetric voxel-based morphometry showed that the first and the second group have a reduced gray matter volume in both the anterior rostral prefrontal cortex (Brodmann area 10), important in higher cognitive functions, such as memory, judgment, or problem solving (Burgess et al., 2007), and in temporal poles (Brodmann area 20/38), which are involved in linguistic processes, language comprehension, and production (Ardila et al., 2014). This evidence confirmed that there are brain differences between violent offenders with and without psychopathy and healthy non-offenders.

Fazel and Danesh conducted a study in 2002 showing that 47% of the male population in prison and 21% of the female population suffer from antisocial personality disorders. Following these statistics, about 25% of inmates fall within the psychopathic diagnostic criteria (Lilienfeld and Arkowitz, 2007). In a survey of British inmates, it was found that 7.7% of men and 1.9% of women suffered from psychopathy (Coid et al., 2009). Murders are the most frequent crime found in psychopaths (93.3%), both in "cold blood" and premeditated. The percentage drops significantly for non-psychopaths (48.4%), who are more likely to commit a homicide for a passional reason (Woodworth and Porter, 2002). Indeed, psychopaths mostly use instrumental violence, rather than reactive violence, diffused among other offenders. The main difference is that instrumental violence, also defined as proactive and predatory violence, is purpose-driven, controlled, and cognitively mediated, while reactive violence is emotion-mediated and could derive from a provocation or uncontrolled rage. Individuals who use instrumental violence are less likely to be involved in the criminal justice system thanks to their capacity to methodically plan and organize crimes. On the contrary, individuals who use reactive violence have more difficulties in hiding their crimes, because they react following an impulse (Chase et al., 2001; Woodworth and Porter, 2002).

The model proposed by Hare seems to apply only to forensic populations (Debowska et al., 2017) for the inclusion of antisocial conduct. However, psychopathy can lead to both criminal and non-criminal paths. For instance, a higher percentage of psychopathic traits were found in a corporate sample (Babiak et al., 2010; Hassall et al., 2015). Also, the most appreciated presidential performances in U.S. were those carried out by presidents with high psychopathic traits (Lilienfeld et al., 2012). Thus, according to Boduszek and Debowska (2016), criminality and violence just partially represent psychopathy. They established a different model for psychopathy, the Psychopathic Personality Traits Model (PPTM). They (Boduszek et al., 2017) considered psychopaths as individuals who have low affective responsiveness and empathy. These characteristics lead to callous traits and difficulty in response to others' emotions, low cognitive responsiveness, cognitive empathy and mentalization ability, high interpersonal manipulation and sense of grandiosity, and egocentricity. The authors identify two elements that most characterize psychopathy, self-love, self-centeredness, and cognition. Indeed, even if psychopaths present difficulties in both affective and cognitive empathy, a recent study on justice-involved psychopaths individuals demonstrated that they understand the cognition and beliefs of others and have a deficit in processing the affective state and emotional words (Intrator et al., 1997; Shamay-Tsoory et al., 2010). These findings need to be interpreted also considering the intelligence quotient (IQ), which could moderate the relationship between psychopathy and emotional responding. Individuals with high traits of psychopathy and higher IQ are more likely to correctly adapt their social response desirably. The cognitive empathy and responsiveness in this case can be a contingent feature of psychopathy or derive from the level of IQ (Boduszek et al., 2017).

In their study, Boduszek et al. (2017) found that psychopathy should be evaluated in a continuum across its main components. The behavior and the tendency to commit a specific crime change based on the level of psychopathy. According to this definition, they identified different groups: low psychopathy, moderate affective/cognitive responsiveness, high interpersonal manipulation, moderate psychopathy, and high psychopathy group. For instance, individuals with high interpersonal manipulation and egocentricity and low affective and cognitive responsiveness are more likely to commit property offenses and white-collar crime than the low psychopathy group. The high psychopathy group represents only 7.1% of the prison population, showing results in contrast with most theorizations on psychopathy, and dispelling the myth that inmates are mostly psychopaths.

Another author who contributed to defining the relationship between empathy, violence, and psychopathy is Simon Baron-Cohen. In "The Science of Evil" (2011), he developed some fundamental assumptions on the relationship between empathy, neuroscience, and violence, specifically psychopathy. Using the neurobiological concept of empathy, Simon Baron-Cohen theorized the possibility of tracing actions traditionally defined as "evil" to an empathic defect. He pointed out that empathy should not be treated as a binary variable–that is, following the criterion of presence/absence–but through a spectrum of increasing degrees. Baron-Cohen theorized seven levels (0 to 6). In this regard, a test on the Empathy Quotient (EQ) was

developed by the scientist's research group for adults and even children (through a specially modified version). The author defined psychopathic disorder as a "zero-negative" disorder, corresponding to grade 0 on the theorized empathy scale, involving a tendency to paying constant attention to oneself, incapacity in understanding others' behavior and emotions, and a consequent negligent or aggressive act. Thus, a zero-negative degree of empathy determines a potential to harm others due to a substantial inability to understand the real consequences of one's actions. In line with recent literature, Baron-Cohen assumed that the level of empathy is attributable to the "Empathic Circuit." Relying on modern fMRI techniques, he found that it was possible to have a clear idea of the brain areas involved in empathic behavior. Baron-Cohen identified areas involved in recognition and processing of others' emotions and adequate responses, such as the inferior parietal lobule and furrow (both, significantly, areas included in the system of mirror neurons), the middle cingulate cortex (MCC), AI, middle prefrontal cortex, the frontal orbital cortex (OFC), tempo parietal junction (TPJ), the superior temporal sulcus (STS) and the amygdala. As previously documented in the introduction, these brain areas are not to be considered as part of some sort of linear chain, but as a brain network having multiple connections. The author highlighted that the correct functioning of this circuit is substantially responsible for the empathy. In accordance with this, it is the connection between regions of the brain that lead to violence, not the single regions themselves (Hirschtritt et al., 2018).

Other neurological and neuroscientific studies underline the importance of those areas in the empathic process. De Oliveira-Souza et al. (2008) found a reduced volume of gray matter in specific areas identified as the "moral brain," involved in moral decisions. These regions are the medial prefrontal cortex, the superior temporal sulcus, and the anterior temporal cortex. Blair et al. (2005) hypothesized that psychopathy might be generated by an early-onset amygdala dysfunction that compromises the processing of negative affect and therefore moral socialization. Individuals with this dysfunction would not be able to associate moral transgression with people's suffering or to correctly judge fear-evoking statements (Marsh and Cardinale, 2014). Blair et al. (2005) also underline the role of the orbitofrontal and ventrolateral cortex in the selection of responses and self-control.

Kiehl (2006) proposes a complementary hypothesis that shifts attention to the "emotional brain." According to the author, psychopathy derives from a disorder of the paralimbic system that causes an anatomical reduction and a lower level of activation in emotional learning and decision-making. This system includes the septum, the amygdala, the subcortical areas (involved in the regulation of emotional responses), the hippocampal areas (related to memory), and the cortical areas (involved in social interactions). The same author also conducted a study with fMRI (Kiehl et al., 2001) focused on the emotional deficit. They found reduced activity in the brain areas important in the acquisition of emotional responses–the amygdala, the anterior and ventral dorsal cingulate cortex, the posterior cingulate, and the ventral striatum–when psychopaths were placed in front of images or words with an emotional impact.

The latest line of the investigation was reported by Malatesti and McMillan (2010) and is linked to the "social brain." Specifically, regarding the processing of facial expressions, the authors noted that psychopaths have reduced activity in the fusiform gyrus when they observe facial expressions that express fear (Deeley et al., 2006), sadness, and happiness (Blair et al., 2001; Dolan and Fullam, 2006; Hastings et al., 2008; Dadds et al., 2009).

The research presented shows that that psychopathy is a complex construct that is yet to be defined.

DYSFUNCTIONAL VIOLENT BRAIN

Our brain allows us to speak, move, and feel emotions. According to recent neuroscientific theories, it could therefore also influence any violent behavior. Raine (2013) elaborated on this possible connection in a study involving forty-one violent crime prisoners in California. Equipped with an escort, handcuffs, and chains, the detainees were subjected to a CT scan. Their brains were also examined with positron emission tomography (PET) scans, allowing the examination of the metabolic activity of major brain regions, such as the prefrontal cortex.

The Continuous Performance Test (Rosvold et al., 1956) was also used to activate this area. The test consisted of pressing a button every time the image of an "O" was projected on a computer for 32 min, without interruptions. For this task, it was essential to maintain high concentration over a long period. After this test, the participants underwent PET, which measured the glucose levels reached during the previous experiment. An increase in glucose metabolism in the PFC corresponded to higher activation during the task. From the analysis of the control group, which involved forty-one men of the same age, it was revealed that in the experimental group, there was a lack of activation in the prefrontal cortex. Furthermore, the experimental group also showed a reduction in prefrontal glucose metabolism compared to the control group. Therefore, it seems that the activation of the prefrontal cortex plays an important role in the violent behavior of an individual (Raine, 2013).

The prefrontal cortex acts on violent behavior based on five different levels:

(1) On an emotional level, a malfunction of this region of the brain could compromise the management of control over the most primitive parts such as the limbic system, which generates primary and instinctive emotions like anger. On the contrary, the evolved prefrontal cortex can manage these primitive emotions which will not result in violent action.
(2) At the behavioral level, however, damage to the prefrontal cortex can cause greater impulsiveness, lower perception of risk, and a failure to comply with the rules. These characteristics are widespread among people convicted of violent crimes.
(3) At a personological level, damage of the prefrontal cortex could lead to variations in an individual's personality. For instance, the famous case study subject Phineas Gage (O'Driscoll and Leach, 1998) had a serious accident in

which the prefrontal cortex suffered enormous damage and completely changed his behavior. From a meek and rational man, he became impulsive and violent.

(4) On a social level, damage to the prefrontal cortex can cause an inability to relate to others. One example is the poor social and life skills possessed by some people convicted of violent crimes. Many of them manage stress and anger solely through violent action or aggressive acting-out, not showing problem-solving and decision-making skills.

(5) Finally, on a cognitive level, the prefrontal cortex regulates intellectual flexibility. In fact, by analyzing the school careers of many people convicted of violent crime, it is possible to deduce various intellectual difficulties that often result in violent actions and anger.

Raine (2013) analyzed two examples of the prefrontal cortex's role in violent behavior. The first one is the story of Antonio Bustamante, a man with a strong bond with his family and who, during a home robbery, killed an elderly a man with his fists, showing a disorganized and chaotic *modus operandi*. At the age of twenty, Bustamante suffered head trauma with a crowbar that caused a change in his personality. Bustamante had transformed from a staid and calm individual to an impulsive and emotionally unstable person. A CT scan showed dysfunction of his prefrontal cortex. After his head trauma, Bustamante was no longer able to have self-control and began to use drugs and commit crimes. Bustamante, together with the damage to the prefrontal cortex – deputy to the decision-making process, behavioral and impulse control, mentalization, and social interactions – also, had injuries to the orbitofrontal cortex, a region associated with automatic discrimination of a stimulus, processing of emotional signals, and affective empathy. These lesions affected his behavioral and emotional control skills: he became more impulsive and unable to reflect on his decisions. This change was also evident in his criminal behavior. Indeed, Bustamante committed an impulsive, unplanned, and disorganized crime, showing reactive violence, a poor capacity to plan and to reflect on the process and the consequences. In fact, Bustamante did not try to erase his tracks and at the time of the arrest, he still had bloodstained clothes on.

The second case is the story of Randy Kraft, a serial killer who killed sixty-four people in 12 years without ever getting arrested. Kraft planned the murders extensively, measuring his actions, predicting, considering alternative plans, and maintaining very high concentration to perform complex tasks. Randy Kraft could represent a psychopath serial killer with high capacity in planning and organization, who commits the so-called "cold blood crimes" (Woodworth and Porter, 2002). Kraft used instrumental violence, purposeful and predatory. His prefrontal cortex was hyper-activated, showing the key role of this region in his capacity to manage social behavior, reduce impulsivity, devise a plan not to get arrested and adapt his conduct according to the context, as shown by studies which demonstrate the role of PFC in impulse and behavioral control, decision-making process and planning (Miller and Cohen, 2001; Spinella, 2004; Palijan et al., 2010; Soyoun and Daeyeol, 2011; Boduszek et al., 2017).

Our brains develop and change in relation and response to the environment, family, and experiences in life, so it is always essential to contextualize the crime and humanize the people in question as well through a deeper analysis which considers social, educational values and environmental and family factors.

AIMS AND PROCEDURE

We conducted a review of the literature on and related to empathy, neuroscience, and violent crimes. Electronic databases utilized included: Columbia Libraries Online Catalog, Scopus, PubMed. This review aims to examine the current knowledge on the relationship between empathy, neurological substrates, violent crime, and psychopathy. Specifically, we extended our research of the literature to a less investigated target (woman and youths), often overlooked as they are less likely to commit violent crimes.

We utilized the following search terms: "empathy," "neuroscience," "violent," "psychopath*," "crim*," "offend*," "female," "child*," "juvenile," and "male." Of the articles returned from the search, eight were retained for the current review after screening their titles and abstracts, as reported in **Table 1**. The inclusion criteria were as follows: (1) articles on empathy or psychopathy, neuroscience, and violent crimes; (2) articles focused on a currently incarcerated population (male, female, adults, and juveniles); (3) original articles written in English; and (4) articles published in peer-reviewed journals between 2017 and 2021.

Articles published in a language other than English, duplicate articles and articles published before 2017 were excluded from the review.

PRINCIPAL FINDINGS

The selected studies analyzed the connection between psychopathic or callous-unemotional (CU) traits and brain abnormalities in people convicted of violent crimes. However, these studies are heterogeneous by sample and research methodology with implications for the generalizability of the results.

A study conducted in 2017 (Aghajani et al., 2017) probed the intrinsic functional connectivity of amygdala networks across a healthy control group and two groups of male juveniles (15–19 years old) clinically diagnosed as conduct-disordered (CD) and convicted of a violent crime: those with CU traits (CD/CU+) and those without CU traits (CD/CU-). Aiming to understand how subregional amygdala connectivity might contribute to callous-unemotionality in conduct-disordered youth, Aghajani et al. (2017) focused on the basolateral amygdala (BLA) and centromedial amygdala (CMA) complexes. The BLA is heavily involved in integrating affective value for incoming emotionally salient stimuli (Sah et al., 2003), while the CMA serves as the primary site for efferent signals from the amygdala, directing physiological and behavioral responses to emotional stimuli (LeDoux, 2007).

Upon collecting magnetic resonance imaging (MRI) data and analyzing functional connectivity for the three groups

TABLE 1 | Authors, year of publication, subjects, and methods of articles selected for the review.

Authors and year of publication	Population of focus	Method/target
Aghajani et al., 2017	Severely antisocial, conduct-disordered male juvenile offenders convicted of violent crimes	MRI for intrinsic functional connectivity analysis of amygdala
Keune et al., 2017	Adult incarcerated males convicted of violent crime in German high security prison	Resting-state EEG recording of frontal cortex
Sajous-Turner et al., 2019	Adult male participants from prisons in New Mexico and Wisconsin (homicide, violent non-homicide, non-violent)	MRI for voxel based morphometric analysis of gray matter
Hofhansel et al., 2020	Adult incarcerated males convicted of violent crime in German high security prison	MRI for voxel based morphometric analysis of gray matter
Vermeij et al., 2018	Adult males placed in Pieter Baan Center (Netherlands) for forensic psychiatric evaluation	Diffusion-weighted MRI of white matter
Raine, 2018	Juveniles and adults with antisocial, violent, and psychopathic behavior	Review: update of neuromoral theory of impairment to neural circuitry in antisocial behaviors
Calzada-Reyes et al., 2020	Adult males and females with psychopathy, incarcerated in Cuba for violent criminal acts	Quantitative EEG, low-resolution electromagnetic tomography (LORETA) to assess electrophysiological sex-influenced differences

of juveniles, the researchers found that CD/CU+ youths had increased right BLA connectivity and decreased left CMA connectivity, including the vmPFC. Additionally, they found that CD/CU+ youth had lower mean bihemispheric amygdalar volumes relative to healthy controls due to hypotrophy of BLA and CMA subregions. These findings show that CD youth with CU traits and convicted of violent crimes have abnormal amygdalar connectivity and volumes in areas consistently implicated in psychopathy.

In another study conducted with adult males in a high security prison convicted of violent offences (Keune et al., 2017), the researchers utilized EEG to measure alpha wave asymmetry, a phenotypic indicator of approach vs. withdrawal behavior patterns, in the frontal cortex (Harmon-Jones et al., 2010). The approach-withdrawal model has linked anger and aggression to an approach pattern and higher relative anterior cortical activity in the left hemisphere (Peterson et al., 2008). Therefore, the researchers hypothesized that CU traits would be associated with approach-related patterns connected to aggression. However, they ended up finding that CU traits were associated with stronger relative anterior cortical activity in the right hemisphere (i.e., withdrawal-related patterns) for the males convicted of violent crimes. This suggests that callousness may be related to withdrawal despite its connection with aggressive and violent behavior.

Another study from 2019 (Sajous-Turner et al., 2019) reported findings on gray matter volume in three groups of adult incarcerated males: those who had committed homicide, those who had committed violent crimes but not homicide, and those who had committed minimally violent or non-violent crimes. MRI scans and subsequent statistical analysis revealed that males convicted of violent crimes had large deficits in the orbitofrontal/ventromedial prefrontal cortex, anterior temporal cortex, insula, medial prefrontal/anterior cingulate and precuneus/posterior cingulate cortex compared to males convicted of non-homicidal and minimally violent crimes. Because these regions have been notably implicated in empathy and general emotional processing (Decety, 2011), these findings provide insight into how abnormalities in regions for social cognition may distinguish the brains of those who commit homicide from those who commit other types of crimes.

A similar study (Hofhansel et al., 2020) focusing on gray matter volume was undertaken with adult incarcerated males convicted of at least one violent crime and a control group, aiming to elucidate specific brain morphology to both reactive aggression and psychopathy. MRI data revealed that increased PCL-R sum scores correlated with decreased gray matter volume in the superior prefrontal cortex, confirming the previous literature linking global psychopathy to reductions in prefrontal gray matter (Pujol et al., 2018). Going further, however, the researchers found that this correlation was primarily driven by the subscale of the PCL-R score related to antisocial behavior, particularly for gray matter reductions in the right superior frontal and left inferior parietal regions. Additionally, decreased gray matter volume in the right middle and superior temporal gyrus were correlated with both reactive aggression and antisocial behavior. With these findings, the researchers suggested that the volume of brain regions involved in ToM (i.e., the ability to understand the beliefs and intentions of others) are reduced in antisocial males convicted of a violent crime.

Vermeij et al. (2018) compared white matter variations in relation to psychopathic traits between incarcerated males with impulse control problems and incarcerated males without impulse control problems. Upon analysis of diffusion-weighted MRI data, interpersonal-affective traits (PCL-R Factor 1) were found to be inversely correlated with white matter integrity in the anterior and posterior temporal lobe and orbitofrontal area in impulsive males. More specifically, increased affective traits (PCL-R Facet 2) were associated with reductions in white matter integrity in the right temporal lobe. Importantly, these findings link disrupted neural connectivity with affective psychopathic deficits specifically in impulsive incarcerated males, refining the associations of brain morphologies to different facets of psychopathy.

In 2018, Raine probed the neuromoral theory of antisocial, violent, and psychopathic behavior. The author noted that the

existing model proposes an overlap in many of the brain regions and mechanisms involved in both antisocial or psychopathic behavior and moral decision-making. Raine verified and revised this model with new empirical findings from the literature. Overall, most individuals convicted of crimes are predicted by the model to have neuromoral impairment in the fronto-polar, medial prefrontal, anterior cingulate, insula, superior temporal gyrus, amygdala, and angular gyrus to some degree. Primary psychopathy is characterized by the core psychopathic features, while secondary psychopathy is characterized more by increased impulsivity and reactive aggression. The neuromoral model predicts that stronger neuromoral impairment is linked more to primary psychopathy and weaker neuromoral impairment is linked to the secondary psychopathy. Raine (Ibidem) showed that this distinction has large implications for violent crime. Indeed, stronger neuromoral impairment is connected to more proactive aggression that is described as predatory and more planned, while milder neuromoral impairment is connected to more reactive aggression that is linked to decreased emotional and impulse control.

There is little existing research that assesses the neurobiological correlates of empathy among psychopathic female or offenders for violent crime. A singular study incorporated females by investigating gender differences in electrophysiology in people with psychopathy and convicted of a violent crime (Calzada-Reyes et al., 2020). Resting EEG visual analyses revealed that both females and males had a high percentage of EEG abnormalities compared to normative database values. The researchers noted specific differences between psychopathic males and females in brain connections and regions that regulate emotion, decision making, and moral judgment. These regions include the bilateral frontal and centroparietal areas, parieto-occipital areas, and the basal ganglia. These findings show that there are similar frequencies of EEG abnormalities in psychopathic males and females, but that there are still significant differences between both groups that may prove beneficial when differentiating and screening the two.

DISCUSSION AND CONCLUSION

The analysis of the cited literature shows the role that empathy has, both on an emotional and cognitive level, (Saladino et al., 2020a) in violent and psychopathic behavior (Nascivera et al., 2019). Empathy aims to guide an individual's behaviors according to the understanding of others' emotional states. In recent years, psychologists and neuroscientists have studied the possible association between empathic deficit, neuroscience, violent crime, and psychopathic personality.

Hare (1991) and Baron-Cohen (2011) were two scientists who studied the construct of psychopathy. Hare classified this concept, structuring a questionnaire to evaluate it, the Psychopathy Checklist-Revised (PCL-R) (Hare, 2003). This questionnaire was used by the author and other researchers among the US prison population, where subsequent results reported a high level of psychopathy diagnosis among violent offenders (Ibidem; Coid et al., 2009; Lavazza and Sammicheli, 2012; León-Mayer et al., 2015).

Simon Baron-Cohen (2011) associated psychopathy with a low level of empathy, assuming that empathy is divided into seven grades and psychopaths are affected by an empathic defect and have zero grade of empathy because of it.

Neuroscientific evidence (Gallese and Goldman, 1998; Preston and de Waal, 2002) identified a core empathy network, which involve several areas of the brain, such as AI, the posterior-anterior, and the anterior medial cingulate cortex, involved in pain processing, perception of emotions, and interoceptive awareness (Kober et al., 2008; Craig, 2009; Duerden and Albanese, 2011; Lindquist et al., 2012); the vmPF, the superior temporal sulcus, the temporoparietal junction, and the posterior cingulate cortex, associated with ToM and mentalization ability; the dorsolateral PFC and dorsomedial PFC, and the inferior parietal cortex, deputy to the perception-based condition of empathy (Danziger et al., 2009; Zaki et al., 2009). Furthermore, the affective empathy is regulated by the amygdala, hypothalamus, and orbitofrontal cortex for the affective arousal; while the cognitive empathy is associated with anterior insula, medial prefrontal cortex, and ventromedial prefrontal cortex for emotion awareness, and OFC, mPFC, and dorsolateral prefrontal cortex for emotion regulation, control of emotion and motivation.

Other studies found a reduction of gray matter in the so-called "moral brain" that can lead to immoral decisions (De Oliveira-Souza et al., 2008); an emotional deficit in the "emotional brain," involved in the management of emotions (Kiehl et al., 2001; Kiehl, 2006); and a social deficit in the "social brain" that can compromise facial expressions' processing (Malatesti and McMillan, 2010).

In his studies, Raine (2013) demonstrated and confirmed the role of the prefrontal cortex in violent and psychopathic behaviors. The author identified five levels of influence of the prefrontal cortex in violence: emotional, behavioral, personological, social level, and cognitive level. Also, the author described two different aggressive behaviors and attitudes that characterized different offenders. He showed two examples of the prefrontal cortex's activation in two violent killers. The first one, Antonio Bustamante, disorganized and impulsive, committed homicide during a robbery; the second, Randy Kraft, always planning and organizing actions, committed sixty-four murders. From the CT scan, Bustamante showed dysfunction of the prefrontal cortex related to a head trauma caused by an accident during his youth. On the contrary, Kraft presented with a hyper-activation of the prefrontal cortex. These results explained Bustamante's impulsiveness and poor self-control and Kraft's organization and meticulousness. Indeed, the damage to both PFC and OFC affected Bustamante's capacity of decision-making and self-control. Bustamante acted using reactive aggression without mentalization of his actions and the related consequences, showing a deficit in affective empathy. Damage of the PFC is known to be associated with an increased impulsivity and a decreased decision-making (Miller and Cohen, 2001; Spinella, 2004; Palijan et al., 2010; Soyoun and Daeyeol, 2011; Boduszek et al., 2017). On the other hand, Randy Kraft

had a hyperactivation of PFC which allowed him to plan his murders for years. He represents a psychopath who act cold blood crimes, using instrumental violence. In this case, the role of PFC was related to the management of social behavior, the reduction of impulsivity, and the adaptability to the context. The two reported cases represent two opposite ways of acting criminal behavior and highlight the role of the PFC in violent actions. Moreover, as reported by Boduszek et al. (2017), the investigation of the IQ related to empathy, psychopathy, and violent crimes is needed. Indeed, according to the authors, IQ can moderate the relations between psychopathy and the ability to emotionally respond. Future research could focus on this connection to better understand the role of IQ in empathy and psychopathy.

Furthermore, several studies have focused on lesions and damage of brain areas involved in the core network of empathy, while less is known about the hyperactivation and the higher functioning of some areas, as PFC, OFC, or NAcc in subjects with psychopathic traits or violent offenders.

The reviewed literature converges on the fact that psychopathy, the lack of empathy, and violent crime relate to abnormalities in brain morphology, connectivity, or activity. However, the targets and methods used in each study were varied. Of the seven empirical studies reviewed, two (Sajous-Turner et al., 2019; Hofhansel et al., 2020) used the same method: MRI for voxel based morphometric analysis of gray matter volume. Both studies confirm that adult males convicted of violent crimes had gray matter reductions in the prefrontal cortex and temporal gyrus, areas consistently implicated in emotional control, antisocial behavior, and reactive aggression. Two other studies also utilized the same method: EEG (Keune et al., 2017; Calzada-Reyes et al., 2020). However, Keune et al. (2017) focused on alpha wave asymmetry to probe approach vs. withdrawal behavior, while Calzada-Reyes et al. (2020) focused on beta activity to analyze differences between psychopathic females and males in terms of excitability or arousal.

The other three studies chose different methods of evaluation. Vermeij et al. (2018) measured connectivity via diffusion tensor imaging of white matter tracts across the whole brain, Aghajani et al. (2017) measured connectivity via MRI in the amygdala specifically. Jones et al. (2018) utilized fMRI to investigate neural correlates of empathy.

In most of the studies, the same brain regions are consistently implicated in relation to CU traits, aggression, or psychopathy: the prefrontal cortex, amygdala, and temporal cortex. As discussed before, the PFC has a key role in emotional and behavioral control, especially over the limbic system, which is related with primary emotions like anger and fear. The PFC is also related to social behavior and adaption to different context. People who suffer from damage in this area can behave aggressively, show poor problem-solving and decision-making skills, or change personality. At the same time, people who have a high level of activation in this area can present some traits of primary psychopathy, such as manipulation, self-overestimation, instrumental violence, pathological lying, superficial charm, lack of emotions, low levels of empathy, and remorse. These subjects can conduct a normal life or commit crimes without being involved in the criminal justice system because they present a strong capacity to adapt their personality to others and social needs, protecting themselves from being noticed.

The amygdala is fundamental in affective empathy and emotional arousal (Hurlemann et al., 2010) and in the perception of external stimuli. Impulsive aggression could derive from an activation of motoric aggressive responses in absence of control by the OFC and the anterior cingulate cortex, which regulate the social behavior according to the reward and punishment expectations. These regions can repress aggressive behavior when individuals perceive negative consequences through the limbic regions, such as the amygdala and insula (Siever, 2008). Stimuli can become triggers for violent behavior due to a perceptive distortion in sensory processing centers. These distortions can derive from alcohol, substance use, or illness and psychopathologies, leading someone to perceive a stimulus as provocative or dangerous and to react aggressively. These stimuli are processed to higher levels from the prefrontal, temporal, and parietal cortices. Then, the processed information can be filtered according to the sociocultural values and experiences of the person (aspects related to the amygdala and limbic regions). Furthermore, there are psychopathologies that, together with negative experiences, can create the condition that leads someone to interpret stimuli as aggressive and respond with violence. For instance, fMRI studies demonstrated the influence of personality disorder and psychopathologies in the perception of external stimuli. Participants with borderline or antisocial personality disorder, characterized by a lack of impulse control and a tendency to be aggressive, perceived anger when evaluating emotional expressions of others (Best et al., 2002; Coccaro et al., 2007); on the other hand, people with anxiety disorder mostly identified fear in facial expressions.

The temporal cortex is involved in moral decisions (De Oliveira-Souza et al., 2008). Mostly, patients with tumors or epilepsy in temporal lobe or with temporal lesions report highly aggressive behavior (Tonkonogy and Geller, 1992; Ito et al., 2007). Moreover, structural alterations in the temporal cortex, together with the medial temporal cortex and hippocampus, are common among people with antisocial personality disorder (Raine et al., 2004).

The role of impairment in function or morphology of the cited regions is supported by converging evidence of the cited literature through different methods of evaluation.

The interplay between CU traits and proactive vs. reactive aggression needs to be further studied. According to the EEG data and the predictions of the neuromoral model (Keune et al., 2017; Raine, 2018), the consensus seems to be that callousness is related to more reactive aggression or withdrawal behavior. However, the implications for the degree of violence in crime committed are still unclear.

Despite several studies on gender difference in neuroanatomy and neuronal structure, as well as the USA National Institute of Mental Health's incorporation of gender as a variable of influence in neurological and psychiatric studies (National Institute of Mental Health, 2011; Zagni et al., 2016), little is known on the role that these differences could have in the association between empathy, violent crime, and psychopathy. Indeed, male populations, specifically offenders, receive greater attention than

females. Some of the main reasons are that men represent a large part of the prison population, are diagnosed psychopaths more than women, and females tend to be more empathic and emotionally sensitive than men (Edwards et al., 2019b; Calzada-Reyes et al., 2020). It is therefore more difficult to find a sample of female prisoners who have committed violent crimes and who can be compared with males. Although a few previous studies and reviews have focused on psychopathy among incarcerated females (Hornsveld et al., 2018; Edwards et al., 2019a; Thomson et al., 2019), they have not specifically probed the neurobiological correlates of psychopathy in relation to violent crimes. The lone study in this review that included females (Calzada-Reyes et al., 2020) is a step toward uncovering more knowledge about individual risk factors and significant trends based on subsets of the population. They reported that there are differences between psychopathic males and females in brain connections and regions, specifically bilateral frontal and centroparietal areas, parieto-occipital areas, and the basal ganglia, involved in emotion regulation, decision-making process, and moral judgment. However, there are similar frequencies of EEG abnormalities in both samples. By expanding the breadth of research in terms of gender and age, the generalizability of these results can be more readily evaluated.

Lastly, the need for interdisciplinary research on this complicated topic at the intersection of sociology and neuroscience is pressing. Social conditions influence the level of engagement in crime, the development of psychopathologies, or personality disorders related to crime. For instance, criminogenic or poor environments could increase exposure to drugs, violence, and dysfunctional behaviors, which, especially during childhood and adolescence, can develop in antisocial personality disorder, psychopathy, and other related issues (Saladino et al., 2020c). Additionally, the development of empathic abilities derives also from daily learning and from exposure to positive and prosocial environments (Lamm et al., 2011). The parent-children's attachment, the parenting and the communication style, and the family climate affect the level of emotional regulation, the processing of emotions, and the ability to understand and react to social stimuli (Saladino et al., 2020b). In fact, research in the field of developmental psychology and social psychology shows how neglect, violence, poor communication, and inadequate education can affect the socialization and development of the child (Hetherington, 1987; Massarwi and Khoury-Kassabri, 2017). As illustrated by the multifactorial theories on crime, it is not possible to give a univocal explanation for criminal behavior, but all the co-necessary factors must be evaluated. One of the main limits is certainly connected to the fragmentation of knowledge and the separation of the psychological, sociological, and neuroscientific side, which should instead collaborate to give a more effective and truthful vision of the criminogenic phenomenon and its neuro-sociological implications (Auriemma et al., 2020).

As Raine (2018) mentions in his review, one of the biggest weaknesses of the current neuromoral theory is its lack of incorporation of social circumstances. The heterogeneity of violent behavior and crimes exhibited by the incarcerated individuals studied makes it difficult to match and include a control community sample, as one study found (Sajous-Turner et al., 2019). Additionally, the studies reviewed cannot account for whether the setting in which their subjects are incarcerated influences the results that are attributed to psychopathy, callous-unemotional traits, and violent behavior (i.e., whether institutionalization causes violence and exacerbates psychopathic traits or vice versa).

By not accounting for policing and sentencing biases, the varying definitions of crime, and the complexities of the criminal legal system, neuroscientific research by itself cannot provide an accurate picture of violent crime, a multi-faceted issue that must consider the social world.

AUTHOR CONTRIBUTIONS

VS, HL, EZ, and VV conceptualized the contribution. VS, EZ, and HL wrote the manuscript. VV reviewed the manuscript. All authors approved the submission of the manuscript.

FUNDING

This research was published thanks to the contribute of the Institute for the Study of Psychotherapies, Rome, Italy; and the Department of Human, Social and Health Sciences of the University of Cassino and Southern Lazio, Cassino, Italy.

ACKNOWLEDGMENTS

The authors are grateful to the reviewers for improving and enrich the manuscript with their revisions.

REFERENCES

Adolphs, R., Damasio, H., Tranel, D., Cooper, G., and Damasio, A. R. (2000). A role for somatosensory cortices in the visual recognition of emotion as revealed by three-dimensional lesion mapping. *J. Neurosci.* 20, 2683–2690. doi: 10.1523/JNEUROSCI.20-07-02683.2000

Aghajani, M., Klapwijk, E. T., van der Wee, N. J., Veer, I. M., Rombouts, S. A. R. B., Boon, A. E., et al. (2017). Disorganized amygdala networks in conduct-disordered juvenile offenders with callous-unemotional traits. *Biol. Psychiatry* 82, 283–293. doi: 10.1016/j.biopsych.2016.05.017

Allman, J. M., Tetreault, N. A., Hakeem, A. Y., Manaye, K. F., Semendeferi, K., Erwin, J. M., et al. (2010). The von economo neurons in frontoinsular and anterior cingulate cortex in great apes and humans. *Brain Struct. Funct.* 214, 495–517. doi: 10.1007/s00429-010-0254-0

Amodio, D. M., and Frith, C. D. (2006). Meeting of minds: the medial frontal cortex and social cognition. *Nat. Rev. Neurosci.* 7, 268–277. doi: 10.1038/nrn1884

Ardila, A., Bernal, B., and Rosselli, M. (2014). The elusive role of the left temporal pole (BA38) in language: a preliminary meta-analytic connectivity study. *Int. J. Brain Sci.* 2014:946039. doi: 10.1155/2014/946039

Auriemma, V., Iorio, G., Roberti, G., and Morese, R. (2020). Cyberbullying and empathy in the age of hyperconnection: an interdisciplinary approach. *Front. Sociol.* 5:551881. doi: 10.3389/fsoc.2020.551881

Babiak, P., Neumann, C. S., and Hare, R. (2010). Corporate psychopathy: talking the walk. *Behav. Sci. Law* 28, 174–193. doi: 10.1002/bsl.925

Baron-Cohen, S. (2011). *The Science of Evil. On the Empathy and the Origins of Cruelty*. New York, NY: Basic Books.

Batson, C. D. (2009). "These things called empathy," in *The Social Neuroscience of Empathy*, eds J. Decety and W. Ickes (Cambridge, MA: MIT Press), 16–31.

Bernhardt, B. C., and Singer, T. (2012). The neural basis of empathy. *Annu. Rev. neurosci.* 35, 1–23. doi: 10.1146/annurev-neuro-062111-150536

Best, M., Williams, J. M., and Coccaro, E. F. (2002). Evidence for a dysfunctional prefrontal circuit in patients with an impulsive aggressive disorder. *Proc. Natl. Acad. Sci. U.S.A.* 99, 8448–8453. doi: 10.1073/pnas.112604099

Bird, G., Silani, G., Brindley, R., White, S., Frith, U., and Singer, T. (2010). Empathic brain responses in insula are modulated by levels of alexithymia but not autism. *Brain* 133, 1515–1525. doi: 10.1093/brain/awq060

Blair, R. J. R., Colledge, E., Murray, L., and Mitchell, D. G. V. (2001). A selective impairment in the processing of sad and fearful expressions in children with psychopathic tendencies. *J. Abnorm. Child psychol.* 29, 491–498. doi: 10.1023/A:1012225108281

Blair, R. J. R., Mitchell, D. G. V., and Blair, K. (2005). *The Psychopath: Emotion and the Brain*. Oxford: Blackwell.

Boduszek, D., and Debowska, A. (2016). Critical evaluation of psychopathy measurement (PCL-R and SRP-III/SF) and recommendations for future research. *J. Crim. Justice* 44, 1–12. doi: 10.1016/j.jcrimjus.2015.11.004

Boduszek, D., Debowska, A., and Willmott, D. (2017). "Psychopathic Personality Traits Model (PPTM): A new approach to defining psychopathy," in *Routledge International Handbook of Psychopathy and Crime*, ed. M. DeLisi (Milton Park: Routledge Taylor & Francis Group).

Bogerts, B., Schöne, M., and Breitschuh, S. (2018). Brain alterations potentially associated with aggression and terrorism. *CNS Spectr.* 23, 129–140. doi: 10.1017/S1092852917000463

Burgess, P. W., Gilbert, S. J., and Dumontheil, I. (2007). Function and localization within rostral prefrontal cortex (area 10). *Philos. Trans. R. Soc. Lond. Ser. B Biol. Sci.* 362, 887–899. doi: 10.1098/rstb.2007.2095

Calzada-Reyes, A., Alvarez-Amador, A., Galan-Garcia, L., and Valdes-Sosa, M. (2020). Sex differences in QEEG in psychopath offenders. *Clin. EEG Neurosci.* 51, 146–154. doi: 10.1177/1550059419872414

Caretti, V., and Craparo, G. (2010). La personalità psicopatica. *Sistemi Intelligenti* XXII, 229–240. doi: 10.1422/32622

Chase, K. A., O'Leary, K. D., and Heyman, R. E. (2001). Categorizing partner-violent men within the reactive-proactive typology model. *J. Consult. Clin. Psychol.* 69, 567–572. doi: 10.1037/0022-006X.69.3.567

Coccaro, E. F., McCloskey, M. S., Fitzgerald, D. A., and Phan, K. L. (2007). Amygdala and orbitofrontal reactivity to social threat in individuals with impulsive aggression. *Biol. Psychiatry* 62, 168–178. doi: 10.1016/j.biopsych.2006.08.024

Cohen, M. X., Axmacher, N., Lenartz, D., Elger, C. E., Sturm, V., and Schlaepfer, T. E. (2009). Good vibrations: cross-frequency coupling in the human nucleus accumbens during reward processing. *J. Cogn. Neurosci.* 21, 875–889. doi: 10.1162/jocn.2009.21062

Coid, J., Yang, M., Ullrich, S., Roberts, A., Moran, P., Bebbington, P., et al. (2009). Psychopathy among prisoners in England and Wales'. *Int. J. Law Psychiatry* 32, 134–141. doi: 10.1016/j.ijlp.2009.02.008

Cox, C. L., Uddin, L. Q., Di Martino, A., Castellanos, F. X., Milham, M. P., and Kelly, C. (2011). The balance between feeling and knowing: affective and cognitive empathy are reflected in the brain's intrinsic functional dynamics. *Soc. Cogn. Affect. Neurosci.* 7, 727–737. doi: 10.1093/scan/nsr051

Craig, A. D. B. (2009). How do you feel—now? The anterior insula and human awareness. *Nat. Rev. Neurosci.* 10, 59–70. doi: 10.1038/nrn2555

Dadds, M. R., Hawes, D. J., Frost, A. D., Vassallo, S., Bunn, P., Hunter, K., et al. (2009). Learning to 'talk the talk': the relationship of psychopathic traits to deficits in empathy across childhood. *J. Child Psychol. Psychiatry* 50, 599–606. doi: 10.1111/j.1469-7610.2008.02058.x

Danziger, N., Faillenot, I., and Peyron, R. (2009). Can we share a pain we never felt? Neural correlates of empathy in patients with congenital insensitivity to pain. *Neuron* 61, 203–212. doi: 10.1016/j.neuron.2008.11.023

De Oliveira-Souza, R., Hare, R. D., Bramati, I. E., Garrido, G. J., Azevedo, I. F., Tovar-Moll, F., et al. (2008). Psychopathy as a disorder of the moral brain: fronto-temporo-limbic grey matter reductions demonstrated by voxel-based morphometry. *Neuroimage* 40, 1202–1213. doi: 10.1016/j.neuroimage.2007.12.054

de Quervain, D. J. F., Fischbacher, U., Treyer, V., Schellhammer, M., Schnyder, U., Buck, A., et al. (2004). The neural basis of altruistic punishment. *Science* 305, 1254–1258. doi: 10.1126/science.1100735

Debowska, A., Boduszek, D., Dhingra, K., Willmott, D., Sherretts, N., and DeLisi, M. (2017). Can we use Hare's psychopathy model within forensic and non-forensic populations? An empirical investigation. *Deviant Behav.* 39, 224–242. doi: 10.1080/01639625.2016.1266887

Decety, J. (2005). "Perspective taking as the royal avenue to empathy," in *Other Minds: How Humans Bridge the Divide Between Self and Others*, eds B. F. Malle and S. D. Hodges (New York, NY: Guilford Press), 135–149.

Decety, J. (2007). "A social cognitive neuroscience model of human empathy," in *Social Neuroscience: Integrating Biological and Psychological Explanations of Social Behavior*, eds E. Harmon-Jones and P. Winkielman (New York, NY: Guilford Press), 246–270.

Decety, J. (2011). Dissecting the neural mechanisms mediating empathy. *Emot. Rev.* 3, 92–108. doi: 10.1177/1754073910374662

Decety, J., and Jackson, P. L. (2004). The functional architecture of human empathy. *Behav. Cogn. Neurosci. Rev.* 3, 71–100.

Decety, J., and Meyer, M. (2008). From emotion resonance to empathic understanding: a social developmental neuroscience account. *Dev. Psychopathol.* 20, 1053–1080. doi: 10.1017/S0954579408000503

Deeley, Q., Daly, E., Surguladze, S., Tunstall, N., Mezey, G., Beer, D., et al. (2006). Facial emotion processing in criminal psychopathy. Preliminary functional magnetic resonance imaging study. *Br. J. Psychiatry* 189, 533–539. doi: 10.1192/bjp.bp.106.021410

Diamond, A. (2002). "Normal development of prefrontal cortex from birth to young adulthood: Cognitive functions, anatomy, and biochemistry," in *Principles of Frontal Lobe Function*, eds D. T. Stuss and R. T. Knight (New York, NY: Oxford University Press), 446–503. doi: 10.1093/acprof:oso/9780195134971.003.0029

Dolan, M., and Fullam, R. (2006). Face affect recognition deficits in personality-disordered offenders: association with psychopathy. *Psychol. Med.* 36, 1563–1569. doi: 10.1017/S0033291706008634

Dondi, M., Simion, F., and Caltran, G. (1999). Can newborns discriminate between their own cry and the cry of another newborn infant? *Dev. Psychol.* 35, 418–426. doi: 10.1037//0012-1649.35.2.418

Duerden, E. G., and Albanese, M. C. (2011). Localization of pain-related brain activation: a meta-analysis of neuroimaging data. *Hum. Brain Mapp.* 34, 109–149. doi: 10.1002/hbm.21416

Edwards, B. G., Carre, J. R., and Kiehl, K. A. (2019a). A review of psychopathy and Cluster B personality traits and their neural correlates in female offenders. *Biol. Psychol.* 148:107740. doi: 10.1016/j.biopsycho.2019.107740

Edwards, B. G., Ermer, E., Salovey, P., and Kiehl, K. A. (2019b). Emotional intelligence in incarcerated female offenders with psychopathic traits. *J. Pers. Disord.* 33, 370–393. doi: 10.1521/pedi_2018_32_349

Fan, Y. T., Chen, C., Chen, S. C., Decety, J., and Cheng, Y. (2014). Empathic arousal and social understanding in individuals with autism: evidence from fMRI and ERP measurements. *Soc. Cogn. Affect. Neurosci.* 9, 1203–1213. doi: 10.1093/scan/nst101

Fazel, S., and Danesh, J. (2002). Serious mental disorder in 23000 prisoners: a systematic review of 62 surveys. *Lancet* 359, 545–550. doi: 10.1016/S0140-6736(02)07740-1

Fornari, U. (2012). *Delitti Folli, Delitti di Folli*. Torino: Espress Edizioni.

Frith, C. D., and Frith, U. (2006). The neural basis of mentalizing. *Neuron* 50, 531–534. doi: 10.1016/j.neuron.2006.05.001

Gallese, V., and Goldman, A. (1998). Mirror neurons and the simulation theory of mind-reading. *Trends Cogn. Sci.* 2, 493–501. doi: 10.1016/S1364-6613(98)01262-5

Glenn, A., Raine, A., and Schug, R. (2009). The neural correlates of moral decision-making in psychopathy. *Mol. Psychiatry* 14, 5–6. doi: 10.1038/mp.2008.104

Gregory, S., Ffytche, D., Simmons, A., Kumari, V., Howard, M., Hodgins, S., et al. (2012). The antisocial brain: psychopathy matters: a structural mri investigation of antisocial male violent offenders. *Arch. Gen. Psychiatry* 69, 962–972. doi: 10.1001/archgenpsychiatry.2012.222

Hamlin, J. K., Wynn, K., and Bloom, P. (2007). Social evaluation by preverbal infants. *Nature* 450, 557–560. doi: 10.1038/nature06288

Hare, R. (1999). *Without Conscience*. New York, NY: Guilford Press, 166–177.

Hare, R. D. (1991). *The Hare Psychopathy Checklist – Revised*. Toronto, ON: Multi-Health Systems.

Hare, R. D. (2003). *Manual for the Revised Psychopathy Checklist*, 2nd Edn. Toronto, ON: Multi-Health Systems.

Harmon-Jones, E., Gable, P. A., and Peterson, C. K. (2010). The role of asymmetric frontal cortical activity in emotion-related phenomena: a review and update. *Biol. Psychol.* 84, 451–462. doi: 10.1016/j.biopsycho.2009.08.010

Harris, G. T., Skilling, T., and Rice, M. (2001). The construct of psychopathy. *Crime Justice* 28, 197–264. doi: 10.1086/652211

Hassall, J., Boduszek, D., and Dhingra, K. (2015). Psychopathic traits of business and psychology students and their relationship to academic success. *Pers. Individ. Dif.* 82, 227–231. doi: 10.1016/j.paid.2015.03.017

Hastings, M. E., Tangney, J. P., and Stuewig, J. (2008). Psychopathy and identification of facial expressions of emotion. *Pers. Individ. Dif.* 44, 1474–1483. doi: 10.1016/j.paid.2008.01.004

Hetherington, E. M. (1987). "Family relations six years after divorce," in *Remarriage and Stepparenting: Current Research and Theory*, eds K. Pasley and M. Ihinger-Tallman (New York, NY: The Guilford Press), 185–205.

Hirschtritt, M. E., Carroll, J. D., and Ross, D. A. (2018). Using neuroscience to make sense of psychopathy. *Biol. Psychiatry* 84, 61–63. doi: 10.1016/j.biopsych.2018.08.012

Hofhansel, L., Weidler, C., Votinov, M., Clemens, B., Raine, A., and Habel, U. (2020). Morphology of the criminal brain: gray matter reductions are linked to antisocial behavior in offenders. *Brain Struct. Funct.* 225, 2017–2028. doi: 10.1007/s00429-020-02106-6

Hornsveld, R. H. J., Zwets, A. J., Leenaars, E. P. E. M., Kraaimaat, F. W., Bout, R., Lagro-Janssen, T. A. L. M., et al. (2018). Violent female offenders compared with violent male offenders on psychological determinants of aggressive behavior. *Int. J. Offender Ther. Comp. Criminol.* 62, 450–467. doi: 10.1177/0306624X16648109

Hurlemann, R., Patin, A., Onur, O. A., Cohen, M. X., Baumgartner, T., and Metzler, S. (2010). Oxytocin enhances amygdala-dependent, socially reinforced learning and emotional empathy in humans. *J. Neurosci.* 30, 4999–5007. doi: 10.1523/JNEUROSCI.5538-09.2010

Intrator, J., Hare, R., Stritzke, P., Brichtswein, K., Dorfman, D., Harpur, T., et al. (1997). A brain imaging (single photon emission computerized tomography) study of semantic and affective processing in psychopaths. *Biol. Psychiatry* 42, 96–103. doi: 10.1016/S0006-3223(96)00290-9

Ito, M., Okazaki, M., Takahashi, S., Muramatsu, R., Kato, M., and Onuma, T. (2007). Subacute postictal aggression in patients with epilepsy. *Epilepsy Behav.* 10, 611–614. doi: 10.1016/j.yebeh.2007.02.016

Jones, S., Cisler, J., Morais, H., and Bai, S. (2018). Exploring neural correlates of empathy in juveniles who have sexually offended. *Sex. Abuse* 30, 82–103. doi: 10.1177/1079063216630980

Keillor, J. M., Barrett, A. M., Crucian, G. P., Kortenkamp, S., and Heilman, K. M. (2002). Emotional experience and perception in the absence of facial feedback. *J. Int. Neuropsychol. Soc.* 8, 130–135.

Keune, P. M., Mayer, S. V., Jusyte, A., and Schonenberg, M. (2017). Frontal alpha asymmetry and callous-unemotional traits in imprisoned violent offenders: a pilot study. *Psychophysiology* 55:e12981. doi: 10.1111/psyp.12981

Kiehl, K. A. (2006). A cognitive neuroscience perspective on psychopathy: evidence for paralimbic system dysfunction. *Psychiatry Res.* 142, 107–128. doi: 10.1016/j.psychres.2005.09.013

Kiehl, K. A., Smith, A. M., Hare, R. D., Mendrek, A., Forster, B. B., Brink, J., et al. (2001). Limbic abnormalities in affective processing by criminal psychopaths as revealed by functional magnetic resonance imaging. *Biol. Psychiatry* 50, 677–684. doi: 10.1016/s0006-3223(01)01222-7

Kober, H., Barrett, L. F., Joseph, J., Bliss-Moreau, E., Lindquist, K., and Wager, T. D. (2008). Functional grouping and cortical–subcortical interactions in emotion: a meta-analysis of neuroimaging studies. *Neuroimage* 42, 998–1031. doi: 10.1016/j.neuroimage.2008.03.059

Kumari, V., Barkataki, I., Goswami, S., Flora, S., Das, M., and Taylor, P. (2009). Dysfunctional, but not functional, impulsivity is associated with a history of seriously violent behaviour and reduced orbitofrontal and hippocampal volumes in schizophrenia. *Psychiatry Res.* 173, 39–44. doi: 10.1016/j.pscychresns.2008.09.003

Lamm, C., Decety, J., and Singer, T. (2011). Meta-analytic evidence for common and distinct neural networks associated with directly experienced pain and empathy for pain. *Neuroimage* 54, 2492–2502. doi: 10.1016/j.neuroimage.2010.10.014

Lavazza, A., and Sammicheli, L. (2012). *Il Delitto del Cervello. La Mente tra Scienza e Diritto*. Torino: Codice Edizioni.

LeDoux, J. (2007). The amygdala. *Curr. Biol.* 17, 868–874. doi: 10.1016/j.cub.2007.08.005

León-Mayer, E., Folino, J. O., Neumann, C., and Hare, R. D. (2015). The construct of psychopathy in a Chilean prison population. *Braz. J. Psychiatry* 37, 191–196. doi: 10.1590/1516-4446-2014-1540

Lilienfeld, S. O., and Arkowitz, H. (2007). *What "Psychopath" Means. It is Not Quite What You May Think*. Available online at: https://www.scientificamerican.com/article/what-psychopath-means/ (accessed May 30, 2021)

Lilienfeld, S. O., Waldman, I. D., Landfield, K., Watts, A. L., Rubenzer, S., and Faschingbauer, T. R. (2012). Fearless dominance and the US presidency: implications of psychopathic personality traits for successful and unsuccessful political leadership. *J. Pers. Soc. Psychol.* 103, 489–505. doi: 10.1037/a0029392

Lindquist, K. A., Wager, T. D., Kober, H., Bliss-Moreau, E., and Barrett, L. F. (2012). The brain basis of emotion: a meta-analytic review. *Behav. Brain Sci.* 35, 121–202. doi: 10.1017/S0140525X11000446

Malatesti, L., and McMillan, J. (2010). "Defending PCL-R," in *Responsability and Psychopathy*, eds L. Malatesti and J. McMillan (Oxford: Oxford University Press), 79–91.

Marsh, A. A., and Cardinale, E. M. (2014). When psychopathy impairs moral judgments: neural responses during judgments about causing fear. *Soc. Cogn. Affect. Neurosci.* 9, 3–11. doi: 10.1093/scan/nss097

Massarwi, A. A., and Khoury-Kassabri, M. (2017). Serious physical violence among Arab-Palestinian adolescents: the role of exposure to neighborhood violence, perceived ethnic discrimination, normative beliefs, and, parental communication. *Child Abus. Negl.* 63, 233–244. doi: 10.1016/j.chiabu.2016.11.002

Miller, E. K., and Cohen, J. D. (2001). An integrative theory of prefrontal cortex function. *Annu. Rev. Neurosci.* 24, 167–202. doi: 10.1146/annurev.neuro.24.1.167

Molenberghs, P., Gapp, J., Wang, B., Louis, W. R., and Decety, J. (2016). Increased moral sensitivity for outgroup perpetrators harming ingroup members. *Cereb. Cortex* 26, 225–233. doi: 10.1093/cercor/bhu195

Molenberghs, P., and Louis, W. R. (2018). Insights from fMRI studies into ingroup bias. *Front. Psychol.* 9:868. doi: 10.3389/fpsyg.2018.01868

Nascivera, N., Annunziato, T., Messina, M., Di Leva, A., Letterese, M., and Alfano, Y. M. (2019). Il grado zero dell'empatia: capacità empatiche e correlate neurali nella psicopatia. *Phenom. J.* 1, 76–82. doi: 10.32069/pj.2019.1.49

Nathani, M., Jaleel, V., Turner, A., Dirvonas, C., Suryadevara, U., and Tandon, R. (2020). When you hear hoofbeats, think horses and zebras: the importance of a wide differential when it comes to frontotemporal lobar degeneration. *Asian J Psychiatr* 47:101875. doi: 10.1016/j.ajp.2019.101875

National Institute of Mental Health (2011). *Sex differences in brain, behavior, mental health and mental disorders*. Bethesda, MD: National Institute of Mental Health.

O'Driscoll, K., and Leach, J. P. (1998). "No longer Gage": an iron bar through the head. Early observations of personality change after injury to the prefrontal cortex. *BMJ* 317, 1673–1674. doi: 10.1136/bmj.317.7174.1673a

Palijan, T. Z., Radeljak, S., Kovač, M., and Kovačević, D. (2010). Relationship between comorbidity and violence risk assesment in forensic psychiatry–the implicaton of neuroimaging studies. *Psychiatr. Danub.* 22, 253–256.

Peterson, C. K., Shackman, A. J., and Harmon-Jones, E. (2008). The role of asymmetrical frontal cortical activity in aggression. *Psychophysiology* 45, 86–92. doi: 10.1111/j.1469-8986.2007.00597.x

Preston, S. D., and de Waal, F. B. M. (2002). Empathy: its ultimate and proximate bases. *Behav. Brain Sci.* 25, 1–72. doi: 10.1017/S0140525X02000018

Pujol, J., Harrison, B. J., Contreras-Rodriguez, O., and Cardoner, N. (2018). The contribution of brain imaging to the understanding of psychopathy. *Psychol. Med.* 49, 20–31. doi: 10.1017/S0033291718002507

Raine, A. (2013). *The anatomy of violence: The biological roots of crime*. New York, NY: Pantheon/Random House.

Raine, A. (2018). The neuromoral theory of antisocial, violent, and psychopathic behavior. *Psychiatry Res.* 27, 64–69. doi: 10.1016/j.psychres.2018.11.025

Raine, A., Ishikawa, S. S., Arce, E., Lencz, T., Knuth, K. H., Bihrle, S., et al. (2004). Hippocampal structural asymmetry in unsuccessful psychopaths. *Biol. Psychiatry* 55, 85–91. doi: 10.1016/s0006-3223(03)00727-3

Rosvold, H. E., Mirsky, A. F., Sarason, I., Bransome, E. D., and Beck, L. H. (1956). A continuous performance test of brain damage. *J. Consult. Psychol.* 20, 343–350. doi: 10.1037/h0043220

Sah, P., Faber, E. S., Lopez De Armentia, M., and Power, J. (2003). The amygdaloid complex: anatomy and physiology. *Physiol. Rev.* 83, 803–834. doi: 10.1152/physrev.00002.2003

Sajous-Turner, A., Anderson, N. E., Widdows, M., Nyalakanthi, P., Harenski, K., Harenski, C., et al. (2019). Aberrant brain gray matter in murderers. *Brain Imaging Behav.* 14, 2050–2061. doi: 10.1007/s11682-019-00155-y

Saladino, V., Algeri, D., and Auriemma, V. (2020a). The psychological and social impact of Covid-19: new perspectives of well-being. *Front. Psychol.* 11:577684. doi: 10.3389/fpsyg.2020.577684

Saladino, V., Hoelzlhammer, L., and Verrastro, V. (2020b). Criminality, substance abuse and problematic family relations in adolescence. *J. Addict. Med. Ther. Sci.* 6, 016–020. doi: 10.17352/2455-3484.000031

Saladino, V., Mosca, O., Lauriola, M., Hoelzlhammer, L., Cabras, C., and Verrastro, V. (2020c). is family structure associated with deviance propensity during adolescence? The role of family climate and anger dysregulation. *Int. J. Environ. Res. Public Health* 17:9257. doi: 10.3390/ijerph17249257

Saladino, V., Sabatino, A. C., Iannaccone, C., Pastorino, G. M. G., and Verrastro, V. (2020d). Filmmaking and video as therapeutic tools: case studies on autism spectrum disorder. *Arts Psychother.* 71:101714. doi: 10.1016/j.aip.2020.101714

Schiffer, B., Pawliczek, C., Müller, B. W., Wiltfang, J., Brüne, M., Forsting, M., et al. (2017). Neural mechanisms underlying affective theory of mind in violent antisocial personality disorder and/or schizophrenia. *Schizophr. Bull.* 43, 1229–1239. doi: 10.1093/schbul/sbx012

Shackman, A. J., Salomons, T. V., Slagter, H. A., Fox, A. S., Winter, J. J., and Davidson, R. J. (2011). The integration of negative affect, pain and cognitive control in the cingulate cortex. *Nat. Rev. Neurosci.* 12, 154–167. doi: 10.1038/nrn2994

Shamay-Tsoory, S. G., Aharon-Peretz, J., and Perry, D. (2009). Two systems for empathy: a double dissociation between emotional and cognitive empathy in inferior frontal gyrus versus ventromedial prefrontal lesions. *Brain* 132, 617–627. doi: 10.1093/brain/awn279

Shamay-Tsoory, S. G., Harari, H., Aharon-Peretz, J., and Levkovitz, Y. (2010). The role of the orbitofrontal cortex in affective theory of mind in criminal offenders with psychopathic tendencies. *Cortex* 46, 668–677. doi: 10.1016/j.cortex.2009.04.008

Shamay-Tsoory, S. G., Tomer, R., Berger, B. D., and Aharon-Peretz, J. (2003). Characterization of empathy deficits following prefrontal brain damage: the role of right ventromedial prefrontal cortex. *Cogn. Behav. Neurol.* 18, 55–67. doi: 10.1162/089892903321593063

Shamay-Tsoory, S. G., Tomer, R., Berger, B. D., Goldsher, D., and Aharon-Peretz, J. (2005). Impaired affective theory of mind is associated with right ventromedial prefrontal damage. *J. Cogn. Neurosci.* 15, 1–14. doi: 10.1097/01.wnn.0000152228.90129.99

Siever, L. J. (2008). Neurobiology of aggression and violence. *Am. J. psychiatry* 165, 429–442. doi: 10.1176/appi.ajp.2008.07111774

Silani, G., Bird, G., Brindley, R., Singer, T., Frith, C., and Frith, U. (2008). Levels of emotional awareness and autism: an fMRI study. *Soc. Neurosci.* 3, 97–112. doi: 10.1080/17470910701577020

Singer, T., and Lamm, C. (2009). The social neuroscience of empathy. *Ann. N. Y. Acad. Sci.* 1156, 81–96. doi: 10.1111/j.1749-6632.2009.04418.x

Skeem, J. L., Polaschek, D., Patrick, C. J., and Lilienfeld, S. O. (2011). Psychopathic personality: bridging the gap between scientific evidence and public policy. *Psychol. Sci. Public Interest* 12, 95–162. doi: 10.1177/1529100611426706

Snowden, J. S., Gibbons, Z. C., Blackshaw, A., Doubleday, E., Thompson, J., Craufurd, D., et al. (2003). Social cognition in frontotemporal dementia and Huntington's disease. *Neuropsychologia* 41, 688–701. doi: 10.1016/s0028-3932(02)00221-x

Soyoun, K., and Daeyeol, L. (2011). Prefrontal cortex and impulsive decision making. *Biol. Psychiatry* 69, 1140–1146. doi: 10.1016/j.biopsych.2010.07.005

Spinella, M. (2004). Neurobehavioral correlates of impulsivity: evidence of prefrontal involvement. *Int. J. Neurosci.* 114, 95–104. doi: 10.1080/00207450490249347

Stone, V. (2006). The moral dimensions of human social intelligence. *Philos. Explor.* 9, 55–68. doi: 10.1080/13869790500492516

Takahashi, H., Kato, M., Matsuura, M., Mobbs, D., Suhara, T., and Okubo, Y. (2009). When your gain is my pain and your pain is my gain: neural correlates of envy and schadenfreude. *Science* 323, 937–939. doi: 10.1126/science.1165604

Thomson, N. D., Vassileva, J., Kiehl, K. A., Reidy, D., Aboutanos, M., McDougle, R., et al. (2019). Which features of psychopathy and impulsivity matter most for prison violence? New evidence among female prisoners. *Int. J. Law Psychiatry* 64, 26–33. doi: 10.1016/j.ijlp.2019.01.001

Tonkonogy, J. M., and Geller, J. L. (1992). Hypothalamic lesions and intermittent explosive disorder. *J. Neuropsychiatry Clin. Neurosci.* 4, 45–50.

Vaish, A., Carpenter, M., and Tomasello, M. (2009). Sympathy through affective perspective-taking, and its relation to prosocial behavior in toddlers. *Dev. Psychol.* 45, 534–543. doi: 10.1037/a0014322

Vermeij, A., Kempes, M. M., Cima, M. J., Mars, R. B., and Brazil, I. A. (2018). Affective traits of psychopathy are linked to white-matter abnormalities in impulsive male offenders. *Neuropsychology* 32, 735–745. doi: 10.1037/neu0000448

Warneken, F., and Tomasello, M. (2009). The roots of human altruism. *Br. J. Psychol.* 100, 455–471. doi: 10.1348/000712608X379061

Woodworth, M., and Porter, S. (2002). In cold blood: characteristics of criminal homicides as a function of psychopathy. *J. Abnorm. Psychol.* 111, 436–445. doi: 10.1037/0021-843X.111.3.436

Zagni, E., Simoni, L., and Colombo, D. (2016). Sex and gender differences in central nervous system-related disorders. *Neurosci. J.* 2016:2827090. doi: 10.1155/2016/2827090

Zaki, J., Weber, J., Bolger, N., and Ochsner, K. (2009). The neural bases of empathic accuracy. *Proc. Natl. Acad. Sci. U.S.A.* 106, 11382–11387. doi: 10.1073/pnas.0902666106

Zelazo, P., Carlson, S., and Kesek, A. (2008). "The development of executive function in childhood," in *Handbook of developmental cognitive neuroscience*, eds C. A. Nelson and M. Luciana (Cambridge: MIT Press), 553–574.

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.

frontiers in Psychology

ORIGINAL RESEARCH
published: 12 August 2021
doi: 10.3389/fpsyg.2021.734147

Emotional Information in News Reporting on Audience Cognitive Processing in the Age of Posttruth: An Electroencephalogram and Functional Connectivity Approach

Ya Yang, Lichao Xiu and Guoming Yu**

Lab of Cognitive Neuroscience and Communication, School of Journalism and Communication, Beijing Normal University, Beijing, China

The purpose of the present study is to explore how the emotionalized expression of news content in the posttruth era affects the cognitive processing of the audiences. One news that was text-written with two different expression types (emotional expression vs. neutral expression) was adopted as an experiment material in the study, and changes in cortical activity during news reporting reading tasks were examined with electroencephalograms, sampled from nine sites and four channels and analyzed with weighted phase lag index (wPLI) based on brain functional connectivity (FC) method. The results show that emotional discourses caused a stronger cortical brain activity and more robust brain FC (beta oscillations); besides, reading emotionalized expression consumed more attention resources but fewer cognitive resources, which may impede further rational thinking of the audiences.

Keywords: emotion, posttruth, news reporting, EEGs, wPLI, functional connectivity

OPEN ACCESS

Edited by:
Vincenzo Auriemma, University of Salerno, Italy

Reviewed by:
Ester Miranda, Ordine Degli Psicologi Della Campania, Italy
Ivana Ferrara, Ordine Degli Psicologi Della Campania, Italy

****Correspondence:***
Ya Yang
yangya@bnu.edu.cn
Guoming Yu
yuguoming@126.com

Specialty section:
This article was submitted to Cognitive Science, a section of the journal Frontiers in Psychology

Received: *30 June 2021*
Accepted: *19 July 2021*
Published: *12 August 2021*

Citation:
Yang Y, Xiu L and Yu G (2021) Emotional Information in News Reporting on Audience Cognitive Processing in the Age of Posttruth: An Electroencephalogram and Functional Connectivity Approach. Front. Psychol. 12:734147. doi: 10.3389/fpsyg.2021.734147

INTRODUCTION

Posttruth, which was selected as the annual word by Oxford Dictionary in 2016, is defined as that emotion and personal belief that is more effective than objective facts in shaping public opinions (Scheufele and Krause, 2019). The narration of the posttruth, tracing to the description for political events, has been used to serve a particular political purpose manipulating truths and facts with the discourse. Previous studies have shown a commonly shared concern of scholars that the fundamental belief of truths and facts has gradually been faded away in the global scene (Laybats and Tredinnick, 2016; Oxford Dictionaries, 2016; Gewin et al., 2017; Rochlin, 2017).

Posttruth alludes to the recognition of the influence of other factors for the truth rather than a denial of truth. The concept of the posttruth has expanded from the political region to more extensive fields, and it is defined in the process of information receiving the reaction of audiences to all forms of truth (Keane and Wight, 2017). It is emphasized that the analysis of the posttruth should originate from more standpoints of the audiences, involving their individualized interpretation of information from different perspectives and their emotions, experiences, and feelings, which would interrupt their own cognition of the truth (Weeks, 2015). It could be seen that emotional expression is an essential feature of media information in the age of posttruth.

Currently, the critical role of emotions has been realized in studies such as cognitive neuroscience and communication (Meyer et al., 2014; Crilley, 2018), where a number of primary researches have explored the impact of emotionalized expression on the audiences under the context of new media. In particular, emotionalized information could affect the cognition of information of the audiences through emotional contagion, besides their judgment on the usefulness of the information with further influence of their follow-up communication behaviors (Ding et al., 2014; Kramer, 2014; Hong et al., 2016). However, self-report or computational online data analysis involved is more frequently used to measure how emotionalized information would affect the cognition and behavior of the individuals. It is often criticized for lacking accuracy or being too macroscopic, and so on the microlevel, the cognitive processing and emotional experience of the individuals could not be reflected in real time.

In cognitive neuroscience experiments, which could be considered as good open science practices, electroencephalography (EEG) measure has been widely applied, which comprehensively reflects through a record of neural activity in the cerebral cortex the cognitive mechanism of the individual in the information processing. The technology is harmless to humans, and the data recording is facilitated with higher time-resolution, leading to a distinct advantage in the implicit monitoring of real-time information processing of an individual. In the previous research, EEG technology has played an essential role in the emotional experience measurement of the individuals, especially when some subtle emotional stimuli could not be easily perceived subjectively, with different emotion statuses that could be reflected by the fluctuations of EEG signals (Kamarajan et al., 2004; Ohme et al., 2009, 2010; Vecchiato et al., 2011; Cartocci et al., 2016; Chen et al., 2017). By far, many studies to have proved a close relationship between the emotional experience of the individuals and their cognitive processes through EEG experiments.

Emotional cognitive processing, additionally, involves the coordination of multiple brain regions; thus, it is necessary to investigate the functional connectivity (FC) between different EEG channels. FC analysis enables the description of cognitive processes within the human brain to support further stage distinctions of brain activities (Torres-Valencia et al., 2017) and is also widely applied in exploring emotion processing mechanism. For instance, the non-linear connectivity of phase-locking value in alpha, beta, and theta oscillations have been used to study the FC of positive and negative emotions induced by different types of stimuli in the brain network (Dasdemir et al., 2017). Moreover, the weighted phase lag index (wPLI) is an acknowledged and robust estimation to detect alterations of functional brain connectivity at the consciousness level (Imperatori et al., 2019).

Hence, the study has been undertaken with the hypothesis that the emotionalized expression of news content in the posttruth era could affect the cognitive activities of the audiences. One news text that was written with two different expression types (emotional expression vs. neutral expression) was adopted as the experiment material in this study, with the EEG measures to record brain signals in the reading process, and the FC method was used to analyze the FC of EEG signals in different oscillations to observe the influence of emotional discourse on individual cognitive activities.

MATERIALS AND METHODS

Participants

A total of 50 right-handed undergraduates and graduates were recruited and randomly divided into two groups; one experimental group (13 women and 12 men, mean age 22.16 ± 1.91), and one control group (13 women and 12 men, mean age 22.96 ± 2.32). All the participants reported normal or corrected-to-normal vision, had no history of current or past neurological or psychiatric illness, and took no medications known to affect the central nervous system. Their emotional statuses were assessed normal by the Chinese beck anxiety inventory, beck depression inventory, and the positive and negative affect scale (as shown in **Table 1**). There was no significant difference in the scores of positive and negative emotions [t (48) = 1.240, p = 0.221; t (48) = 0.303, p = 0.763] between the two groups before the experiment. They signed consent before the experiments and were paid for their participation.

Materials

The two groups were asked to read two news texts (with emotional expression vs. neutral expression). Control group read the news article *The United States Will Begin Compulsory Labeling of Genetically Modified Foods* with 1,369 Chinese characters, concerning the unbiased introduction of the technology of Genetically Modified (GM) foods and food labeling regulation; while the experimental group read the news version which was modified with more emotional expressions and discourses based on the previous one, the original argument was kept unchanged, with 1,343 Chinese characters. All the news materials were printed on A4 papers of size 210 mm × 297 mm.

Procedure

The participants were instructed to have a 3-min resting state before the experiment, and then they were asked to read the text in detail. After the reading, they were asked to answer six questions related to the versions to deepen the image of the content. After finishing the experiment, they took a 3-min

TABLE 1 | Age, BAI, BDI, and PANAS scores of the experimental and control group.

	Experimental group (N = 25)	Control group (N = 25)
Male	12	12
Female	13	13
Age	22.16 ± 1.91	22.96 ± 2.32
BAI	29.56 ± 5.65	28.04 ± 4.46
BDI	9.00 ± 6.17	7.80 ± 6.44
Positive emotion	29.60 ± 5.46	20.92 ± 6.65
Negative emotion	31.46 ± 5.00	20.29 ± 7.85

tranquillization to recover the emotion status to benchmark. The reading time was about 4 min, and the total experiment time was about 10 min.

Recordings and Analysis

The raw EEG data were real-time recorded from Cognionics Quick-30 32 channels amplifier (CGX, San Diego, CA, United States), which is a dry and non-contact wireless bioelectric sensor system, and sampled at 1,000 Hz, with a 0–100 Hz bandpass. The left mastoid electrodes were used as a reference during recording, and a standard average reference was calculated off-line. Artifacts were corrected using independent component analysis method, and the averaged EEG signals were low-pass filtered at 30 Hz and divided by every 2 s, using EEG Lab 14.1.1 software.

The EEG recording sites were F3, Fz, F4, C3, Cz, C4, P3, Pz, and P4. The average power spectral density (PSD), which were extracted from all the sites on four bands of delta (1–4 Hz), theta (4–8 Hz), alpha (8–13 Hz), and beta (13–30 Hz), were analyzed and the PSD values between the two groups were compared with independent *t*-test using SPSS 24.0.

Furthermore, the brain FC neuroscience method was also used to show scale-free current source density (CSD) to investigate the brain activity of the audience in the processing of reading news texts. CSD was extracted from the four bands and then the wPLI index was calculated. Whole-brain connectivity was drawn based on the average wPLI, with independent *t*-test and false discovery rate adjusting, to analyze interregional brain interactions.

RESULTS

PSD Results

As presented in **Table 2**, the scalp EEG PSD values show significant differences between the experimental group and the control group (reading emotional news text vs. neutral news text).

First, the delta EEG rhythm wave [t (48) = −2.728, p = 0.009, Cohen's d = −0.614], which related to the complexity of the task (Harmony et al., 1996), shows that in the experimental group the participants encountered a more complex reading task, that is, to say a reading with emotional discourse, leading to more attention resources to be input.

Second, the theta oscillations index [t (48) = −2.764, p = 0.008, Cohen's d = −0.410], which is related to the arousal and control of working memory (Gevins et al., 1997; Krause et al., 2000; Raghavachari et al., 2001; Deiber et al., 2007), shows that in experimental group the participants had left fewer attention resources for memory.

Third is the alpha EEG power [t (48) = −2.952, p = 0.005, Cohen's d = −0.381]. The weaker the alpha was (Davidson, 1995; Sarlo et al., 2005), the stronger cortical activity the participants had during the emotional text reading task.

Fourth, it is worthy to note what the beta EEG rhythm oscillation [t (48) = −3.518, p = 0.001, Cohen's d = −0.399] showed. As the PSD value of beta wave in the experimental group was lower than that of the control group, and the beta wave is related to awareness and cognition (Haenschel et al., 2000; Tibbetts, 2013), it shows that the participants of the emotional text reading group had a weaker cognitive resource input, which could indicate that the news content with emotional expression may hinder deep thinking of the individuals in the process of reading.

FC Results

In **Table 3**, the differences in the whole-brain connectivity wPLI on all the bands are presented. Notedly, FC on beta band was significant [t (48) = 58.382, p = 0.0008, Cohen's d = 17.250], across all sites and conditions, but there was no main significance on other bands [alpha, t (48) = 0.521, p = 0.605, Cohen's d = 0.104; delta, t (48) = 0.650, p = 0.519, Cohen's d = 0.182; and theta, t (48) = 0.199, p = 0.843, Cohen's d = 0.091], respectively.

On beta band, whole-brain connectivity is presented in **Figure 1**, the wPLI interaction metrics is presented in **Figure 2**, and the significant interaction dynamics (F4–C4, FC5–C4, FC6–Cz) are presented in **Figure 3**.

Moreover, the study compared wPLI performances between the two groups and found out that the FC of the experimental group was significantly stronger than that of the control group in frontal brain regions in F4–C4 comparison [t (48) = 3.818, p = 0.0002, Cohen's d = 1.103], FC5–C4 comparison [t (48) = 3.701, p = 0.0003, Cohen's d = 1.079], and FC6–Cz comparison [t (48) = 3.636, p = 0.0003, Cohen's d = 1.056], as shown in **Table 4**.

CONCLUSION

The present study incorporated the cognitive neuroscience experiment, with the EEG measures to record brain signals in the news-reading process, and FC method and CSD to analyze FC

TABLE 2 | PSD value (δ, θ, α, and β) and *t*-test between experimental group and control group.

EEG Rhythm Wave	Experimental Group (*N* = 25)	Control Group (*N* = 25)	t
	(*M* ± *SD*)	(*M* ± *SD*)	(*df* = 48)
δ	2.792 ± 0.686	3.406 ± 0.892	−2.728**
θ	0.939 ± 0.448	1.349 ± 0.592	−2.764**
α	0.178 ± 0.417	0.558 ± 0.491	−2.952**
β	−0.660 ± 0.379	−0.261 ± 0.421	−3.518***

***$p \leq 0.001$; $0.001 < **p \leq 0.01$.

TABLE 3 | The differences between two groups in the whole-brain connectivity wPLI (M ± SD).

	Experiment group (*N* = 25)	Control group (*N* = 25)
Delta band	0.485 ± 0.022	0.480 ± 0.032
Theta band	0.418 ± 0.012	0.414 ± 0.010
Alpha band	0.353 ± 0.008	0.354 ± 0.011
Beta band	0.358 ± 0.008	0.220 ± 0.008

$p < 0.05$.

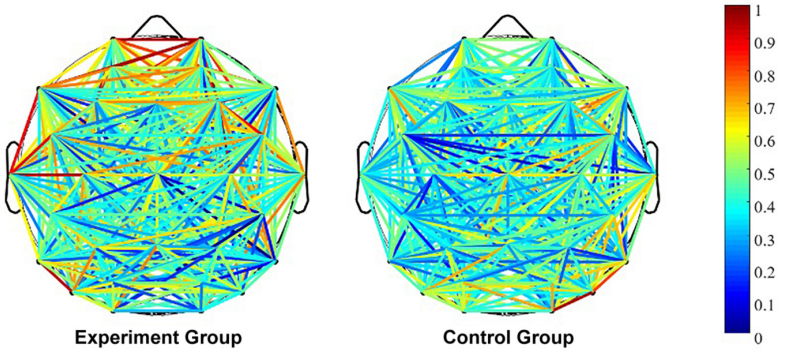


FIGURE 1 | The whole-brain connectivity on beta band. Note: wPLI values presented in line colors.

of EEG signals in different oscillations to observe the influence of two different materials (emotional texts vs. neutral texts) on cognitive processing of individuals, indicating that emotional discourses of news content in the posttruth era could affect the cognitive activities of the audiences.

Electroencephalogram results with δ, θ, α, and β bands revealed that news with emotionalized expression caused a stronger cortical brain activity, consuming more attention resources but fewer cognitive resources (beta oscillations), which may further impede rational thinking of the audiences. More importantly, also on the beta band, it was showed that the brain FC of the emotional news reading group was stronger than that of the control group. This robust connectivity appeared in the central frontal region, consistent with the findings of previous studies (Aydin et al., 2018), and mainly in the right brain hemisphere.

The cross brain regional FC of the beta wave was enhanced, which is related to early emotional processing rather than sustained status (Knyazev et al., 2016), and so individuals may locate more attention resources into emotion-related task processing, and less cognitive resources for content-related tasks, which would lead to the weakening of deep processing, showing the PSD in every band to be significantly reduced, especially the theta band, related to working memory, and the delta band related to complex cognitive tasks (Harmony et al., 1996; Gevins et al., 1997; Krause et al., 2000; Deiber et al., 2007).

On top of that, the synchronous activity on beta band represents an implicit mechanism of perceptual emotion regulation, which may be related to the stress for negative

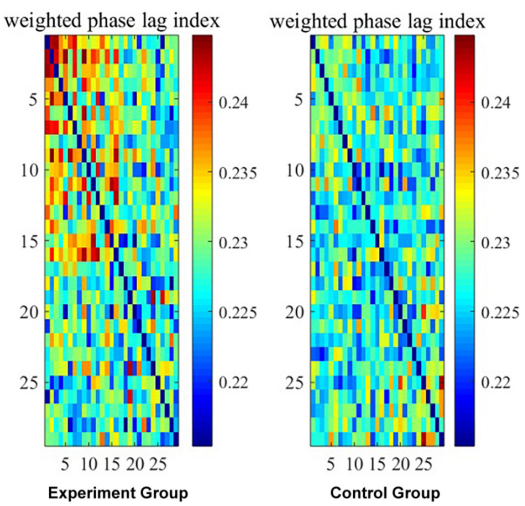


FIGURE 2 | The wPLI interaction metrics on beta band. Note: the wPLI values presented in color blocks.

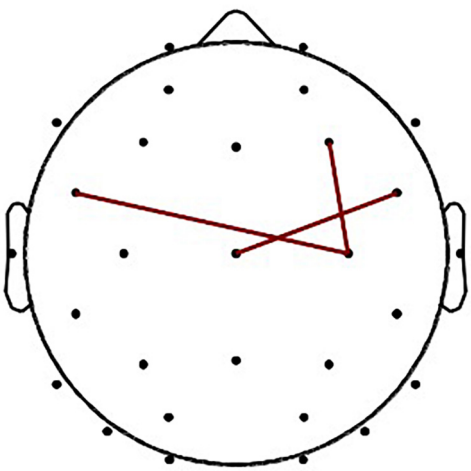


FIGURE 3 | The wPLI in Experiment Group (interaction: F4–C4, FC5–C4, FC6–Cz).

TABLE 4 | The significantly higher wPLI value in the experimental group than that in the control group on beta band (M ± SD).

	Experiment group (*N* = 25)	Control group (*N* = 25)
F4-C4	0.243 ± 0.021	0.222 ± 0.018
FC5-C4	0.236 ± 0.015	0.217 ± 0.020
FC6-Cz	0.243 ± 0.018	0.223 ± 0.020

emotion (Wyczesany et al., 2018a,b). The emotional discourses in the experiment, particularly negative emotions in the news text, have functioned as a stressor and elicited the brain regions in the right hemisphere to regulate these emotional threats automatically. In this condition, a massive amount of cognitive resources have been consumed in the emotion regulation process rather than in deep thinking and rational processing of news content, also in accordance with the typical performance of the individuals of the posttruth era (Higgins, 2016; Gewin et al., 2017; Rochlin, 2017).

DISCUSSION

Belief echoes in the public sphere (Thorson, 2016) states that in the long term, the attitude of the audiences would maintain even if opposite pieces of truth were provided. In the posttruth era, emotions and bias integrate with worldviews and have created "an alternative epistemology that does not conform to conventional standards of evidentiary support" (Lewandowsky et al., 2017). Emotions affect our cognitive processing of information, thus making a difference to our judgment and cognitive strategies (Forgas, 1995, 2010; Milyavsky et al., 2019). The more exposed we are to negative emotional materials, the more time and energy we squander in distracting tasks to deal with them (Isen, 1987). It is concluded that the emotion triggers a priming effect, and emotional expression serves as the noise of communication. Thus, the era of posttruth discourse prioritizes emotion over facts, be it GM food news or other kinds of information.

In summary, in the posttruth era, the news context with emotionalized expression could easily activate cortical activity and connectivity, and attract the attention of the audiences, explaining the phenomenon that conveying information and reporting with emotionalized expression would be easier in the media channels. Compared with the neutral and objective discourses, emotional content is equipped with subjective standpoints, ready to arouse the interest of the audiences when it is consistent with their presumed values, beliefs, and attitudes. Meanwhile, the study has found that audiences may dedicate much more cognition resources to handling those with emotionalized expression with little attention to the actual content or fact itself. In other words, the audience would prefer superficially to stay in the emotions while the emotionalized expression hinders possible deeper consideration of the truth. With the principle of news objectivity unprecedentedly challenged, news content rendered with emotions and opinions induces the truth to be no longer fact-based or objective, one of the critical problems faced by news production as well as the receivers in the age of posttruth.

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 Ethics Committee at the School of Journalism and Communication, Beijing Normal University. The patients/participants provided their written informed consent to participate in this study.

AUTHOR CONTRIBUTIONS

YY, LX, and GY participated in the design of the study. YY performed the conceptualization, wrote, and edited the manuscript. LX performed the data analysis and virtualization and wrote the experiment draft. YY and LX conducted the experiment. GY performed the funding acquisition. All authors read and approved the final manuscript.

ACKNOWLEDGMENTS

This manuscript was funded by the National Social Science Fund of China (Grant No. 17CXW039), the Fundamental Research Funds for the Central Universities (2020NTSS10), and the China Postdoctoral Science Foundation (2018T110062). We are very grateful to the help of Feifan Qian, Yao Chen, Ting Han, Xuejiao Chen, and other students in the data collecting and processing.

REFERENCES

Aydin, S., Demirtas, S., and Yetkin, S. (2018). Cortical correlations in wavelet domain for estimation of emotional dysfunctions. *Neural Comput. Applicat.* 30, 1085–1094. doi: 10.1007/s00521-016-2731-8

Cartocci, G., Cherubino, P., Rossi, D., Modica, E., Maglione, A. G., Di Flumeri, G., et al. (2016). Gender and age-related effects while watching TV advertisements: an EEG study. *Computat. Intellig. Neurosci.* 5, 1–10.

Chen, M., Li, L. J., and Liu, Y. (2017). Analysis of Correlation Between EEG Signal and Personal Emotional State. *J. Front. Comput. Sci. Technol.* 11, 794–801.

Crilley, R. (2018). International relations in the age of 'post-truth' politics. *Int. Affairs* 94, 417–425. doi: 10.1093/ia/iiy038

Dasdemir, Y., Yildirim, E., and Yildirim, S. (2017). Analysis of functional brain connections for positive–negative emotions using phase locking value. *Cognit. Neurodynam.* 11, 487–500. doi: 10.1007/s11571-017-9447-z

Davidson, R. J. (1995). Cerebral asymmetry, emotion, and affective style. *Massachusetts Instit. Technol.* 12, 361–387.

Deiber, M. P., Missonnier, P., Bertrand, O., Gold, G., Fazio-Costa, L., Ibanez, V., et al. (2007). Distinction between perceptual and attentional processing in working memory tasks: a study of phase-locked and induced oscillatory brain dynamics. *J. Cognit. Neurosci.* 19, 158–172. doi: 10.1162/jocn.2007.19.1.158

Ding, X. W., Wu, Z., and Xia, Z. J. (2014). The empirical research of sentiment factors effect on users' retweet behavior. *J. Modern Informat.* 34, 147–155.

Forgas, J. P. (1995). Mood and judgment: the affect infusion model (AIM). *Psychol. Bull.* 117, 39–66. doi: 10.1037/0033-2909.117.1.39

Forgas, J. P. (2010). The role of emotion in social judgments: an introductory review and an affect infusion model (AIM). *Eur. J. Soc. Psychol.* 24, 1–24. doi: 10.1002/ejsp.2420240102

Gevins, A., Smith, M. E., McEvoy, L., and Yu, D. (1997). High-resolution EEG mapping of cortical activation related to working memory: effects of task

difficulty, type of processing, and practice. *Cereb. Cortex* 7, 374–385. doi: 10.1093/cercor/7.4.374

Gewin, V., Hayhoe, K., Basurto, X., and Brossard, D. (2017). Communication: post-truth predicaments. *Nature* 541, 425–427. doi: 10.1038/nj7637-425a

Haenschel, C., Baldeweg, T., Croft, R. J., Whittington, M., and Gruzelier, J. (2000). Gamma and beta frequency oscillations in response to novel auditory stimuli: a comparison of human electroencephalogram (EEG) data with in vitro models. *Proc. Natl. Acad. Sci.* 97, 7645–7650. doi: 10.1073/pnas.120162397

Harmony, T., Fernández, T., Silva, J., Bernal, J., Díaz-Comas, L., Reyes, A., et al. (1996). EEG delta activity: an indicator of attention to internal processing during performance of mental tasks. *Int. J. Psychophysiol.* 24, 161–171. doi: 10.1016/s0167-8760(96)00053-0

Higgins, K. (2016). Post-truth: a guide for the perplexed. *Nature* 540, 9–9. doi: 10.1038/540009a

Hong, Y., Huang, N., Burtch, G., and Li, C. (2016). Culture, conformity and emotional suppression in online reviews. *J. Associat. Informat. Syst.* 17, 16–20.

Imperatori, L. S., Betta, M., Cecchetti, L., Canales-Johnson, A., Ricciardi, E., Siclari, F., et al. (2019). EEG functional connectivity metrics wPLI and wSMI account for distinct types of brain functional interactions. *Sci. Rep.* 9:8894. doi: 10.1038/s41598-019-45289-7

Isen, A. M. (1987). Positive affect, cognitive processes, and social behavior. *Adv. Exp. Soc. Psychol.* 20, 203–253. doi: 10.1016/s0065-2601(08)60415-3

Kamarajan, C., Porjesz, B., Jones, K. A., Choi, K., Chorlian, D. B., Padmanabhapillai, A., et al. (2004). The role of brain oscillations as functional correlates of cognitive systems: a study of frontal inhibitory control in alcoholism. *Int. J. Psychophysiol.* 51, 155–180. doi: 10.1016/j.ijpsycho.2003.09.004

Keane, J., and Wight, C. (2017). *For and against truth. Post Truth Initiative,* in the University of Sydney. Sydney: University of Sydney.

Knyazev, G. G., Savostyanov, A. N., Bocharov, A. V., Dorosheva, E. A., Tamozhnikov, S. S., and Saprigyn, A. E. (2016). Oscillatory correlates of moral decision-making: effect of personality. *Soc. Neurosci.* 11, 233–248. doi: 10.1080/17470919.2015.1072110

Kramer, L. (2014). Learning emotional understanding and emotion regulation through sibling interaction. *Early Educat. Dev.* 25, 160–184. doi: 10.1080/10409289.2014.838824

Krause, J. B., Taylor, J. G., Schmidt, D., Hautzel, H., Mottaghy, F. M., and Müller-Gärtner, H. W. (2000). Imaging and neural modelling in episodic and working memory processes. *Neural Networks* 13, 847–859. doi: 10.1016/s0893-6080(00)00068-x

Laybats, C., and Tredinnick, L. (2016). Post truth, information, and emotion. *Bus. Informat. Rev.* 33, 204–206. doi: 10.1177/0266382116680741

Lewandowsky, S., Ecker, U. K. H., and Cook, J. (2017). Beyond misinformation: understanding and coping with the "post-truth" era. *J. Appl. Res. Memory Cognit.* 6, 353–369. doi: 10.1016/j.jarmac.2017.07.008

Meyer, T., Quaedflieg, C. W. E. M., Giesbrecht, T., Meijer, E. H., Abiad, S., and Smeets, T. (2014). Frontal EEG asymmetry as predictor of physiological responses to aversive memories. *Psychophysiology* 51, 853–865. doi: 10.1111/psyp.12230

Milyavsky, M., Webber, D., Fernandez, J. R., Kruglanski, A. W., Goldenberg, A., Suri, G., et al. (2019). To reappraise or not to reappraise? Emotion regulation choice and cognitive energetics. *Emotion* 19, 964–981. doi: 10.1037/emo0000498

Ohme, R., Reykowska, D., Wiener, D., and Choromanska, A. (2009). Analysis of neurophysiological reactions to advertising stimuli by means of EEG and galvanic skin response measures. *J. Neurosci. Psychol. Econom.* 2, 21–31. doi: 10.1037/a0015462

Ohme, R., Reykowska, D., Wiener, D., and Choromanska, A. (2010). Application of frontal EEG asymmetry to advertising research. *J. Econom. Psychol.* 31, 785–793. doi: 10.1016/j.joep.2010.03.008

Oxford Dictionaries (2016). *Post-truth*. Oxford: Oxford Dictionaries.

Raghavachari, S., Kahana, M. J., Rizzuto, D. S., Caplan, J. B., Kirschen, M. P., Bourgeois, B., et al. (2001). Gating of human theta oscillations by a working memory task. *J. Neurosci.* 21, 3175–3183. doi: 10.1523/jneurosci.21-09-03175.2001

Rochlin, N. (2017). Fake news: belief in post-truth. *Library HiTech* 35, 386–392. doi: 10.1108/lht-03-2017-0062

Sarlo, M., Buodo, G., Poli, S., and Palomba, D. (2005). Changes in EEG alpha power to different disgust elicitors: the specificity of mutilations. *Neurosci. Lett.* 382, 291–296. doi: 10.1016/j.neulet.2005.03.037

Scheufele, D. A., and Krause, N. M. (2019). Science audiences, misinformation, and fake news. *Proc. Natl. Acad. Sci.* 116, 7662–7669. doi: 10.1073/pnas.1805871115

Tibbetts, P. E. (2013). Reviewed work: Principles of Neural Science by Eric R. Kandel, James H. Schwartz, Thomas M. Jessell, Steven A. Siegelbaum, A. J. Hudspeth, & Sarah Mack (The University of Chicago Press). *Quart. Rev. Biol.* 88, 139–140. doi: 10.1086/670559

Thorson, E. (2016). Belief echoes: experimental evidence for the persistent effects of false information. *Polit. Commun.* 33, 460–480.

Torres-Valencia, C., Alvarez-Meza, A., and Orozco-Gutierrez, A. (2017). "Emotion assessment based on functional connectivity variability and relevance analysis," in *Natural and Artificial Computation for Biomedicine and Neuroscience*, Vol. 10337, eds J. M. F. Vicente, J. R. A. Sanchez, F. D. Lopez, J. T. Moreo, and H. Adeli (Cham: Springer International Publishing Ag), 353–362. doi: 10.1007/978-3-319-59740-9_35

Vecchiato, G., Toppi, J., Astolfi, L., Fallani, F. D. V., Cincotti, F., Mattia, D., et al. (2011). Spectral EEG frontal asymmetries correlate with the experienced pleasantness of TV commercial advertisements. *Med. Biol. Engine. Comput.* 49, 579–583. doi: 10.1007/s11517-011-0747-x

Weeks, B. E. (2015). Emotions, partisanship, and misperceptions: how anger and anxiety moderate the effect of partisan bias on susceptibility to political misinformation. *J. Communicat.* 65, 699–719. doi: 10.1111/jcom.12164

Wyczesany, M., Capotosto, P., Zappasodi, F., and Prete, G. (2018a). Hemispheric asymmetries and emotions: evidence from effective connectivity. *Neuropsychologia* 121, 98–105. doi: 10.1016/j.neuropsychologia.2018.10.007

Wyczesany, M., Ligeza, T. S., Tymorek, A., and Adamczyk, A. (2018b). The influence of mood on visual perception of neutral material. *Acta Neurobiol. Exp.* 78, 163–172. doi: 10.21307/ane-2018-015

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.

frontiers in Behavioral Neuroscience

OPINION
published: 07 September 2021
doi: 10.3389/fnbeh.2021.709365

Online Communication and Body Language

Paolo Paradisi[1,2]*, *Marina Raglianti*[3] and *Laura Sebastiani*[4]

[1] Istituto di Scienza e Tecnologie Dell'Informazione "A. Faedo" (ISTI-CNR), Pisa, Italy, [2] BCAM-Basque Center for Applied Mathematics, Bilbao, Spain, [3] Departamento de Educación de la Facultad de Educación y Humanidades, Universidad de Tarapacá, Arica, Chile, [4] Department of Translational Research and New Technologies in Medicine and Surgery, University of Pisa, Pisa, Italy

Keywords: COVID-19, interpersonal online communication, perceived interpersonal distance, dance movement therapy, body movements, mirroring, social interactivity, cooperation

INTRODUCTION

The COVID-19 emergency brought out the role of online digital technologies. The increase in online social interactivity was accelerated by social distancing, which has been recognized to have adverse effects due to physical and emotional isolation (Canet-Juric et al., 2020).

Body language is central to social interactions, and its role is clearly diminished when going online, but the relevance of this change is still not clear. This transition toward online could affect the wellness of the people, especially the population with specific fragilities, e.g., young people and seniors (Beam and Kim, 2020; Canet-Juric et al., 2020; Fernández Cruz et al., 2020).

We here briefly present our viewpoint on some issues concerning changes in body interactions in online interpersonal communication. Our aim is to encourage constructive discussion and raise awareness about these very topical issues.

ONLINE COMMUNICATION PLATFORMS: TOWARD NEW COMMUNICATION STRATEGIES?

Progress in digital technologies is having a profound impact on interpersonal communication. The natural face-to-face modality is nowadays often replaced by interactions through video-mediated online communication platforms (VMOCPs) (mediatized communication). Furthermore, the duration of restrictions related to the COVID-19 emergency determined, in a very short time, an acceleration in the diffusion and an intensification in the use of VMOCPs.

In fact, VMOCPs are now ubiquitously used for meetings and courses in different contexts, such as work environments, education, and, in general, for whatever activity involving social interaction, thus, determining rapid changes in the everyday lives of the people (Chan et al., 2020; Dorn, 2021).

Interestingly, also the seniors, which were only marginal users of these technologies, were forced to use them as their only chance for social contacts (López et al., 2020; Pelicioni and Lord, 2020).

The new form of communication has brought great improvement in communication possibilities, by overcoming the limitations of time and space. However, VMOCPs have also modified the communication rules, e.g., those related to proxemics (Hall, 1966). Proxemics assumes a direct proportionality between the geometrical peripersonal/extrapersonal space and different types of interpersonal acquaintanceship: intimate, personal, social, and public. When people communicate through VMOCPs, the geometrical distance separating the screen image and the real interlocutor is a few tens of centimeters, which is smaller than the distance between persons involved in a social/public face-to-face conversation. Then, when passing online, does a short "perceived" distance imply a personal/intimate level? In our opinion, the answer to this question is not obvious as going online likely brings non-trivial changes in the proxemics rules.

For example, such a physical closeness would presuppose an intimacy between persons and

Edited by:
Vincenzo Auriemma, University of Salerno, Italy

Reviewed by:
Chiara Iannaccone, University of Salerno, Italy
Carmen Taleghani-Nikazm, The Ohio State University, United States
Giulia Melani, L'altro Diritto, Centro Interuniversitario di Ricerca su Carcere, Marginalità, Devianza e Governo Delle Migrazioni, Italy

***Correspondence:**
Paolo Paradisi
paolo.paradisi@cnr.it

Specialty section:
This article was submitted to Individual and Social Behaviors, a section of the journal Frontiers in Behavioral Neuroscience

Received: *13 May 2021*
Accepted: *09 August 2021*
Published: *07 September 2021*

Citation:
Paradisi P, Raglianti M and Sebastiani L (2021) Online Communication and Body Language. Front. Behav. Neurosci. 15:709365. doi: 10.3389/fnbeh.2021.709365

a mutual disposition to the potential use of the tactile channel (handshake, hug, and tap on the shoulder). However, despite this virtual closeness, we cannot touch (Drag, 2020).

Another important change concerns the communicative role of eye gaze. In fact, in agreement with the "fractured ecologies" concept (Heath and Luff, 1992; Luff et al., 2003), the eye contact and the meaning it conveys (Drag, 2020), when mediated by the camera, is unrecoverable by the interacting participants.

In summary, the above discussed issues suggest that changes from live to online communication are complex, as the direct proportionality between (apparent) geometrical distance and interpersonal acquaintanceship is deeply changed both quantitatively and qualitatively.

BODY MOTION AND VIDEO-MEDIATED ONLINE COMMUNICATION PLATFORMS: A FOCUS ON ONLINE EDUCATION AND THERAPEUTIC INTERVENTION

Body movements and language are crucial in both emotion-based non-verbal communication and cognitive-based social interactions. It is foreseeable that extensive use of online technologies could have important effects on cognitive processes, not only those involving learning/educational/training activities but also those related to emotion-driven relationships in social living. To date, however, the role of body movements in inter-subject online interaction has been scarcely investigated (Zuo et al., 2021).

Let us discuss two different examples: online education and dance movement therapy (DMT).

Serious games are interactive virtual simulations whose goal is to train while entertaining. They were proposed as useful tools to improve learning performances (Hanus and Fox, 2015) and, with the COVID-19 emergency, have been thought as a possible mainstream solution to mitigate the problem of social distancing in online teaching (Koivisto and Hamari, 2019).

This approach, although certainly useful, needs to be reviewed considering the concept of "embodied education," which refers to the embodied cognition (EC) theory (Kiverstein and Miller, 2015; Shapiro, 2019). According to it, cognition is formed by the processing of informative stimuli from and through the body. Some authors found a positive correlation between learning performances and movement synchronization in the teacher–learner interaction (Sacheli et al., 2018; Shapiro and Stolz, 2019; Madsen et al., 2020; Pan et al., 2021). Furthermore, mobility strategies of the teachers in the classroom (classroom proxemics) at various stages of a lesson and according to the task of the students have been found to have positive effects on engagement (Chin et al., 2017), motivation (Fernandes et al., 2011), and disruptive behavior of the students (Gunter et al., 1995).

DMT is a complementary therapy where body movements are employed to promote personal and social wellbeing. This is reached by eliciting the harmonization of mental, somatic, and relational manifestations of the individual through the creative use of movement improvization and dance (ADTA—American Dance Therapy Association, 2014). DMT emphasizes the communicational aspect of dance (Karkou and Sanderson, 2006). In fact, the DMT setting presupposes a social component triggered by interpersonal interactions mediated by body language and, in particular, movements. Indeed, the social component through body interaction has a crucial role in DMT functioning: the game of distances, perspectives, and reciprocity creates the communicative context in which movement takes place. The circle, for example, is a DMT basic figure (Karampoula and Panhofer, 2018) in which all group members can see everyone else, thus, having direct access to verbal and nonverbal cues of the participants. The basic elements of a circle include mirroring, echoing of emotional states, containment and holding, and physical contact through the holding of hands. Mirroring consists of matching/echoing the movements of the person (Tortora, 2006) and, in a circle, is multiple (multimirror). This technique has been shown to be effective in strengthening the self-confidence and physical resilience of the group members but also social integration and affiliation by promoting empathy. The "motor theory of empathy," in fact, proposes that the human mirror system may participate to the understanding of the intentions and feelings of others (Rizzolatti and Fabbri-Destro, 2008) and that empathy may stem from the link between perception and action (Iacoboni, 2009; Zardi et al., 2021). In brief, understanding of action may promote empathizing with others (Carr et al., 2003). Despite this theory being criticized (Hickok, 2014), phenomena based on motor resonance (i.e., a direct link between the perception of an action and its execution), namely, mimicry, synchrony, and automatic imitation, are considered involved in higher social cognition, including empathy, and in promoting positive social effects both in the adult and during development (Rauchbauer and Grosbras, 2020).

WHAT IS MISSING ONLINE?

In DMT, the dyadic relationship between the conductor/participant is at least partially preserved (APID—Associazione professionale italiana danzamovimentoterapia, 2021). The conductor can stimulate the participant with the voice, music, and gestures also through the screen. The participant, by observing the conductor on the screen, can be accompanied in the experimentation of his own movement aimed at creating an internal/external dialog. Indeed, evidence from trials of online meditation (Cavalera et al., 2019; Yang et al., 2019) supports the idea that online, it is possible to work on the "vertical dimension of energy" that is on the individual depth of feelings. In contrast, the transversal level, which includes all the non-verbal interactions between participants, is greatly impaired. Even with groups of three to four persons, most of the interpersonal and transpersonal components of movement cannot be reproduced.

The example of DMT shows that online sensory interaction is very different from a live one. The visual and auditory sensory channels are essentially the only online communication modalities. Actually, images on the screen are two-dimensional (2D), thus, reducing tridimensional visual perception to a *quasi*

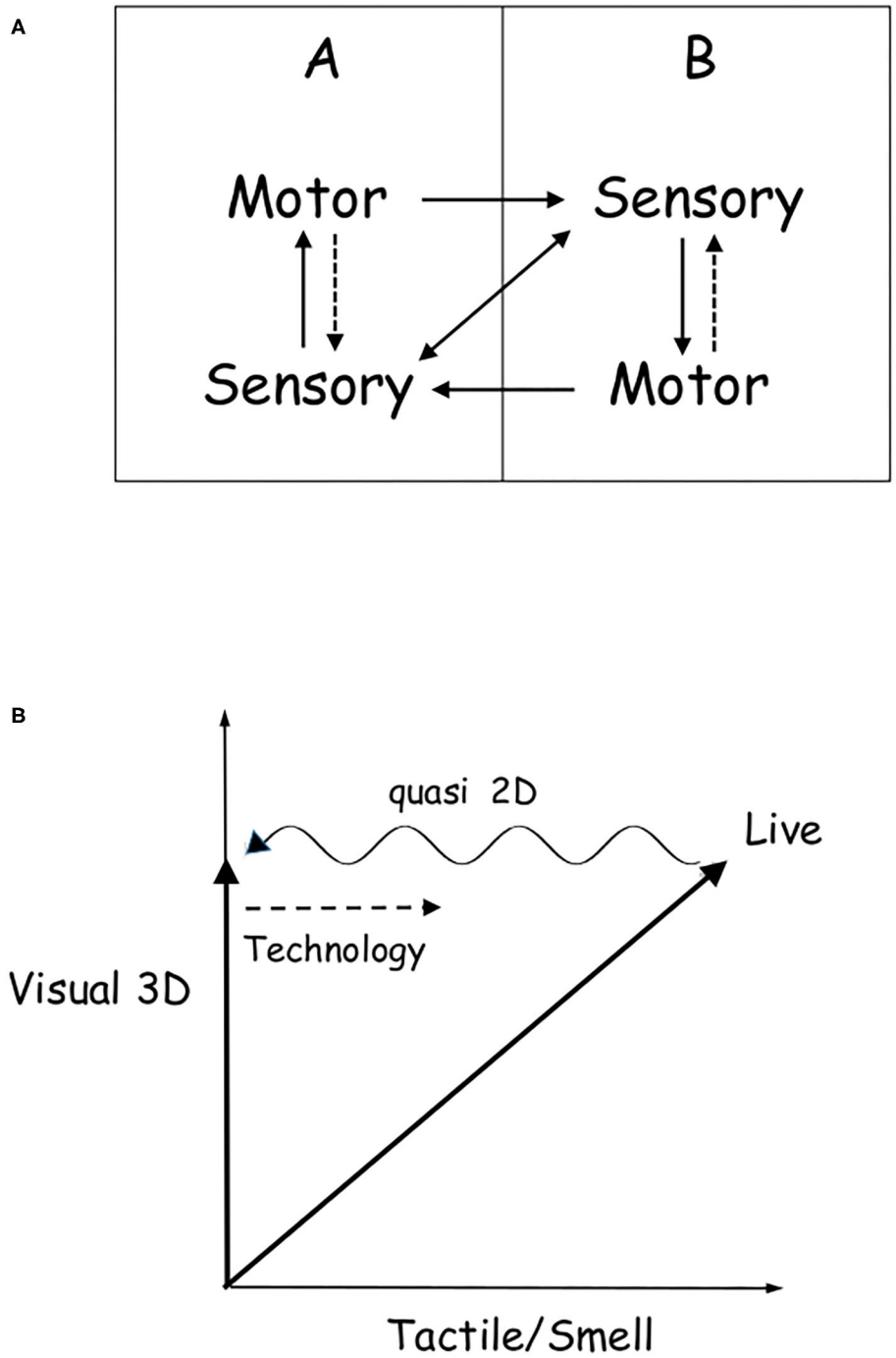


FIGURE 1 | (A) Simple scheme of a live interaction between individuals A and B. The two horizontal arrows indicate the mutual feedback between A and B, while the vertical ones denote the individual internal information exchanges between the sensory and motor systems. The vertical motor-to-sensory dashed arrows indicate the increased strength of sensory-to-motor (continuous arrows) when an individual interacts, thus, triggering the clockwise feedback loop, which represents the emergence of self-organizing behavior of A–B as a whole. The double diagonal arrow represents the direct interaction through the sensory system, e.g., eye contact or touch. **(B)** Qualitative sketch of the passage from live to online interactions. Live interactions involve both visual and tactile/smell senses, while online determines a reduced perception, represented in the figure as a shift toward the *quasi* 2D vision. The wave in the left arrow denotes that the projection on the vision axis is neither two- nor three-dimensional, but in between. The right dashed arrow represents technologies needed to (partially) fill the online–live interactivity gap. Being almost unchanged, auditory is not reported.

2D one[1]. Other modalities such as the tactile and olfactory ones cannot be directly employed. Human touch has been suggested to play a large role in establishing a sense of "proximity" between persons and to facilitate affiliative behavior and social bonding (Morrison et al., 2010). Previous studies have demonstrated a close association between pleasant social touch and the release of oxytocin, which is a crucial modulator of social behavior and emotions across species (Olff et al., 2013; Walker et al., 2017; Kendrick et al., 2018; Tang et al., 2020).

The sense of smell is also involved in the non-verbal social communication of humans; in fact, through smell, humans can involuntarily convey personal information (de Groot et al., 2017; Parma et al., 2017; Pause, 2017; Roberts et al., 2020).

Some authors claim that chemosignal communication critically contributes to the formation and maintenance of social groups and has a role in the evolution of the social brain (Dunbar and Shultz, 2007; Parma et al., 2017).

A new multidisciplinary discipline involving psychology and chemistry (sociochemistry) is studying the chemical basis of olfactory communication emphasizing the role of psychological states and traits in modulating body odorant composition (de Groot et al., 2020). Interestingly, data from patients with no or reduced olfactory capabilities show that the loss of smell severely affects the richness of social relationships over the lifespan from the early developmental stages to the old age (Boesveldt et al., 2017).

FINAL DISCUSSION

We can argue that in online social interactions:

(i) smell and touch are absent;
(ii) visual is limited to a *quasi* 2D perception;
(iii) auditory is almost unchanged;
(iv) changes in the relationship between perceived geometrical distances and acquaintanceship
are expected, but still unclear;
(v) there are no direct bodily interactions.

According to the "fractured ecologies" concept, when online, interacting persons cannot recover most of the relevant features of the environment and bodily behavior of others (gesture, eye contact) and behave accordingly (Luff et al., 2003).

These changes may undermine the emotional and empathetic aspects of interpersonal communication. However, cooperation is still possible through the auditory and the reduced *quasi* 2D visual perception.

A better understanding of these aspects could need a partial revision of classical communication theories (McLuhan, 1964; Hall, 1966; Bolter and Grusin, 1999; Jensen, 1999) in order to consider the new modalities of communication introduced by online interactions. Thus, the consequences of passing online probably include *remediation* mechanisms related to the use of the new digital technologies (Bolter and Grusin, 1999). These mechanisms are compatible with the *self-organization* paradigm of complexity: cooperative social dynamics between different individuals/groups trigger the emergence of a new dynamical equilibrium in a relatively short time due to an environmental change (in this case, the new digital technologies) (Zeleny, 1977; Santos et al., 2006; Paradisi et al., 2015; Paradisi and Allegrini, 2017; Mahmoodi et al., 2018). The equilibrium is constrained to the optimization of social interactivity mediated by the new technology, the optimum possibly being a condition as nearest as possible to live interactivity. Thus, the question that should be answered should not only be "what is lost?" but also "what is new?," possibly involving the development of *virtual proxemics*.

An open question that deserves further investigations is the quantification of perceived virtual distances in online interactions. For example, the distance between the screen and the individual could be used, but the effect of the image size on the screen should also be clarified.

Figure 1 reports a graphical summary of our discussion. Panel (A) is a scheme of self-organizing live interaction between two individuals. Panel (B) sketches the passage from live to online interactions.

To address the challenges of online communications and to mitigate the effect of emotional isolation, an interdisciplinary research is needed that would have to (i) monitor the social change, (ii) develop new communication models, and (iii) develop strategies and technologies to partially fill the online-live interactivity gap.

AUTHOR CONTRIBUTIONS

PP and LS wrote the paper and carried out the bibliographic search with many insights from MR regarding DMT and body language in social communication. All authors equally discussed and developed the idea of the paper.

[1]Here "quasi" is related to a partial mental reconstruction of vision depth that the brain can operate on the basis of past live experiences, by elaborating what is actually a two-dimensional image on the screen.

REFERENCES

ADTA—American Dance Therapy Association (2014). *What is Dance/Movement Therapy*. Available online at: https://adta.memberclicks.net/what-is-dancemovement-therapy (accessed April 2021).

APID—Associazione professionale italiana danzamovimentoterapia (2021). Available online at: https://www.apid.it/ (accessed April, 2021).

Beam, C. R., and Kim, A. J. (2020). Psychological sequelae of social isolation and loneliness might be a larger problem in young adults than older adults. *Psychol. Trauma* 12, S58–S60. doi: 10.1037/tra0000774

Boesveldt, S., Yee, J. R., McClintock, M. K., and Lundström, J. N. (2017). Olfactory function and the social lives of older adults: a matter of sex. *Sci. Rep*. 7:45118. doi: 10.1038/srep45118

Bolter, J. D., and Grusin, R. (1999). *Remediation: Understanding New Media*. Cambridge, MA: MIT Press.

Canet-Juric, L., Andrés, M. L., del Valle, M., López-Morales, H., Po,ó, F., Galli, J. I., et al. (2020). A longitudinal study on the emotional impact cause by the COVID-19 pandemic quarantine on general population. *Front. Psychol.* 11:565688. doi: 10.3389/fpsyg.2020.565688

Carr, L., Iacoboni, M., Dubeau, M. C., Mazziotta, J. C., and Lenzi, G. L. (2003). Neural mechanisms of empathy in humans: a relay from neural systems for imitation to limbic areas. *Proc. Natl. Acad. Sci. USA*. 100, 5497–5502. doi: 10.1073/pnas.0935845100

Cavalera, C., Rovaris, M., Mendozzi, L., Pugnetti, L., Garegnani, M., Castelnuovo, G., et al. (2019). Online meditation training for people with multiple sclerosis: a randomized controlled trial. *Mult. Scler. J.* 25, 610–617. doi: 10.1177/1352458518761187

Chan, A. K. M., Nickson, C. P., Rudolph, J. W., Lee, A., and Joynt, G. M. (2020). Social media for rapid knowledge dissemination: early experience from the COVID-19 pandemic. *Anaesthesia* 75, 1579–1582. doi: 10.1111/anae.15057

Chin, H. B., Mei, C. C. Y., and Taib, F. (2017). Instructional proxemics and its impact on classroom teaching and learning. *Int. J. Mod. Lang. Appl. Ling.* 1, 1–20. doi: 10.24191/ijmal.v1i1.7637

de Groot, J. H. B., Croijmans, I., and Smeets, M. A. M. (2020). More data, please: machine learning to advance the multidisciplinary science of human sociochemistry. *Front Psychol.* 11:581701. doi: 10.3389/fpsyg.2020.581701

de Groot, J. H. B., Semin, G. R., and Smeets, M. A. M. (2017). On the communicative function of body odors: a theoretical integration and review. *Perspect. Psychol. Sci*. 12, 306–324. doi: 10.1177/1745691616676599

Dorn, S. D. (2021). Backslide or forward progress? Virtual care at U.S. healthcare systems beyond the COVID-19 pandemic. *NPJ Dig. Med.* 4, 1–3. doi: 10.1038/s41746-020-00379-z

Drag, K. (2020). Revaluation of the proxemics code in mediatized communication. *Soc. Commun*. 1, 93–105. doi: 10.2478/sc-2020-0010

Dunbar, R. I. M., and Shultz, S. (2007). Evolution in the social brain. *Science* 317, 1344–1347. doi: 10.1126/science.1145463

Fernandes, A. C., Huang, J., and Rinaldo, V. (2011). Does where a student sits really matter? The impact of seating locations on student classroom learning. *Int. J. Appl. Educ. Stud*. 10, 66–77.

Fernández Cruz, M., Álvarez Rodríguez, J., Ávalos Ruiz, I., Cuevas López, M., de Barros Camargo, C., Díaz Rosas, F., et al. (2020). Evaluation of the emotional and cognitive regulation of young people in a lockdown situation due to the Covid-19 pandemic. *Front. Psychol.* 11:565503. doi: 10.3389/fpsyg.2020.565503

Gunter, P. L., Shores, R. E., Jack, S. L., Rasmussen, S. K., and Flowers, J. (1995). On the move using teacher/student proximity to improve students' behavior. *Teach. Except. Child*. 28, 12–14. doi: 10.1177/004005999502800103

Hall, E. T. (1966). *The Hidden Dimension (1st ed.)*. New York, NY: Doubleday and Co.

Hanus, M. D., and Fox, J. (2015). Assessing the effects of gamification in the classroom: a longitudinal study on intrinsic motivation, social comparison, satisfaction, effort, and academic performance. *Comput. Educ*. 80, 152–161. doi: 10.1016/j.compedu.2014.08.019

Heath, C., and Luff, P. (1992). Media space and communicative asymmetries: preliminary observations of video-mediated interaction. *Hum. Comput. Interact*. 7, 315–346. doi: 10.1207/s15327051hci0703_3

Hickok, G. (2014). *The Myth of Mirror Neurons: The Real Neuroscience of Communication and Cognition*. New York, NY: W. W. Norton and Company.

Iacoboni, M. (2009). Imitation, empathy, and mirror neurons. *Annu. Rev. Psychol.* 60, 653–670. doi: 10.1146/annurev.psych.60.110707.163604

Jensen, J. F. (1999). "Interactivity," in *Tracking a New Concept in Media and Communication Studies, Computer Media and Communication*, ed. P. Mayer (Oxford: Oxford University Press).

Karampoula, E., and Panhofer, H. (2018). The circle in dance movement therapy: a literature review. *Arts Psychother.* 58, 27–32. doi: 10.1016/j.aip.2018.02.004

Karkou, V., and Sanderson, P. (2006). *Arts Therapies: A Research-Based Map of the Field*. Edinburgh: Elsevier

Kendrick, K. M., Guastella, A. J., and Becker, B. (2018). Overview of human oxytocin research. *Curr. Top. Behav. Neurosci.* 35, 321–348. doi: 10.1007/7854_2017_19

Kiverstein, J., and Miller, M. (2015). The embodied brain: towards a radical embodied cognitive neuroscience. *Front. Hum. Neurosci.* 9:237. doi: 10.3389/fnhum.2015.00237

Koivisto, J., and Hamari, J. (2019). The rise of motivational information systems: a review of gamification research. *Int. J. Inf. Manag.* 45, 191–210. doi: 10.1016/j.ijinfomgt.2018.10.013

López, J., Perez-Rojo, G., Noriega, C., Carretero, I., Velasco, C., Martinez-Huertas, et al. (2020). Psychological well-being among older adults during the COVID-19 outbreak: a comparative study of the young-old and the old-old adults. *Int. Psychogeriatr*. 32, 1365–1370. doi: 10.1017/S1041610220000964

Luff, P., Heath, C., Kuzuoka, H., Hindmarsh, J., and Yamazaki, K. (2003). Fractured ecologies: creating environments for collaboration. *Hum. Comput. Interact*. 18, 51–84. doi: 10.1207/S15327051HCI1812_3

Madsen, K. L., Aggerholm, K., and Jensen, J.-O. (2020). Enactive movement integration: results from an action research project. *Teach. Teach. Educ*. 95, 103139. doi: 10.1016/j.tate.2020.103139

Mahmoodi, K., West, B. J., and Grigolini, P. (2018). Self-organized temporal criticality: bottom-up resilience versus top-down vulnerability. *Complexity* 2018:8139058. doi: 10.1155/2018/8139058

McLuhan, M. (1964). *Understanding Media. The Extensions of Man*. New York, NY: McGraw-Hill.

Morrison, I., Löken, L., and Olausson, H. (2010). The skin as a social organ. *Exp. Brain Res*. 204:305–314 doi: 10.1007/s00221-009-2007-y

Olff, M., Frijling, J. L., Kubzansky, L. D., Bradley, B., Ellenbogen, M. A., Cardoso, C., et al. (2013). The role of oxytocin in social bonding, stress regulation and mental health: an update on the moderating effects of context and interindividual differences. *Psychoneuroendocrinology* 38, 1883–1894. doi: 10.1016/j.psyneuen.2013.06.019

Pan, Y., Novembre, G., Song, B., Zhu, Y., and Hu, Y. (2021). Dual brain stimulation enhances interpersonal learning through spontaneous movement synchrony. *Soc. Cogn. Affect. Neurosci*. 16, 210–221. doi: 10.1093/scan/nsaa080

Paradisi, P., and Allegrini, P. (2017). "Intermittency-driven complexity in signal processing," in *Complexity and Nonlinearity in Cardiovascular Signals*, ed R. Barbieri (Cham: Springer), 161–195. doi: 10.1007/978-3-319-58709-7_6

Paradisi, P., Kaniadakis, G., and Scarfone, A. M. (2015), The emergence of self-organization in complex systems. *Preface Chaos Solitons Fractals* 81, 407–411. doi: 10.1016/j.chaos.2015.09.017

Parma, V., Gordon, A. R., Cecchetto, C., Cavazzana, A., and Lundström, J. N. (2017). "Processing of human body odors," in *Springer Handbook of Odor*, ed. A. Buettner (New York, NY: Springer), 963–986. doi: 10.1007/978-3-319-26932-0_51

Pause, B. M. (2017). "Human chemosensory communication," in *Springer Handbook of Odor*, ed. A. Buettner (New York, NY: Springer), 987–1010. doi: 10.1007/978-3-319-26932-0_52

Pelicioni, P. H. S., and Lord, S. R. (2020). COVID-19 will severely impact older people's lives, and in many more ways than you think! *Braz. J. Phys. Ther*. 24, 293–294. doi: 10.1016/j.bjpt.2020.04.005

Rauchbauer, B., and Grosbras, M.-H. (2020). Developmental trajectory of interpersonal motor alignment: positive social effects and link to social cognition. *Neurosci. Biobehav. Rev*. 118, 411–425. doi: 10.1016/j.neubiorev.2020.07.032

Rizzolatti, G., and Fabbri-Destro, M. (2008). The mirror system and its role in social cognition. *Curr. Opin. Neurobiol.* 18, 179–184. doi: 10.1016/j.conb.2008.08.001

Roberts, S. C., Havlíček, J., and Schaal, B. (2020). Human olfactory communication: current challenges and future prospects. *Philos. Trans. R. Soc. B* 375:20190258. doi: 10.1098/rstb.2019.0258

Sacheli, L. M., Arcangeli, E., and Paulesu, E. (2018). Evidence for a dyadic motor plan in joint action. *Sci. Rep*. 8:027. doi: 10.1038/s41598-018-23275-9

Santos, F. C., Pacheco, J. M., and Lenaerts, T. (2006). Cooperation prevails when individuals adjust their social ties. *PLoS Comput. Biol.* 2:e140. doi: 10.1371/journal.pcbi.0020140

Shapiro, L. (2019). *Embodied Cognition*. New York, NY: Routledge (Taylor and Francis). ISBN: 978-1-315-18038-0

Shapiro, L., and Stolz, S. A. (2019). Embodied cognition and its significance for education. *Theory Res. Educ*. 17, 19–39. doi: 10.1177/1477878518822149

Tang, Y., Benusiglio, D., Lefevre, A., Hilfiger, L., Althammer, F., Bludau, A., et al. (2020). Social touch promotes interfemale communication via activation of parvocellular oxytocin neurons. *Nat. Neurosci.* 23, 1125–1137. doi: 10.1038/s41593-020-0674-y

Tortora, S. (2006). *The Dancing Dialogue: Using the Communicative Power of Movement with Young Children*. Baltimore: Paul H. Brookes Pub.

Walker, S. C., Trotter, P. D., Swaney, W. T., Marshall, A., and Mcglone, F. P. (2017). C-tactile afferents: cutaneous mediators of oxytocin release during affiliative tactile interactions? *Neuropeptides* 64, 27–38. doi: 10.1016/j.npep.2017.01.001

Yang, M., Jia, G., Sun, S., Ye, C., Zhang, R., and Yu, X. (2019). Effects of an online mindfulness intervention focusing on attention monitoring and acceptance in pregnant women: a randomized controlled trial. *J. Midwifery Womens Health* 64, 68–77. doi: 10.1111/jmwh.12944

Zardi, A., Carlotti, E. G., Pontremoli, A., and Morese, R. (2021). Dancing in your head: an interdisciplinary review. *Front. Psychol.* 12:649121. doi: 10.3389/fpsyg.2021.649121

Zeleny, M. (1977). Self-organization of living systems: a formal model of autopoiesis. *Int. J. General Syst.* 4, 13–28. doi: 10.1080/03081077708960651

Zuo, Y., Ma, Y., Zhang, M., Wu, X., and Ren, Z. (2021). The impact of sharing physical activity experience on social network sites on residents' social connectedness: a cross-sectional survey during COVID-19 social quarantine. *Glob. Health* 17:10. doi: 10.1186/s12992-021-00661-z

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.

frontiers in Sociology

ORIGINAL RESEARCH
published: 27 September 2021
doi: 10.3389/fsoc.2021.695991

The Cage Case. Arts and Social Neuroscience

Amendola Alfonso[1] *and Jessica Camargo Molano*[2]*

[1]*Department of Political and Social Studies, University of Salerno, Rome, Italy,* [2]*Mind and Technologies in the Digital Society, Psychology Department, International Telematic University "UniNettuno", Rome, Italy*

A great story told by a musician is the basis of the best stage experimentation of the second half of the 20th century. The musician is John Cage, whose work synthesizes the entire system of arts within the extraordinary world of the avant-garde. This great story begins with the experimental artistic activities which were developed in the 1920s, consolidated in the thirties and continued through the post-war period up to the dawn of the fifties. Apart from the socio-historical cross-section Cage's experimentation provides, it is also a pretext for reflecting on the artist's work as well as the relationship between neuroscience and art. Important contributions to this topic come from the neuro-scientific-social research on new expressions "of creativity, imagination, genius" (Pecchinenda, 2018). This study is based on the assumption that Cage was the forerunner of neuronal experimentation that would be central to the experiments and research of many other artists. The theoretical reference model can be found in the research of the neuroscientist Kandel et al, whose work was the starting point for this investigation. Kandel grasps the definitive break between scientific logic and humanistic sensitivity in the methodological reductionism practiced by neuroscience and in the experiments of contemporary creativity. According to Kandel, both neuroscience and artistic experimentation have similar objectives and problems, and in some respects seem to develop similar methodological practices. Kandel identifies the use of memory, synthesis and knowledge of the world in authors such as Mondrian, de Kooning, Pollock, Rothko, Louis, Warhol as well as the New York school of which Cage was an important member. The relationship between art and neuroscience is synthetized in the avant-garde action of Cage and in all the artists who launched continuous attacks against traditional forms. The transition from figurative art to abstraction is "comparable" to the reductionist process that is used in the scientific field to explain complexity and phenomenology. The prolegomena of this discourse are anticipated by a previous work written by Kandel in 2012 and can also be found in other studies on the relationship between neuroscience and art, in particular in the reflections of the neurobiologist and father of neuroaesthetics, Semir Zeki. Zeki analyzed artists work as a practice perfectly comparable to the research carried out by neuroscientists. Cage, the focus of this investigation, carried out a sound-stage-vision experimentation affecting theatre, media and art which can be examined from at least two different perspectives. The first concerns the definitive subversion of "innate rules of perception" (Kandel) and the second deals with the relationship between art and neuroscience.

Keywords: john cage, happening, art, music, theatre, neuroscience

OPEN ACCESS

Edited by:
Rosalba Morese,
University of Italian Switzerland, Switzerland

Reviewed by:
Valeria Saladino,
University of Cassino, Italy
Andrea Zardi,
University of Turin, Italy

***Correspondence:**
Jessica Camargo Molano
j.cavalagliocamar@students.uninettunouniversity.net

Specialty section:
This article was submitted to Sociological Theory, a section of the journal Frontiers in Sociology

Received: *15 April 2021*
Accepted: *23 August 2021*
Published: *27 September 2021*

Citation:
Alfonso A and Camargo Molano J (2021) The Cage Case. Arts and Social Neuroscience. Front. Sociol. 6:695991. doi: 10.3389/fsoc.2021.695991

INTRODUCTION

We often consider an artistic work as an experience belonging to the humanistic, social or cultural dimension, ignoring the biological component that contributes to creating it.

Art originates primarily in the functions and structures of the nervous system, which not only guarantees the entire apparatus of perceptive and executive possibilities but also pre-constitutes the linguistic architecture of the artistic work.

Among all artistic disciplines, music seems to be the one able to involve, simultaneously and deeply, the largest number of cortical and subcortical networks. This contingency has led to numerous studies on the "ability of musical practice to impose itself not only as an operational model to investigate the functioning of the brain in its complexity, but also as an enriching experience in terms of psychic activity, even independently of the cultural dimension"[1].

This context is the starting point of the present research that analyzes the relationship between art and neuroscience. In particular, the analysis focuses on the work of John Cage, an artist who embodies the spirit of the avant-garde of the second half of the 20th century. Cage (1912–1992) is a central figure for any experience linked to contemporary experimentation. His work, which starts from the late surrealist rediscovery of Breton and Duchamp, ranges from *musique concrète* and aleatory music to dance, from Zen to theatre and media.

According to Semir Zeki's theories, artists act in the same way as neurologists who study the brain and its organization through their art. The function of the brain is to "grasp eternity in what is desperately transient"[2], a function similar to that of art which has always tried to show the true nature of things beyond mere reproduction. This was accentuated by the advent of the camera: photography could perfectly reproduce objects and individuals, but painting could overcome the mere representation of the visible and show the invisible essence of things. Citing the French critic Jacques Rivière, Zeki points out that "the true purpose of painting is to represent objects as they are in reality, not as we see them. Painting always tends to give us their perceptible essence, their presence and that is the reason why its images do not resemble their ever-changing appearance"[3].

Zeki's definition compares two temporal concepts: eternity and transiency. Can art make what is transient eternal and is there a more transient form of art than *happening*? To answer these questions, the research focuses on John Cage who can be considered the father of *happening* for his performance at Black Mountain College in 1952. (De Marinis, 1987; Bonomo, Furghieri, 1998; Sylvester, 2012; Amendola, Frammenti d'immagine. Scene schermi video per una sociologia della sperimentazione, 2006; Cuomo, Distasio 2013; Fronzi 2014; Cage 2015)

Furthermore, Cage's art is not an exclusively visual art; he staged musical experiments that stimulated the audience's hearing and performances that implied movements. According to the concept that there is not one single aesthetic sense, Cage's art can stimulate the different areas of the brain.

From neuroscientific studies, it has emerged that the inferior temporal cortex is the most involved part of the brain when an individual is observing or listening to a work of art, but it is not the only one. Art can involve the amygdala and, consequently, generate emotions. Therefore, art does not only make what is transient eternal, but also generates emotions.

Neurophysiologist Luciano Fadiga (2009); Fadiga (2019) associates the cerebral representations activated by art, in particular by music, with "a synaesthesia of a high order, which involves deep feelings, gives us the flavor of sensations and experiences, and makes the Spring by Vivaldi much more "spring" than the other three seasons of the same composition. This is due not only to the fact that the music sequence is in tune with the colors, scents, sounds of spring, but also to the fact that it evokes its movement, its destination"[4].

Fadiga's studies on music and on the areas of the brain activated at the moment of listening are in line with the work carried out by Cage, especially with regard to the analyses that the neurophysiologist carried out on the basis of Bukhard Maess studies. "By inserting unexpected harmonics Maess and co-workers created a sort of musical "syntactic" violation. Using magnetoencephalography (MEG), they studied the neuronal counterpart of hearing harmonic incongruity and they found an early right anterior negativity (ERAN) usually associated with harmonic violation"[5].

These studies revealed the similarity between the network of the human brain involved in the elaboration of music and that of language processing. In particular, when an individual is subjected to unexpected musical chords, such as those that characterise Cage's work, Broca's and Wernicke's areas, the superior temporal sulcus, Heschl's gyrus, plana polaris and temporalis, and the anterior superior insular cortices are activated.

The object of the introduction is to explain the point of view from which Cage's work will be analyzed in this paper which is organized as follows: *Materials and Methods* illustrates the sources and materials on which the research is based and the study methodologies used; *Results* analyzes John Cage's artistic output, starting from the 1952 *happening* at Black Mountain College, in relation with some avant-garde artists of the second half of the 20th century; *Discussion* examines Cage's work from a neuroscientific point of view.

MATERIALS AND METHODS

This essay can be defined a comparative research design, as the topic is analyzed from different points of view. In fact, the

[1]Piricò, M. L., and Rigamonti, M. (2015). "La musica e le neuroscienze cognitive ed affettive: ricadute pedagogiche e scolastiche," in Scuola Ticinese (Anno XLIV -Serie), IV. Bellinzona: DECS, 132, 55–59.

[2]Zeki, S. (1999). Inner Vision. An Exploration of Art and the Brain. New York: Oxford University Press

[3]Ibid.

[4]Fadiga, L. (2019). Preface in Neuroscienze cognitive della musica. Il cervello musicale tra arte e scienza. Bologna: Zanichelli

[5]Fadiga, L., Craighero, L., D'Ausilio, A. (2009). "Broca's Area in Language, Action, and Music", in The Neurosciences and Music III—Disorders and Plasticity: Ann. N.Y. Acad. Sci. 1169: 448–458 (2009). doi: 10.1111/j.1749-6632.2009.04582.x

research is not limited to the artistic world, but it is also extended to the sociological and neuroscientific fields. The methodology used followed the phases as listed below:

Reconstruction of the Object of Study Through Sources

The study is based on reports and analyses of Cage's work. In particular, the sources consulted to study *happening* as an artistic phenomenon are the volume *Happening* by M. Kirby (1968) and "*Qualcosa deve succedere*" in *Nuovo teatro 1947–1970* by De Marinis (1987).

To understand the influence of Cage on the system of arts, important materials for the analysis are A. Amaducci (2014), *Videoarte. Storia, autori, linguaggi*, V. Valentini (2015), *Nuovo teatro made in Italy 1963–2013*, A. Amendola (2006), *Frammenti d'immagine. Scene schermi video per una sociologia della sperimentazione*, and A. Amendola (2012), *Videoculture. Storia, teorie ed esperienze artistiche dell'audiovisivo sperimentale.*

Correlation Between the Object of Study and the Historical-Cultural Context

It was essential to set Cage's work in the historical era in which the artist lived. Even in this case, the analysis was conducted through sources. As regards Oskar Schlemmer (1888–1943), Walter Adolph Gropius (1883–1969) and the other Bauhaus masters, the reference text is *Bauhaus* by Wingler, (1969), as well as the materials produced within the same school of art. For a reflection on the Bauhaus in contemporary society, the reference texts are A. Amendola and Camargo Molano, (2019), *Bauhaus, un'idea di sperimentazione*, and J. Camargo Molano (2021), *Bauhaus 2.0*.

Insertion of the Object of Study in Schemes and Categories

This research aims to read John Cage's work from a neuroscientific viewpoint. The innovative element of this study lies in the distinct perspective in reading Cage's work.

In the neuroscientific field, the main references are the studies conducted by Eric Kandel and Semir Zeki. Analyzing John Cage's artistic output, the research tries to adopt the same method used by Zeki in examining the receptive field (Mondrian and Malevič), kinetic art, neurology of abstract and figurative arts in *Inner Vision. An Exploration of Art and the Brain* (1999). The comparison with the most recent research in this sector was also very important. In particular, the studies of Stefan Koelsch (2009), Roger Beaty et al. (2014), Dennis Ramirez (2015), Davis Bashwiner et al. (2016), Kenneth Heilman (2016) and Wolfgang Mastnak (2020) were taken into consideration.

Discussion on the Results

The neuroscientific reading of Cage's work is studied and compared with recent theories on the relationship between music and human brain. This process leads to a reflection on what was analyzed.

RESULTS

It was the year 1952. John Cage's sound experiments and aleatory music were already well known. He had founded his orchestra of percussion instruments only, created compositions for "prepared piano", mixed extra-artistic objects in his musical production and revolutionized dance in collaboration with Merce Cunningham. Moreover, he had researched noise, silence and rejection of harmony and established his own orientation in the history of music towards the work of Henry Cowell and Edgard Varèse. In particular, he made it clear that music holds a continuous dialogue with all arts.

This section deals with the sensational *happening* that took place at Black Mountain College in North Caroline in the summer of 1952. It is a work rich in ideas, elements, procedures, proposals, language research, interference, quotations, games and fragmentations which characterize a large part of the subsequent media and stage experimentation. The stars M.C. Richards, Charles Olsen, David Tudor, Robert Rauschenberg and Merce Cunningham led by Cage, dressed in black, came on stage. This great event of the distant summer of 1952 was characterized by a free, albeit coherent explosion of linguistic forms that, starting from sound, ranged from painting to music, from cinema to improvisational gestural-instinctive theatre. Different languages and actions interacted with each other in fragmented scenes, creating a new dimension that had little to do with conventional theatre. The show, which was not staged by any director, had no guide and offered scenes full of irony and daring improvisation. It aimed at an experimental communication in which the language was of an auditory and visual nature. This is the aim of every *happening*: an expressive construction involving both the sense of hearing and that of seeing. Cage offered "a puzzle made of gestures, matters and noises"[6]. He invented a very innovative form of artistic expression. From then on, nothing was the same as before. In fact, the main and most significant experiences of *happening* show a continuous fragmentation of environments, cultural attitudes, linguistic constructs and trends. Recurring themes of this form of art are action, redundancy, repetition and difference. *Happening* uses a range of different spaces (art galleries, squares, beaches, warehouses), rejects any concert-theatre logic and creates irruptions, variations, new systems and forms. This triumph of fragmented creativity, which only an inattentive individual would identify as "chaos" without grasping the innovations of such creative experiences, is not an end in itself, or the result of a disorganized planning. *Happening* is characterized by a disrupted and not completely defined nature. It is a work in progress, "but this does not mean that happening has no structure"[7]. Its structure is based precisely on disruption, readaptation, contamination, new creativity.

It should be noted that some experiments had already appeared in the field of music research a few decades earlier. Among the abundant traces left by the historical avant-garde or

[6]Puppa, P. (1990). Teatro e spettacolo nel secondo Novecento. Roma-Bari: Laterza, p.268

[7]Kirby, M. (1968). Happening. Bari: De Donato, p.16

even before, two names are noteworthy: Arnold Schönberg and Oskar Schlemmer. But it is also necessary to go back to Richard Wagner, whose vision includes the unification of all arts in *Gesamtkunstwerk*, a total art work. With *Der Ring des Nibelungen*, Wagner aimed *to bring the unconscious part of human nature to the level of consciousness* through the symbolism of theatrical actions, through an iconography that can be compared to a sort of interface design, where every sound motif reminds the spectators of an emotion, a concept, a character, an event. Schönberg tried to define *Gesamtkunstwerk* as a possible way to synthesize the totality of "musikdrama" in an abstract form of expression. It is no coincidence that *Die Glückliche Hand* was composed (1912–1913) in the same years in which Kandinsky painted his first pictures. Schönberg's work, which expresses the moody visions of a man tormented by a continuous spiritual search, incorporates unprecedented stage techniques. Examples of these techniques include: a menacing choir of statues, mimic gestures illuminated by spotlights with a "ghost" effect and accompanied by mysterious chords, a rapid crescendo of lights together with changeable music structures through a series of fast, synchronized beats written on the score. Walter Gropius's vision of theatre broke the scheme of the "spatial separation" between stage and auditorium with the aim of identifying an interactive medium that made the spectator participate in the play on the stage. Moholy-Nagy, continuing in the same direction and staging his mechanistic visions, created a synthesis between forms and movements, lights and sounds, colors and aromas. At the same time, Schlemmer planned performances based on the spatial dimensions of the human figure. *Circus* and variety entertainments combined with theatre and oriental puppets allowed him to create the new form of the theatre of illusion. Schlemmer's thought focused not only on the human figure but also on the extension of the spatial dimensions of the stage. *Das Triadisches Ballet* embodies Schlemmer's vision of *Gesamtkunstwerk*, a symbiosis of geometric elements influenced by machine technology and architecture, as well as by Kandiskian shapes and colors. The triad is made up of "t*he three parts of architectural composition and the fusion of dance, costumes and music*"[8]. The mechanistic choreography derives from the author's passion for machines. And the actors? They are nothing more than dolls moving in a music box. On the stage, the geometric environment is balanced by joyful rhythms and bright colors and expands beyond the boundaries imposed by stage machinery. The multidisciplinary language is precise, coherent and abstract. As Schlemmer said, the stage, as an arena for progressive and transient actions, offers shapes and colors in motion. At first, they are showed in their primary aspect as separate and individually mobile entities, colored or uncolored, linear, flat or plastic and subsequently as transformable architectural structures, mobile and floating spaces. Such a kaleidoscope, that is both infinitely variable and tightly organized, would theoretically represent the absolute visual stage.

Besides these influences, it is worth mentioning the fact that, in the course of his experimentation, Cage also approached oriental philosophies becoming a Zen master. This knowledge of Zen emerges especially in Cage's collaboration with the choreographer Merce Cunningham. "The collaboration of Merce Cunningham and John Cage brings together two art forms using minimalism and indeterminacy. Cunningham's choreography explores the use of repetition and chance, Cunningham also used the I Ching (traditional Chinese text considered by Confucius to be the book of wisdom) that was passed along by Cage"[9]. The element that unites Cunningham's choreographies and Cage's works is chance: "His method of dance compositions in which the scenic designer, the composer, and the choreographer each worked independently of one another, knowing the climate of a dance but not its particulars"[10]. The two artists worked separately, Cage did not see Cunningham's choreography and likewise Cunningham did not listen to Cage's compositions. "By using "dancers" with no prior dance experience, Cunningham was able to teach them new movements without having preset movements in their body Performers now become audience members and audience members now become performers. Everyday people, not dancers, are asked for, hoped for. For the possibility of chance choreography, that new ideas not set movement would be expanded upon. The element of chance which has no real mood, meaning, and never a beginning or an ending thought was the biggest idea brought to concert dance. Nothing has to be or needs to be done for a reason. The music doesn't drive the dance and the dance doesn't persuade the music"[11].

Dance plays a fundamental role in Cage's work and it is also a point of reference in the neuroscientific framework of the artist's activity. In particular, studies by Julia F. Christensen and Beatriz Calvo-Merino (2013) analysed which and how different areas of the brain are activated when a subject attends a dance performance.

[12]demonstrated that the perception of emotion expressed through bodily actions is related to activity in the superior temporal sulcus, recuneus and geniculate nucleus. Observing the emotional body movements of musicians performing a piece of music - shown in silence, without the music - also increases activity in the inferior parietal gyrus, insula and anterior cingulate cortex[13].

[8]Schlemmer, O. (1996). The theater of the Bauhaus. Baltimora: John Hopkins University Press

[9]Morrison, J. M. (2005). "The Effects of Minimalism/Indeterminacy on the Merce Cunningham and John Cage Collaboration" in The Journal of Undergraduate Research (JUR) at Minnesota State University, volume 5, p.4

[10]Kostelanetz, R. (1992) Merce Cunningham: Dancing in Space and Time. Atlanta: A Cappella Book, p.2

[11]Morrison, J. M. (2005). "The Effects of Minimalism/Indeterminacy on the Merce Cunningham and John Cage Collaboration" in The Journal of Undergraduate Research (JUR) at Minnesota State University, volume 5, p.6

[12]Van den Stock, J., Tamietto, M., Sorger, B., Pichon, S., Grézes, J., & deGelder, B. (2011). "Cortico-subcortical visual, somatosensory, and motoractivations for perceiving dynamic whole-body emotional expressionswith and without striate cortex (V1)" in Proceedings of the National Acad-emy of Sciences, USA, 108,16188–16193. doi:10.1073/pnas.1107214108

[13]Petrini, K., Crabbe, F., Sheridan, C., & Pollick, F. E. (2011). "The music ofyour emotions: Neural substrates involved in detection of emotionalcorrespondence between auditory and visual music actions" in PLoS One, 6, e19165. doi:10.1371/journal.pone.0019165

The identification of the emotion expressed in point views of human emotional movements is accompanied by increased activity in the EBA [14]. The observation of whole-body emotional gestures is also related to increases in the activity in the EBA, as well as the ventral striatum [15,16].

The musical discourse, as a project of fragmentation of the scene and not only of the scene, held an absolute supremacy in the following decades. It contributed to developing a combination of formal and informal language, from which mass-media drew their terminology, fragmentation and reproduction as key elements of *happening*, and theatre as a fusion of genres and experiences. Thanks to Cage's "creature", *happening* materializedd a sound-stage-vision experimentation that affected theatre, media and art.

A reading, which is certainly outdated today, considered this form of art to be closely linked to certain forms of psychiatric therapy such as psychodrama. The "genre" was particularly influenced by the techniques used by Stanislavski in rehearsal to free actors from any inhibition and drive them to completely identify themselves with their characters. In the United States, a group of movie and theatre directors and actors (Elia Kazan, etc.) were attracted by these techniques, which they used to create successful films and plays through improvisation or free "expression". It is probable that *happening* was influenced by the so-called *theatre of the absurd* and by some of Brecht's experiments. It is clear that *happening* was only analyzed as a theatre product, ignoring the visual elements which were present in its fragmentation.

Today's reader realizes that the 1952 *happening* and subsequent similar experiences are rich in socio-cultural elements, beginning from visual experimentation (action painting, new dada and subsequently pop-art) to the way of thinking about the function of theatre as a marked contamination of forms and styles.

The experimentation of *happening* can be better read through the magnifying lens of the historical avant-garde: from the editing of Futurism to the Dadaist improvisations of the Cabaret Voltaire in Zurich and to the surrealist exhibitions animated by Marcel Duchamp, from the structural technicality of the Bauhaus to the assemblages of Pop-art, and even *musique con*crète and serialism, avant-garde cinema, dance, poetry. It is therefore necessary to go back to the 1952 *happening* coordinated by Cage, which appears to be the most indicative moment of a new form of expression based on interrelation and fusion. Cage's "concerted action" at Black Mountain College was not only an event that immediately became so famous that it is always mentioned, in more or less mythical terms, in any speech on the origins of the artistic neo-avant-garde in America, but also a synthetic anticipation of almost all the most important elements that characterize the proposals of the new theatre (American theatre and otherwise). Such elements are the participation of different artists (musicians, dancers, poets, painters), the type of actions, the way of organizing the space where these actions take place and the relationship between the artists on the stage and the public. Obviously, Cage continued carrying out his experiments throughout his career, influencing different sectors of the world avant-garde within and beyond the music field, including art, cinema, theatre, dance and many other spheres.

DISCUSSION

On the basis of his research, Eric Kandel asserts that "the reductionist approaches of scientists and artists are analogous: they both aim at the bases, at the nervous[17] (Reductionism in Art and Brain Science, 2016).

Artists perform the same action of reductionism as scientists, but they do it with a different purpose: "while scientists use reductionism to solve complex problems, abstract artists exploit it to elicit a new perceptive and emotional response"[18].

The emotion caused by observing or listening to a work of art is determined by the centers of affectivity and emotivity in the limbic system. According to Kandel's studies, it is possible to state that every perceptive, emotional, mental or motor process is based "on distinct groups of specialized neuronal circuits located according to an ordered hierarchical arrangement in specific regions of the brain. The brain structures are anatomically and functionally linked to each other and therefore cannot be physically separated"[19]. It follows that art influences all the other categories of conscience and is influenced by them.

The analysis of Cage's work fits into this theoretical framework. First of all, it is necessary to highlight that Kandel's studies mainly focused on visual art, especially painting, a branch of art to which John Cage does not belong. Cage's work is tipically musical, although the visual component of his works should not be absolutely neglected (just think of the 1952 *happening* at Black Mountain College).

Unlike the "visual brain" which consists of various areas, each of which is specializied in a specific function, the human brain does not have a single "music center". Listening to music involves different networks distributed throughout the brain.

From the studies of Oliver Sacks (2011) it emerges that listening to music is not only an auditory, but also an emotional and motor experience. But the fundamental element in the analysis of music and consequently of Cage's work, from a neuroscientific perspective is memory. "Much of what happens during the perception of music

[14]Atkinson, A. P., Vuong, Q. C., & Smithson, H. E. (2012). "Modulation ofthe face- and body-selective visual regions by the motion and emotion ofpoint-light face and body stimuli" in NeuroImage, 59,1700–1712. doi:10.1016/j.neuroimage.2011.08.073

[15] Peelen, M. V., & Downing, P. E. (2007). "The neural basis of visual bodyperception" in Nature Reviews Neuroscience, 8,636–648. doi:10.1038/nrn2195

[16]Christensen, J. F., & Calvo-Merino, B. (2013). "Dance as a subject for empirical aesthetics" in Psychology of Aesthetics, Creativity, and the Arts, 7(1), 76–88. https://doi.org/10.1037/a0031827

[17]Kandel, E.R. (2016). Reductionism in Art and Brain Science. New York: Columbia University Press

[18]Ibid.

[19]Ibid.

can also take place even when it is played in the mind. The imagination of music, even in relatively unmusical individuals, tends to be very faithful to the original: not only in melody and sentiment, but also in absolute pitch and time. At the basis of all that there is the extraordinary tenacity of music memory"[20].

As stated by Stefan Koelsch[21], listening to music activates mirror neurons: "mirror neurons are active during both perception and action, auditory working memory relies on sensorimotor codes that encode and maintain information, syntactic processing of music involves brain structures also involved in speech production, and the premotor cortex also serves a variety of cognitive tasks, such as working memory sequencing, and serial prediction."

The cortical areas in charge of vision make use of two processes that Zeki calls *bottom-up* and *top-down*. The bottom-up process is based on higher-order mental and cognitive functions, first of all on memory, but also on attention, expectations and learned visual associations. The *top-down* process involves a creative task since the visual brain is required to integrate and complete the information that comes from the outside and is ambiguous or incomplete. For this reason, Kandel believes that the process activated by observing or listening to a work of art is a *top-down* process: the more ambiguous or essential the image is, the more active the observer's imagination is.

Zeki comes to sthe same conclusion by carrying out a comparative analysis between abstract art and figurative art. "The works of art in conflict with the ordinary experience of the visual world - for example Magritte, De Chirico or Max Ernst - intensely involve the parts of the frontal lobe that are also activated by the paintings of the Fauves. In these works there is a conflict to be solved, that is the conflict between the present vision and the records of past experiences, and it seems that the frontal lobe is involved in this task"[22].

Therefore, the analogy with Cage's work is evident. John Cage offered his audience some new, unexpected sounds, different from what they had known until then. In observing a work of abstract art or listening to a work by Cage, the brain is required to perform that function that Kandel defines as a creative function. Observing shapes or listening to sounds that seem not to be part of his/her memory, an individual has to make an effort to decrypt, but above all, to complete the information he/she receives. Each individual will complete the information on the basis of his/her memory, reacting to observing or listening to the same work in a different way.

The creativity, which generates the work of art, also generates creativity in the public. It creates a circular link in which art and the public interact: art, as works originated by artistic gestures, makes the public, who enjoy them, artists, albeit within their own brain.

Neuroscience studies creativity through the underlying brain mechanisms (Heilman, 2016) and the dynamics of the brain network (Beaty et al., 2016).

Beaty asserts that creativity is based on the interactivity of different regions of the brain that define the default mode network (DMN), which is made up of the posterior cingulate cortex, the precuneus, the medial prefrontal cortex, the angular gyrus and the hippocampus.

Wolfgang Mastank[23] thinks that DMN can be considered a form of inner intelligence, highly sensitive to music. For this reason it should be developed through an adequate musical education. This theory is shared by Bashwiner et al. (2016), who considers that "musically creative people have greater cortical surface area or volume in 1) regions associated with domain-specific higher-cognitive motor activity and sound processing 2) domain-general creative-ideation regions associated with the default mode network and 3) emotion-related regions These findings suggest that domain-specific musical expertise, default mode cognitive processing style, and intensity of emotional experience might all coordinate to motivate and facilitate the drive to create music"[24].

From the analysis conducted, it emerges that John Cage's work can be read from several points of view that, in some cases, intersect and influence each other.

Cage's innovations are a cornerstone of the avant-garde of the 20th century. His experimentation influenced the history of music both of his period and the subsequent time. His innovative impetus can be also studied from a social point of view with the aim of understanding how Cage was able to revolutionize the world of art and his society.

Finally, the setting of Cage's work in a neuroscientific context is grafted onto the broader scenario of contemporary research regarding the perception of music by the human brain. This analysis can be the starting point for revising the great masters of the avant-garde of the 20th century and reading their works in a different perspective.

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

AA analyzed Cage's work by placing it in the context of the avant-garde. JC placed Cage's work in the neuroscientific context.

[20]Sacks, O. (2011). Musicophilia: Tales of Music and the Brain. London: Pan Edition

[21]Koelsch, S. (2009). "A Neuroscientific Perspective on Music Therapy" in The Neurosciences and Music III—Disorders and Plasticity: Ann. N.Y. Acad. Sci. 1169, p. 374–384

[22]Zeki, S. (1999). Inner Vision. An Exploration of Art and the Brain. New York: Oxford University Press

[23]Sangiorgio, A., Mastnak, W. (2020). Creative Interactions. Dynamic Processes in Group Music Activities. Munich: University of Music and Performing Arts Munich

[24]Bashwiner, D.M., Wertz, C.J., Flores, R.A., & Jung, R.E. (2016). "Musical creativity "revealed" in brain structure: Interplay between motor, default mode, and limbic networks" in Scientific Reports, 6, 20482

REFERENCES

Amaducci, A. (2014). *Videoarte. Storia, Autori, Linguaggi*. Torino: Kaplan.

Amendola, A. (2006). *Frammenti D'immagine. Scene Schermi Video Per Una Sociologia Della Sperimentazione*. Napoli: Liguori Editore.

Amendola, A. (2012). *Videoculture. Storia, Teorie Ed Esperienze Artistiche Dell'audiovisivo Sperimentale. Latina: Tunué*.

Amendola, A., and Camargo Molano, J. (2019). ""Bauhaus, un'idea di sperimentazione"," in *Filiberto Menna. Progettare Il Futuro*. Editors N. Martino and A. Tolve (Roma: Arshake).

Beaty, R. E., Benedek, M., Wilkins, R. W., Jauk, E., Fink, A., HodgesSilvia, D. A., et al. (2014). Creativity and the Default Network: A Functional Connectivity Analysis of the Creative Brain at Rest. *Neuropsychologia* 64, 92–98. doi:10.1016/j.neuropsychologia.2014.09.019

Beaty, R. E. (2015). The Neuroscience of Musical Improvisation. *Neurosci. Biobehav Rev.* 51, 108–117. doi:10.1016/j.neubiorev.2015.01.004

Beaty, R. E., Benedek, M., Silvia, P. J., and Schacter, D. L. (2016). Creative Cognition and Brain Network Dynamics. *Trends Cogn. Sci.* 20 (2), 87–95. doi:10.1016/j.tics.2015.10.004

Camargo Molano, J. (2021). *Bauhaus 2.0*. Salerno: Edizioni FdA.

De Marinis, M. (1987). *Il Nuovo Teatro 1947-1970*. Roma: Bompiani.

Heilman, K. M. (2016). Possible Brain Mechanisms of Creativity. *Arch. Clin. Neuropsychol.* 31 (4), 285–296. doi:10.1093/arclin/acw009

Proverbio, A. M. (2019). *Preface in Neuroscienze cognitive della musica. Il cervello musicale tra arte e scienza*. Bologna: Zanichelli.

Ramirez, D. (2015). *Default Mode Network (DMN): Structural Connectivity, Impairments and Role in Daily Activities*. Hauppauge: Nova Science Publishers.

Valentini, V. (2015). *Nuovo Teatro Made in Italy 1963-2013*. Roma: Bulzoni.

Wingler, H. M. (1969). *Bauhaus: Weimar, Dessu*. Berlin, ChicagoCambridge: MIT Press.

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.

frontiers in Behavioral Neuroscience

REVIEW
published: 04 January 2022
doi: 10.3389/fnbeh.2021.814796

Contributions of Socioneuroscience to Research on Coerced and Free Sexual-Affective Desire

Sandra Racionero-Plaza, Lídia Puigvert, Marta Soler-Gallart and Ramon Flecha*

Department of Sociology, University of Barcelona, Barcelona, Spain

Neuroscience has well evidenced that the environment and, more specifically, social experience, shapes and transforms the architecture and functioning of the brain and even its genes. However, in order to understand how that happens, which types of social interactions lead to different results in brain and behavior, neurosciences require the social sciences. The social sciences have already made important contributions to neuroscience, among which the behaviorist explanations of human learning are prominent and acknowledged by the most well-known neuroscientists today. Yet neurosciences require more inputs from the social sciences to make meaning of new findings about the brain that deal with some of the most profound human questions. However, when we look at the scientific and theoretical production throughout the history of social sciences, a great fragmentation can be observed, having little interdisciplinarity and little connection between what authors in the different disciplines are contributing. This can be well seen in the field of communicative interaction. Nonetheless, this fragmentation has been overcome *via* the theory of communicative acts, which integrates knowledge from language and interaction theories but goes one step further in incorporating other aspects of human communication and the role of context. The theory of communicative acts is very informative to neuroscience, and a central contribution in socioneuroscience that makes possible deepening of our understanding of most pressing social problems, such as free and coerced sexual-affective desire, and achieving social and political impact toward their solution. This manuscript shows that socioneuroscience is an interdisciplinary frontier in which the dialogue between all social sciences and all natural sciences opens up an opportunity to integrate different levels of analysis in several sciences to ultimately achieve social impact regarding the most urgent human problems.

Keywords: socioneuroscience, neurosociology, social sciences, sociology, gender violence, social impact, communicative acts, social interaction

OPEN ACCESS

Edited by:
Vincenzo Auriemma,
University of Salerno, Italy

Reviewed by:
Ana Vidu,
University of Deusto, Spain
Ester Miranda,
Ordine Degli Psicologi Della Regione Campania, Italy
Ivana Ferrara,
Ordine Degli Psicologi Della Campania, Italy

****Correspondence:***
Marta Soler-Gallart
marta.soler@ub.edu

Specialty section:
This article was submitted to Individual and Social Behaviors, a section of the journal Frontiers in Behavioral Neuroscience

Received: *14 November 2021*
Accepted: *09 December 2021*
Published: *04 January 2022*

Citation:
Racionero-Plaza S, Puigvert L, Soler-Gallart M and Flecha R (2022) Contributions of Socioneuroscience to Research on Coerced and Free Sexual-Affective Desire. Front. Behav. Neurosci. 15:814796. doi: 10.3389/fnbeh.2021.814796

NEUROSCIENCE ASKS THE SOCIAL SCIENCES

Neuroscience has already demonstrated the influence of social experience and social action on the constitution of the brain (Kentner et al., 2019). Santiago Ramón y Cajal (1989), known as the father of modern neuroscience, already suggested it when he said that each person can, if s/he wants to, be the architect of her/his own brain.

The capacity of the brain to change with social experience and action builds upon the hypothesis of brain plasticity, first coined also by Ramón y Cajal (Kandel, 2006), and which is today one of the cornerstones of neuroscience. Brain plasticity refers to the ability of synapses, neurons, and entire brain regions to change their properties in response to use or to different profiles of stimuli (Ramón y Cajal, 1959; Kandel et al., 1991; Kandel, 2006). Eric Kandel, another Nobel Laureate in the field, and one of the most prominent figures in neuroscience today, has also published that "even though I had long been taught that the genes of the brain are the governors of behavior, the absolute masters of our fate, our work showed that, in the brain as in bacteria, genes also are servants of the environment. They are guided by events in the outside world (p. 154)". Research on twins with identical genes is among the most powerful in showing the influence of experience on the brain, as such studies demonstrate that differences in brain architecture in twin siblings are the result of life trajectories that differ in social experiences and social interactions (Bouchard et al., 1990; Kandel et al., 1991; Kandel, 2006).

Today, there are several studies, particularly in the field of adversity in development, that have proven the ability of social experience to shape the brain. Neuroscientific research (Eluvathingal et al., 2006; Behen et al., 2008) of children raised with little social stimuli and children who are victims of abuse and neglect are particularly enlightening about the negative impact of deprivation of quality social interaction in both brain architecture and brain functioning with subsequent implications that those neural changes can have in deteriorating mental and physical health (Kathryn, 2019; Callaghan et al., 2019). Linking with Kandel's idea that genes are servants of the environment, studies in epigenetics have proven that the epigenome can be influenced by environmental factors, such as toxic stress derived from violent social experiences, and can end up producing phenotypes and be inherited (Zhang and Meaney, 2010; Hayes, 2018). Along this line, research in animals and humans has shown that traumatic experiences in parents, in particular, emotional trauma, may change their children's biology (Kaiser, 2014; Curry, 2019). Despite this science still being young, and many questions remain open to exploration, the hypothesis that an individual's experience might alter the cells and behavior of their children and grandchildren, that our own actions and experiences could biologically affect the lives of our children, puts a very different spin on how we choose to live and also to the decisions that we make throughout life.

Importantly, all this research has evidenced that the ability of the brain to change its properties as a result of environmental stimuli can have two different directions, for the good and for the bad. That is, while some social stressors harm the brain, quality human relationships and quality social experiences benefit the brain. In this sense, longitudinal neuroscientific research on human development, among which the Harvard Adult Development Study stands out, evidences that quality human relationships are better predictors of a healthier, longer, and happier life than genes, IQ or socio-economic status (Waldinger and Schulz, 2010; Harvard Second Generation Study, 2021). That people with better relationships have healthier brains and stronger biological profiles is now well evidenced.

SOME SOCIAL SCIENCES' CONTRIBUTIONS TO NEUROSCIENCE

In the inquiry into brain plasticity and neural development, neuroscience has embraced contributions from the social sciences. As an example, Eric Kandel, in his seminal book "Principles of Neural Science" (1991) and in "In search of memory" (Kandel, 2006) mentions the behaviorists several times. In particular, he refers to Pavlov, Thorndike, and Skinner and their investigations on reflexive learning as crucial in informing the neuroscientific understanding of implicit memory (Kandel, 2006). Kandel explicitly writes that William James, Thorndike, Pavlov, Skinner, Ulric Neisser, and Freud, who had investigated learning and memory, influenced his work considerably: "Their thinking, and even their errors, provided a wonderfully rich cultural background for my later work" (Kandel, 2006).

The contributions of the social sciences to neuroscience can also be seen in neuroscientific research looking at the effects of adversity, violence, and stress on the brain, and its mitigation. A good example of this is that of the collaboration between the Nobel Laureate Elisabeth Blackburn, and Elissa Epel, a psychologist. Blackburn (1991, 2005) and Armanios and Blackburn (2012) had investigated that poor sleep quality, absence of exercise, unhealthy diet, and even certain chemicals profoundly affect our telomeres, shortening them, meaning an acceleration of the cellular oxidation. This oxidation implies an acceleration of the biological aging of the individual which, in turn, implies an increased likelihood of alterations in immune function and increases in inflammatory markers, which are known to be associated with poorer health outcomes. Yet in looking at the telomere data also from a psychological perspective, attending to socio-economic and socio-cultural factors, but especially to strained and toxic relationships, Blackburn and Epel saw that such relationships produced negative thoughts and chronic stress that also shortened the telomeres (Blackburn and Epel, 2017). Thus, knowledge from clinical and developmental psychology made it possible to make new and complementary meanings of the data, achieving a deeper understanding of telomere functioning and the influence of quality relationships on it *via* the mediation of emotional states.

One more example of contributions of the social sciences to neuroscience is in the field of studies on the neurobiology of attachment (Buchheim et al., 2017). The psychological theory of attachment (Bowlby, 1969, 1982) described attachment as lasting psychological connectedness between human beings (Bowlby, 1969), an emotional bond with another person. Given that humans are social, attachment plays a crucial role in healthy development in any person throughout life. The behaviorists suggested that attachment was a learned process, mostly dependent on feeding. But Bowlby and others proposed that children are born with an innate motivation to form attachments with caregivers. Depending on how social interactions are between babies and caregivers, mostly in terms of responsiveness

and availability, different types of attachment emerge, mostly four, with different implications for the social development of the person and her mental health (Lyons-Ruth, 1996; Young et al., 2019). When primary caregivers are available and responsive to the infant's needs (secure attachment type), then the child acquires a secure base from which to explore the world and other relationships. Contrarily, when secure attachments are not formed early in life, behavior in later childhood and throughout life (Young et al., 2019) can be negatively affected. Neuroscience has embraced this knowledge, for example, in the investigation of the neurobiological implications of impaired early attachment for emotion regulation in abused and neglected children. A famous study in this area is the one on Romanian children raised in institutions during Ceaucescu's dictatorship in the 1990s, the English and Romanian Adoptees (ERA) study (Sonuga-Barke et al., 2017). These children were abandoned as babies and brutally neglected. Studies employing neuroimage demonstrated that the absence of caring and responsive relationships led to shrunken brains and a number of neural alterations in these children (Sonuga-Barke et al., 2017). Likewise, in light of psychological studies on the positive impact of quality human relationships throughout life (Dunkel Schetter, 2017; Pietromonaco and Collins, 2017), neuroscience has identified that "critical periods may be less restrictive than once thought; in some cases they can be extended or 'reopened'" (Kandel et al., 1991), this offering a very transformative view of the brain development of children who have suffered early life adversity (Canzi et al., 2018).

Sociology has also contributed knowledge to current research in cognitive and affective neuroscience. Sociological understandings about primary and secondary socialization (Berger and Luckmann, 1966) have been included in neuroscientific research on the important role that the peer group, and the quality of relationships in it, plays in brain development in adolescence (Telzer et al., 2015). Despite the contributions from the social sciences that the neural sciences have taken into account, they still demand more to make meaning of the many recent and very profound findings on the human brain in relation to social questions such as violence, poverty, racism, etc.

THE FRAGMENTATION OF THE SOCIAL SCIENCES

Social sciences have made, and are increasingly making, contributions promoting social impact (Aiello et al., 2020) in education (Rios-Gonzalez et al., 2019; Yeste et al., 2019; Duque et al., 2020; Ruiz-Eugenio et al., 2020b), ethnic and cultural minorities (Gómez et al., 2019; Khalfaoui, 2019; Garcia Yeste et al., 2020; Serradell et al., 2020), gender, sexuality and masculinities (Foraster and Morlà, 2019; Serrano Amaya and Ríos González, 2019; Merodio et al., 2020; Salceda et al., 2020), communication and digital media (Madrid et al., 2020; Pulido et al., 2020a,b; Rodríguez et al., 2020) or occupation and organizations (Campos et al., 2020; Mara et al., 2020; Redondo-Sama, 2020; Tellado et al., 2020), among others. However, when we look at the scientific and theoretical production throughout the history of social sciences, a great fragmentation can be observed, having little interdisciplinarity and little connection between what authors in the different disciplines are contributing. This is due to the myth that great production and contributions come from individual authors (Soler-Gallart, 2017).

An example of this fragmentation would be in language and interaction. During the 20th century, very relevant contributions have been made from psychology, especially with the work of Herbert Mead on social psychology in the concept of interaction (Mead, 1934, 1964). He proposed that animals only had conversations by gestures and that it is later in the evolution towards the human being when we move from gestures to symbols or signals, that is, to giving shared meaning to gestures and, hence, these become a symbol. Fire, for instance, is not only an indicator that the forest is burning, but it is also a form of communication through smoke signals between different human beings. Then, as these symbols become more complex, they are perfected and become languages. Hence, overcoming the dualism between the individual and society, Mead argues that the interactions between the individual and society form the individual, that the self is a reflection of those interactions. In his own words, "The 'I' is the response of the organism to the attitudes of the others; the 'me' is the organized set of attitudes of others which one himself assumes" (Mead, 1934, 175).

Simultaneously, in parallel and without any connection, another social science such as linguistics and specifically linguistic pragmatics, mainly with Austin (1962) and then his pupil Searle (1969), deepens on what language is and how human language works. These authors develop and make contributions to the theory of speech acts, that is, the role that language plays not only in human communication but in constructing social reality itself. Austin distinguishes between locutionary, illocutionary, and perlocutionary acts; to him, the locutionary act is any expression which has meaning, the illocutionary act constitutes the speaker's intention, and the perlocutionary act would be the action resulting from the act. Searle differs from Austin's conception by arguing that any act includes the speaker's intention and, therefore, does not distinguish between locutionary and illocutionary acts. Instead, Searle proposes the distinction between propositional content and illocutionary force, and adds that there is no perlocutionary act but, rather, the perlocutionary effect of a speech act.

On the other hand, and also in parallel and without any connection, in sociology, whose main author Max Weber (1978) already proposed that the animal only has reactive behaviors, we can see a parallelism with Mead's idea of gestures but without any connection between them. Weber goes on to explain that we go from animals' reactive behavior to human action, which is characterized by the meaning attributed to it. That is, the animal does not attribute meaning to its behavior, but the human being does, and social or collective actions are those in which several human beings participate and give that action a shared meaning.

The fragmentation of the social sciences cannot be sustained today; in order to provide contributions to science and, most importantly, for those contributions to achieve social impacts,

such contributions need to be globalized and in dialogue among the different sciences and disciplines.

THE CONTRIBUTIONS OF COMMUNICATIVE ACTS TO SOCIONEUROSCIENCE ON COERCED AND FREE SEXUAL-AFFECTIVE DESIRE

In the 21st century, an unprecedented scientific revolution is taking place, with citizens not only having access to knowledge but also to the co-creation of that knowledge, which overflows the watertight compartments that each science and even each author had been building from their contributions. Today, in order to improve individuals' lives and societies, we need important research groups and research networks that can contemplate interdisciplinary and global contributions. At this moment, the most advanced point is the dialogic turn that is taking place in societies and in the sciences themselves (Soler-Gallart, 2017; Torras-Gómez et al., 2019). Sciences are becoming increasingly dialogic, not only in establishing interdisciplinarity to contribute from all sciences to the research and creation of knowledge but also in engaging citizens in a co-creation process to produce knowledge (Soler and Gómez, 2020). This ever increasingly dialogic way of conducting science is contributing novel ways in which reality is understood, which in turn entails new ways of researching it.

Within this dialogic shift, the pivotal contribution is the theory of communicative acts (Searle and Soler, 2005; Soler and Flecha, 2010; Soler-Gallart, 2017) developed by the Community of Research on Excellence for All (CREA), which brings together all the contributions of the different social sciences relevant to understand and transform social reality. Yet the development of this theory is not simply a step forward; it is a true Copernican revolution because it globally addresses and gathers all the dimensions and contributions of what we human beings do, which is to communicate with communicative acts. Be it reading a book—as Kandel says, commenting on it, having a sexual relationship, voting, taking a class, participating in a seminar, participating in a musical concert, forming a family, having friendships, etc., all of this is done through communicative acts.

The theory of communicative acts advances and differs from speech acts in four important ways. On the one hand, whereas speech acts only take spoken language into account, communicative acts include any signs of communication in addition to words, such as body language, intonation, gestures, gaze, or context, among others. Second, unlike Austin's (1962) *illocutionary speech acts* which only include understanding, *illocutionary communicative acts* necessarily include the search for consensus. This understanding also differs from Searle (1969), as for him consensus is part of the *perlocutionary effect*, whereas, in the theory of communicative acts, the *perlocutionary effect* of an *illocutionary communicative act* is what is agreed upon by consensus. Hence, the objective of the *illocutionary communicative act* is not to achieve something, but for the people interacting to construct and achieve consensus, and its *perlocutionary effect* will be whatever they freely agree to do by consensus. Third, *illocutionary communicative acts* require a lack of coercion. However, lack of coercion is not a requirement for *perlocutionary communicative acts*. This means that for a communicative act to be illocutionary, seeking and reaching consensus is not enough; this consensus must be constructed free of coercion. Last, sincerity is not necessarily a requirement for *perlocutionary communicative acts*, but it is for *illocutionary communicative acts*. This does not mean that an action resulting from a *perlocutionary communicative act* cannot be achieved by consensus, or that this consensus cannot be based on sincerity and free of coercion. The difference, then, is that consensus is not a prerequisite for a *perlocutionary communicative act*, as its goal is to lead to action regardless of whether this action is achieved by consensus or not—and even if there is consensus, this might be achieved through lack of sincerity and through coercion. Yet for a communicative act to be *illocutionary*, the goal is to achieve consensus and whatever action results from that consensus, which needs to be constructed based on sincerity and free from coercion.

The theory of communicative acts provides us not only with information on how our human communication works but also on the typology of human communication according to the nature of these acts. This sheds light on which communicative acts favor human values, human rights, the Sustainable Development Goals, the purely human progress, and which communicative acts not only do not collaborate in this progress but harm and attack it, playing a crucial role in society's and science's concern for advancing towards the former and overcoming the latter. This framework, thus, allows researchers from all sciences to analyze reality by taking into account all elements of communication, many of which have been overlooked by authors in the social sciences due to the aforementioned fragmentation. By integrating contributions from different sciences, the theory of communicative acts overcomes the imposed speech-body language dichotomy:

> *The concept of communicative acts enables us to overcome the dualism that opposes speech and body language, intellect and emotions, soul and matter. Communicative acts include all dimensions of people, both what for some is the language of the mind and what for others is the language of the body. Communicative acts include words, tones of voice, looks, caresses, smells, like-nesses, desires, emotions, feelings, etc. They may be separately considered for analytical purposes, but we must always consider they are interrelated in the social reality.*
>
> *(Soler-Gallart, 2017, 30)*

In order to better understand reality and contribute to transforming it, the theory of communicative acts has established a typology of *dialogic communicative acts* and *power communicative acts*. *Dialogic communicative acts* are those based on illocutionary communicative acts and in which dialogic interactions prevail. This does not mean that, even when a male boss and a female employee have a dialogic relationship, one in which both freely share actions, feelings, and desires, there are no power interactions such as the social structure involved. Indeed, in dialogic relationships, there are often power-based interactions, but dialogic ones predominate. On the contrary,

communicative acts of power are those in which interactions of power prevail, and they include perlocutionary communicative acts aimed at certain actions. This conceptualization of *dialogic communicative acts* goes beyond (Habermas, 1984, 1987) validity claims and becomes more useful when determining when a relationship is based on equality and freedom or on violence. On the one hand, communicative acts not only analyze a person's claim, but also other elements of the communication such as the social structure in which that claim is said. On the other hand, focusing solely on the claim means only taking into account the speaker's intention. Yet using and extending Weber's (1930) ethics of responsibility, the overall consequences of the communicative act—not only of what the speaker says but also, for instance, of the social structure in which it is said—are taken into account. Last, the theory of communicative acts understands dialogue by taking into account both the Apollonian—rationality—and Dyonisian—emotions, feelings, and desires—dimensions, whereas Weber's validity claims focus only on the Apollonian one.

The different communicative acts, whether they are of power or dialogic, are the ones that neuroscience knows are important for the formation of the brain. What neuroscience has not delved into is what types of communicative acts and interactions constitute one or the other. This is why the contribution of this typology allows neuroscience to study jointly with the human and social sciences how power or dialogic communicative acts influence the brain. In other words, how a power relationship in a couple in which there is psychological or even physical abuse towards a woman or a newborn child influences physical health, mental health, and the brain itself, and how a free, dialogic, satisfactory relationship influences it.

Sexual freedom and consent are increasingly approached by social sciences and discussed in our societies today. We have still not resolved, neither theoretically, nor socially or legally what constitutes consent in a relationship (Flecha et al., 2020). The motto "no means no" has already been substituted by "only yes means yes", implying that for there to be consent in a sexual relationship, there needs to be an affirmative, conscious and voluntary agreement by all the people involved in the relationship. However, current legal cases in which whether a sexual relationship is based on consent or not is being decided spotlight the need to go beyond words in this analysis. That is, a woman might say "yes" to a sexual relationship, but such a yes might be coerced by the man and/or the environment. In turn, two (or more) people who freely desire to have sex do not necessarily say "yes" to indicate their free desire. Desire might be expressed in different ways, not necessarily through words, and at the same time, words of consent might be expressed with no desire to actually engage in the relationship because the person feels coerced and pressured to do so. The theory of communicative acts, therefore, fills the gap of spoken language by shedding light on the different communicative acts which make a sexual-affective relationship one that is based on consent or on coercion. When analyzing consent—or lack thereof—in a sexual relationship, we need to take into account that, for instance, the context in which the communicative act is occurring might be embedded in institutional power. If a university professor makes a sexual proposal/proposition to a student while the two are revising an exam in the former's office, the student will not be able to give free consent, even if she provides it, and even if the professor's sincere aim is to obtain consent. The social hierarchy situates the professor in a power position in which he is in control of the student's grade and academic success. Following the ethics of responsibility, even if the professor does not intent to coerce the student by using his power to manipulate her grades and only wants to have sex with her if she freely desires so, he cannot ignore the social structures that grant him institutional power over the student, which impedes her from expressing her true desire. Hence, if we analyze the social context of the communicative act, we see that there is coercion even if the professor does not intend to coerce the student.

However, institutional power is not the only element impeding sexual freedom and lack of coercion in a given sexual relationship. The theory of communicative acts also takes into account interactive power, which refers to the power that interactions established among people provide. For example, a woman might agree to have sex with a man, even going to his home without the use of physical force, because if she does not her peers will keep reminding her she is the only virgin in the group or will ask her how long has it been since she last had sex.

These pressures from peers and from men with aggressive attitudes and behaviors are part of the coercive dominant discourse (CDD) that imposes the link between attraction and violent attitudes: "due to imbalanced power relationships between men and women, this coercive dominant discourse (e.g., through TV, teen magazines, social networks, popular media, among other things) influences many girls' and women's socialization into linking attractiveness to people with violent attitudes and behaviors" (Puigvert et al., 2019, 2). The theory of communicative acts provides socioneuroscience with a new lens to analyze how the communicative acts that configure the CDD shape the brain and, hence, shape coerced sexual-affective preferences and desires. Through different communicative acts of power, such a discourse forces women, especially adolescents and young girls, into believing that men with aggressive attitudes and behaviors are more exciting and attractive and that egalitarian men are nice but boring and not desirable. The CDD then configures and drives many girls' preferences and desires (Ruiz-Eugenio et al., 2020a), as not only are they pressured to have relationships (especially hook-ups) with these men, but also to tell their "friends" that they liked doing it, even when they did not (Torras-Gómez et al., 2020). By telling and retelling what they recognize to be a false narrative, they end up assuming such a discourse in their own coerced preferences and desires, becoming part of their own cognitive and affective schemata (Puigvert Mallart et al., 2019). In other words, when a girl hooks up for the first time with a boy with aggressive attitudes and behaviors because her friends tell her it is about time she hooked up with someone, she does not like it, she rejects it and is disgusted by it, she feels it is not what she expected or what her friends told her it would feel like. But because she has assumed the CDD deeply, when telling her friends what it was like, she feels that if she shares her true feelings, her friends will think—and say—she has no idea about sex and will laugh at

her. She thus assumes these feelings as her own problem and ends up telling them a different narrative, one in which the boy and the hook-up are portrayed as exciting. Such narrative becomes part of her autobiographical memory, and repeating it over and over again strengthens the synaptic connections that link the boy's despising and dominating attitudes with pleasure and excitement, normalizing despise and humiliation and finding lack of excitement when someone does not treat them that way (Puigvert Mallart et al., 2019; Ruiz-Eugenio et al., 2020a).

However, the theory of communicative acts also informs socioneuroscience on those dialogic communicative acts that contribute to freed sexual-affective desire. Just as power communicative acts socialize many women in linking attraction to violence, dialogic communicative acts can lead them to a process of re-socialization through dialogic contexts which are critical about the CDD, the narratives it imposes, and the coerced sexual-affective preferences and desires. Interventions that promote dialogic communicative acts to spark reflections about past violent relationships have been found to awaken critical memories. By remembering exactly what they felt during those relationships, by adopting a critical awareness of the way in which the CDD controlled their desire and behavior, women can transform their cognitive and affective schemata and dissociate pleasure from violent attitudes, thus freeing desire (Racionero-Plaza et al., 2020). Only through these dialogic communicative acts can individuals and communities "question and modify the cognitive and affective schemata imposed by the dominant coercive discourse, and thus think, feel, and choose in their intimate life by their own volition, and no by a volition also addicted to the dominant coercive discourse." (Puigvert Mallart et al., 2019, 212).

DISCUSSION

From Santiago Ramon y Cajal up to Eric Kandel and other prominent contemporary neuroscientists, neuroscience research has well evidenced that the neural system is greatly influenced and shaped by the social environment. Thus, it is now very clear from neuroscience that the human brain cannot be understood in a vacuum, outside the social world where the person develops. Consequently, it is not only that the human brain facilitates social processes, which is studied by social neuroscience, but also that social experience, social interaction, communication, different types and quality of human relationships, etc., shape the human brain. In turn, those brain changes affect the human experience, including how we feel, who and what is attractive, what is remembered and how, etc., questions that are central in the social problems that individuals and society face. The study of these bidirectional relations between social context and the human brain is the realm of analysis for socioneuroscience. Socioneuroscience takes into account scientific knowledge from all social sciences and all the natural sciences to study the relationships and interlinks between the human brain and human interactions. These interlinks can lead to good or bad directions, depending on which are the social interactions and relationships that individuals are surrounded by and engage in. Research in neuroscience has long had evidence that different interactions and communicative acts lead to very different outcomes. What neuroscience research still lacks is what are the interactions and communicative acts that lead to such different outcomes. This endeavor makes the important role that the social sciences play in neuroscientific studies clear.

Social sciences have made important contributions that have informed neuroscientific research. Kandel (2006), for instance, names several behaviorists as impacting neuroscience's understanding of implicit memory. Other contributions from social sciences have given neuroscientists a deeper and more nuanced understanding, for instance, of the environment on humans' telomeres (Blackburn and Epel, 2017) from clinical and developmental psychology, or of the role of peer groups and the quality of relationships in brain development from sociology (Telzer et al., 2015). However, if we look at the social sciences, we see a great fragmentation among the different disciplines and even among authors within the same discipline, following the false idea that relevant contributions come from individual authors. In spite of great contributions to understanding human communication and experience from authors such as Mead, Weber, Austin, or Searle, among others, the fragmentation within their fields and between their works hinders the further potential impact social sciences could have on neuroscience.

In order to respond to society's increasing demand that science has a clear social impact on the Sustainable Development Goals (SDG), social sciences need to engage in dialogues among themselves, as well as with the natural sciences, in order to deepen into very complex and profound processes that can help individuals and communities improve their lives. Socioneuroscience gathers all these contributions and engages them in dialogue in order to provide theoretical and scientific contributions that will help humanity advance towards its shared goals, such as the SDG. The theory of communicative acts and the empirical research based on it is the pivotal contribution that, as a result of engaging the main works of social sciences, has revolutionized how we study, how we understand, and, most importantly, how we construct and can transform human relationships. Now, we can better understand the development of sexual-affective patterns of attraction, and its neural correlates, that raise the likelihood to engage in violent sexual-affective relationships from a young age; as well as the dialogic and communicative processes that help transform a person's cognitive and affective schemata. Such a contribution has allowed us to inquire into and understand socialization processes that enslave sexual desire by means of associating it to stimuli related to risk, danger, humiliation, and violence overall (Puigvert Mallart et al., 2019; Racionero-Plaza et al., 2020). This association is imposed on individuals *via* internalization of a coercive dominant discourse (Puigvert et al., 2019) that is sustained through power communicative acts. Socioneuroscience examines the potential translation of this discourse, and its stimulus and response association, into neural circuits in the brain that then coerce the person's thinking, desire, and behavior, with negative consequences in both the

physical and the mental health. However, socioneuroscience has also shed light, taking into account the plastic nature of the human brain, that it is possible for individuals to transform these mental, affective and behavioral patterns *via* new social interactions based on dialogic communicative acts—that is, uniting the Apollonian and Dyonisian dimensions of dialogue.

In all, this manuscript has demonstrated that socioneuroscience is an interdisciplinary frontier in which the dialogue between all social sciences and all natural sciences opens up an opportunity to integrate different levels of analysis in several sciences to ultimately achieve social impact regarding the most urgent human problems.

AUTHOR CONTRIBUTIONS

RF and LP conceptualized the contribution. SR-P, LP, MS-G, and RF contributed to the formal analyses and discussion. SR-P wrote the first draft. SR-P, LP, MS-G, and RF revised the manuscript critically for important intellectual content. All authors contributed to the article and approved the submitted version.

REFERENCES

Aiello, E., Donovan, C., Duque, E., Fabrizio, S., Flecha, R., Holm, P., et al. (2020). Effective strategies that enhance the social impact of social sciences and humanities research. *Evid. Policy*. 17, 131–146. doi: 10.1332/174426420X15834126054137

Armanios, M., and Blackburn, E. H. (2012). The telomere syndromes. *Nat. Rev. Genet*. 13, 693–704. doi: 10.1038/nrg3246

Austin, J. (1962). *How to do Things With Words*. Oxford: Oxford University Press.

Behen, M. E., Helder, E., Rothermel, R., Solomon, K., and Chugani, H. T. (2008). Incidence of specific absolute neurocognitive impairment in globally intact children with histories of early severe deprivation. *Child Neuropsychol.* 14, 453–469. doi: 10.1080/09297040802244136

Berger, P., and Luckmann, T. (1966). *The Social Construction of Reality*. New York, NY: Penguin Books. Available online at: http://perflensburg.se/Berger%20social-construction-of-reality.pdf.

Blackburn, E. H. (1991). Structure and function of telomeres. *Nature* 350, 569–573. doi: 10.1038/350569a0

Blackburn, E. H. (2005). Telomeres and telomerase: their mechanisms of action and the effects of altering their functions. *FEBS Lett.* 579, 859–862. doi: 10.1016/j.febslet.2004.11.036

Blackburn, E., and Epel, E. (2017). *The Telomere Effect. A Revolutionary Approach to Living Younger, Healthier, Longer*. UK: Hachette. Available online at: https://assets.optimize.me/philosophers-notes/downloads/pdfs/files/member/the-telomere-effect.pdf.

Bouchard, T. J., Jr., Lykken, D. T., McGue, M., Segal, N. L., and Tellegen, A. (1990). Sources of human psychological differences: the minnesota study of twins reared apart. *Science* 250, 223–228. doi: 10.1126/science.2218526

Bowlby, J. (1969). *Attachment and Loss*. New York, NY: Basic Books.

Bowlby, J. (1982). Attachment and loss: retrospect and prospect. *Am. J. Orthopsychiatry* 52, 664–678. doi: 10.1111/j.1939-0025.1982.tb01456.x

Buchheim, A., George, C., Gündel, H., and Viviani, R. (2017). Editorial: neuroscience of human attachment. *Front. Hum. Neurosci.* 11:136. doi: 10.3389/fnhum.2017.00136

Cajal, R. S. (1989). *Recollections of My Life*. Cambridge, MA: MIT Press.

Callaghan, B. L., Fields, A., Gee, D. G., Gabard-Durnam, L., Caldera, C., Humphreys, K. L., et al. (2019). Mind and gut: associations between mood and gastrointestinal distress in children exposed to adversity. *Dev. Psychopathol.* 32, 309–328. doi: 10.1017/S0954579419000087

Campos, J. A., Aubert, A., Guo, M., and Joanpere, M. (2020). Improved leadership skills and aptitudes in an excellence EMBA program: creating synergies with dialogic leadership to achieve social impact. *Front. Psychol.* 11:17. doi: 10.3389/fpsyg.2020.00017

Canzi, E., Rosnati, R., Palacios, J., and Román, M. (2018). Internationally adopted children's cognitive and social-emotional development during the first post-adoption year: a longitudinal study. *Eur. J. Dev. Psychol.* 15, 517–530. doi: 10.1080/17405629.2017.1316257

Curry, A. (2019). Parents' emotional trauma may change their children's biology. Studies in mice show how. *Science*. doi: 10.1126/science.aay7690

Dunkel Schetter, C. (2017). Moving research on health and close relationships forward—a challenge and an obligation: Introduction to the special issue. *Am. Psychol.* 72, 511–516. doi: 10.1037/amp0000158

Duque, E., Gairal, R., Molina, S., and Roca, E. (2020). How the psychology of education contributes to research with a social impact on the education of students with special needs: the case of successful educational actions. *Front. Psychol.* 11:439. doi: 10.3389/fpsyg.2020.00439

Eluvathingal, T. J., Chugani, H. T., Behen, M. E., Juhász, C., Muzik, O., Maqbool, M., et al. (2006). Abnormal brain connectivity in children after early severe socioemotional deprivation: a diffusion tensor imaging study. *Pediatrics* 117, 2093–2100. doi: 10.1542/peds.2005-1727

Flecha, R., Tomás, G., and Vidu, A. (2020). Contributions from psychology to effectively use and achieving sexual consent. *Front. Psychol.* 11:92. doi: 10.3389/fpsyg.2020.00092

Foraster, M. J., and Morlà, T. (2019). Nuevas masculinidades alternativas, la lucha con y por el feminismo en el contexto universitario. *Masculinities Soc. Change* 8:44. doi: 10.17583/mcs.2019.3936

Garcia Yeste, C., El Miri Zeguari, O., Álvarez, P., and Morlà Folch, T. (2020). Muslim women wearing the niqab in Spain: dialogues around discrimination, identity and freedom. *Int. J. Intercult. Relat.* 75, 95–105. doi: 10.1016/j.ijintrel.2020.02.003

Gómez, A., Padrós, M., Ríos, O., Mara, L.-C., and Pukepuke, T. (2019). Reaching social impact through communicative methodology. Researching with rather than on vulnerable populations: the roma case. *Front. Educ.* 4:9. doi: 10.3389/feduc.2019.00009

Habermas, J. (1984). *The Theory of Communicative Action, volume I*. Boston, MA: Beacon Press.

Habermas, J. (1987). *The Theory of Communicative Action, volume II*. Boston, MA: Beacon Press.

Harvard Second Generation Study. (2021). Available online at: https://www.adultdevelopmentstudy.org/. Accessed October 13, 2021.

Hayes, B. (2018). Epigenetics: what do psychologists need to know?. *Int. J. Educ. Psychol.* 7, 230–247. Available online at: https://dialnet.unirioja.es/servlet/articulo?codigo=6642640.

Kaiser, J. (2014). The epigenetics heretic. *Science* 343, 361–363. doi: 10.1126/science.343.6169.361

Kandel, E. R. (2006). *In Search of Memory: The Emergence of a New Science of Mind*. New York, NY: W. W. Norton & Company. Available online at: https://play.google.com/store/books/details?id=PFnRwWXzypgC.

Kandel, E. R., Schwartz, J. H., and Jessell, T. M. (1991). *Principles of Neural Science*. East Norwalk, CT: Appleton & Lange.

Kathryn, L. H. (2019). Understanding the link between early adversity and disease-Stress, immunity and prevention. *Brain Behav. Immun.* 78, 1–2. doi: 10.1016/j.bbi.2018.12.019

Kentner, A. C., Lambert, K. G., Hannan, A. J., and Donaldson, S. T. (2019). Editorial: environmental enrichment: enhancing neural plasticity, resilience and repair. *Front. Behav. Neurosci.* 13:75. doi: 10.3389/fnbeh.2019.00075

Khalfaoui, A. (2019). Continuidades y cambios en la identidad de la mujer gitana. Un estudio de caso. *Int. J. Roma Studies* 1, 185–203. doi: 10.17583/ijrs.2019.4649

Lyons-Ruth, K. (1996). Attachment relationships among children with aggressive behavior problems: the role of disorganized early attachment patterns. *J. Consult. Clin. Psychol.* 64, 64–73. doi: 10.1037//0022-006x.64.1.64

Madrid, A., Joanpere, M., de Botton, L., and Campdepadrós, R. (2020). Media manipulation against social justice researchers: second-order sexual harassment. *Qual. Inq.* 26, 983–988. doi: 10.1177/1077800420938853

Mara, L.-C., Brunet Icart, I., and Cabré Olivé, J. (2020). Innovation skills training in a lifelong learning programme for unemployed people, in Catalonia (Spain). *Inn. Eur. J. Soc. Sci. Res.* 1–15. doi: 10.1080/13511610.2020.1774353

Mead, G. H. (1934). *Mind, Self and Society*. Chicago, IL: University of Chicago Press. doi: 10.7208/chicago/9780226187112.001.0001

Mead, G. H. (1964). *George Herbert Mead on Social Psychology*. Chicago, IL: University of Chicago Press. doi: 10.7208/chicago/9780226187112.001.0001

Merodio, G., Duque, E., and Axt Peña, J. C. (2020). They are not romeo pimps, they are traffickers: overcoming the socially dominant discourse to prevent the sex trafficking of youth. *Qual. Inq.* 26, 1010–1018. doi: 10.1177/1077800420938881

Pietromonaco, P. R., and Collins, N. L. (2017). Interpersonal mechanisms linking close relationships to health. *Am. Psychol.* 72, 531–542. doi: 10.1037/amp0000129

Puigvert, L., Gelsthorpe, L., Soler-Gallart, M., and Flecha, R. (2019). Girls' perceptions of boys with violent attitudes and behaviours and of sexual attraction. *Palgrave Commun.* 5:56. doi: 10.1057/s41599-019-0262-5

Puigvert Mallart, L., Flecha García, R., Racionero-Plaza, S., and Sordé-Martí, T. (2019). Socioneuroscience and its contributions to conscious versus unconscious volition and control. The case of gender violence prevention. *AIMS Neurosci.* 6, 204–218. doi: 10.3934/Neuroscience.2019.3.204

Pulido, C. M., Ruiz-Eugenio, L., Redondo-Sama, G., and Villarejo-Carballido, B. (2020a). A new application of social impact in social media for overcoming fake news in health. *Int. J. Environ. Res. Public Health* 17:2430. doi: 10.3390/ijerph17072430

Pulido, C. M., Villarejo-Carballido, B., Redondo-Sama, G., and Gómez, A. (2020b). COVID-19 infodemic: more retweets for science-based information on coronavirus than for false information. *Int. Sociol.* 35, 377–392. doi: 10.1177/0268580920914755

Racionero-Plaza, S., Ugalde, L., Merodio, G., and Gutiérrez-Fernández, N. (2020). "Architects of their own brain." Social impact of an intervention study for the prevention of gender-based violence in adolescence. *Front. Psychol.* 10:3070. doi: 10.3389/fpsyg.2019.03070

Ramón y Cajal, S. (1959). *Degeneration & Regeneration of the Nervous System*. New York, NY: Hafner Publishing Company. Available online at: https://play.google.com/store/books/details?id=-mEvAQAAIAAJ.

Redondo-Sama, G. (2020). Supporting democracy through leadership in organizations. *Qual. Inq.* 26, 1033–1040. doi: 10.1177/1077800420938885

Rios-Gonzalez, O., Puigvert Mallart, L., Sanvicén Torné, P., and Aubert Simón, A. (2019). Promoting zero violence from early childhood: a case study on the prevention of aggressive behavior in cappont nursery. *Eur. Ear Child. Edu. Res. J.* 27, 157–169. doi: 10.1080/1350293X.2019.1579544

Rodríguez, C. P., Carballido, B. V., Redondo-Sama, G., Guo, M., Ramis, M., and Flecha, R. (2020). False news around COVID-19 circulated less on sina weibo than on Twitter. How to overcome false information?. *Int. J. Multidiscip. Res. Rev.* 9, 107–128. doi: 10.17583/rimcis.2020.5386

Ruiz-Eugenio, L., Racionero-Plaza, S., Duque, E., and Puigvert, L. (2020a). Female university students' preferences for different types of sexual relationships: implications for gender-based violence prevention programs and policies. *BMC Womens Health* 20:266. doi: 10.1186/s12905-020-01131-1

Ruiz-Eugenio, L., Roca-Campos, E., León-Jiménez, S., and Ramis-Salas, M. (2020b). Child well-being in times of confinement: the impact of dialogic literary gatherings transferred to homes. *Front. Psychol.* 11:567449. doi: 10.3389/fpsyg.2020.567449

Salceda, M., Vidu, A., Aubert, A., and Roca, E. (2020). Dialogic feminist gatherings: impact of the preventive socialization of gender-based violence on adolescent girls in out-of-home care. *Soc. Sci.* 9:138. doi: 10.3390/socsci9080138

Searle, J. R. (1969). *Speech Acts: An Essay in the Philosophy of Language*. Cambridge: Cambridge University Press. Available online at: https://play.google.com/store/books/details?id=t3_WhfknvF0C.

Searle, J., and Soler, M. (2005). Lenguaje y ciencias sociales. Diálogo entre John Searle y CREA. El Roure: Barcelona. Available online at: https://pdfs.semanticscholar.org/f692/45cb7634a33e7fdceb9b11c31f8c019d4c7b.pdf.

Serradell, O., Ramis, M., De Botton, L., and Solé, C. (2020). Spaces free of violence: the key role of moroccan women in conflict prevention in schools. A case study. *Indian J. Gend. Stud.* 29, 161–173. doi: 10.1080/09589236.2019.1620096

Serrano Amaya, J. F., and Ríos González, O. (2019). Introduction to the special issue: challenges of LGBT research in the 21st century. *Int. Sociol.* 34, 371–381. doi: 10.1177/0268580919856490

Soler, M., and Flecha, R. (2010). Desde los actos de habla de austin a los actos comunicativos: perspectivas desde Searle, Habermas y CREA. *Rev. Signos.* 43, 363–375. doi: 10.4067/S0718-09342010000400007

Soler, M., and Gómez, A. (2020). A citizen's claim: science with and for society. *Qual. Inq.* 26, 943–947. doi: 10.1177/1077800420938104

Soler-Gallart, M. (2017). *Achieving Social Impact: Sociology in the Public Sphere*. New York, NY: Springer.

Sonuga-Barke, E. J. S., Kennedy, M., Kumsta, R., Knights, N., Golm, D., Rutter, M., et al. (2017). Child-to-adult neurodevelopmental and mental health trajectories after early life deprivation: the young adult follow-up of the longitudinal english and romanian adoptees study. *Lancet* 389, 1539–1548. doi: 10.1016/S0140-6736(17)30045-4

Tellado, I., Lepori, B., and Morla-Folch, T. (2020). WIEGO: communicative daily life stories to assess social impact in the lives of informal workers. *Qual. Inq.* 26, 962–969. doi: 10.1177/1077800420938680

Telzer, E. H., Fuligni, A. J., Lieberman, M. D., Miernicki, M. E., and Galván, A. (2015). The quality of adolescents' peer relationships modulates neural sensitivity to risk taking. *Soc. Cogn. Affect. Neurosci.* 10, 389–398. doi: 10.1093/scan/nsu064

Torras-Gómez, E., Guo, M., and Ramis, M. (2019). Sociological theory from dialogic democracy. *Int. Multidiscip. J. Soc. Sci.* 8, 216–234. doi: 10.17583/rimcis.2019.4919

Torras-Gómez, E., Puigvert, L., Aiello, E., and Khalfaoui, A. (2020). Our right to the pleasure of falling in love. *Front. Psychol.* 10:3068. doi: 10.3389/fpsyg.2019.03068

Waldinger, R. J., and Schulz, M. S. (2010). What's love got to do with it? Social functioning, perceived health and daily happiness in married octogenarians. *Psychol. Aging* 25, 422–431. doi: 10.1037/a0019087

Weber, M. (1930). *The Protestant Ethic and the Spirit of Capitalism*. New York, NY: Routledge.

Weber, M. (1978). *Economy and Society: An Outline of Interpretive Sociology*. Berkeley, CA: University of California Press. Available online at: https://market.android.com/details?id=book-MILOksrhgrYC.

Yeste, C. G., Eugenio, L. R., and Comas, M. à. (2019). Formación de familiares y voluntariado. Los beneficios de la solidaridad en la escuela. *Multidiscip. J. Edu. Res.* 9, 144–168. doi: 10.17583/remie.2019.4188

Young, E. S., Simpson, J. A., Griskevicius, V., Huelsnitz, C. O., and Fleck, C. (2019). Childhood attachment and adult personality: a life history perspective. *Self Identity* 18, 22–38. doi: 10.1080/15298868.2017.1353540

Zhang, T.-Y., and Meaney, M. J. (2010). Epigenetics and the environmental regulation of the genome and its function. *Annu. Rev. Psychol.* 61, 439–466. doi: 10.1146/annurev.psych.60.110707.163625

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: All claims expressed in this article are solely those of the authors and do not necessarily represent those of their affiliated organizations, or those of the publisher, the editors and the reviewers. Any product that may be evaluated in this article, or claim that may be made by its manufacturer, is not guaranteed or endorsed by the publisher.

frontiers in Sociology

OPINION
published: 25 January 2022
doi: 10.3389/fsoc.2022.814338

Neurosociology and Penal Neuroabolitionism: Rethinking Justice With Neuroscience

Diego Borbón[1,2]*

[1]The Latin American Observatory of Human Rights and Enterprises, NeuroRights Research Group, Universidad Externado de Colombia, Bogotá, Colombia, [2]Rizoma and Legal Psychology Research Groups, Universidad Nacional Abierta y a Distancia, Bogotá, Colombia

Keywords: neurolaw, free will, neuropsychology, penal abolitionism, prison abolition, social control, neurocriminology, punishment

INTRODUCTION

Penal Neuroabolitionism is a complementary thesis to the sociological abolitionism of Nils Christie, Thomas Mathiesen and Louk Hulsman (Borbón, 2021). This new approach is based on the findings of science, especially neuroscience, to provide new arguments to the abolitionist perspective that criminal law is an illegitimate mechanism of social control. In that sense, it closely approximates neurosociology as a new scope for transdisciplinary social analysis. In this brief opinion, we offer three commentaries for future work: on the neuropsychological effects of prison, on the ability of neuroscience to analyze and prevent criminogenic social factors, and a critical perspective on free will as a narrative to justify criminal law as a mechanism of social control. These considerations invite scholars around the world to study, within the field of neuroscience, the new arguments for penal abolitionism.

OPEN ACCESS

Edited by:
Vincenzo Auriemma,
University of Salerno, Italy

Reviewed by:
Valeria Saladino,
University of Cassino, Italy
Chiara Iannaccone,
University of Salerno, Italy

***Correspondence:**
Diego Borbón
diego.borbon01@est.uexternado.edu.co

Specialty section:
This article was submitted to Sociological Theory, a section of the journal Frontiers in Sociology

Received: *15 November 2021*
Accepted: *10 January 2022*
Published: *25 January 2022*

Citation:
Borbón D (2022) Neurosociology and Penal Neuroabolitionism: Rethinking Justice With Neuroscience. Front. Sociol. 7:814338. doi: 10.3389/fsoc.2022.814338

NEUROSOCIOLOGY AND PENAL ABOLITIONISM

The sociological European penal abolitionism led by Christie, Mathiesen and Hulsman denounces the illegitimacy of criminal law, as a sterile and futile way of imposing pain. Abolitionism holds that the criminal justice system is a social problem in itself and the complete abolition of this system is considered to be the only adequate solution (De Folter, 1986). According to Christie, social systems should be built in a way that minimizes the need to impose pain to achieve social control, as the hell created by man through criminal law is avoidable (Christie, 1981). This argument is further supported by the fact that this pain imposed is usually selective, since it historically punishes particularly vulnerable groups of people (Vegh, 2017). In general, sociological abolitionism has created a body of theories to explain the necessary substitution of criminal law for more humane and restorative alternatives (Christie, 1981; Hulsman, 1991; Mathiesen, 2006; Mathiesen, 2015).

In this direction, neurosociology is a new label for thinking about the human brain and its relationship to human interaction and social organization (Franks and Turner, 2013). Indeed, with advances in science, it is possible to glimpse the usefulness of neurosociology as a new scope for transdisciplinary social analysis to provide innovative arguments in favor of the abolitionist thesis. In particular, a transdisciplinary approach is essential when considering individual and social deviant behaviors.

ADVERSE NEUROPSYCHOLOGICAL EFFECTS OF IMPRISONMENT

Imprisonment is the most widely used form of punishment in contemporary penal systems. In 2021, more than 11.5 million people were incarcerated in prisons worldwide (Fair and

Walmsley, 2021). However, multiple authors have exposed the uselessness of imprisonment, except in a few cases of extreme danger, where the prison fulfills a dubious function of "quarantine" or isolation of the offender (Pereboom, 2003; 2019). Thomas Mathiesen (2006) devoted his intellectual effort to show that, when evaluated in terms of the penal system's stated goals, prison is a complete failure. The empirical evidence shows that the objectives of imprisonment are not achieved for the most part: prisons do not rehabilitate, and they do not deter from future crimes (Davis, 2003; Mathiesen, 2006; Cid, 2009; Cullen et al., 2011; Mathiesen, 2015). Furthermore, neuropsychology can provide significant arguments against generalizing prison sentences to be the main sanction in penal systems.

Research has yielded valuable results on the adverse neuropsychological effects of prison (Nurse, 2003; Huey and Mcnulty, 2005; Haney, 2012; Schnittker et al., 2012; Brinkley-Rubinstein, 2013; Meijers et al., 2015; Constantino et al., 2016; Haney, 2017; Meijers et al., 2018; Edgemon and Clay-Warner, 2019; Piper and Berle, 2019; Reiter et al., 2020). Overall, these findings tend to correlate prison with poorer mental health, as impoverished spaces, punitive practices, and the prison environment are profoundly disadvantageous factors for mental health and general well-being. For example, the study by Meijers et al. (2018), suggests that 3 months of imprisonment may lead to reduced self-control, increased risk taking and significant deterioration in attention.

According to research from the World Health Organization, within prisons the prevalence of mental disorders is significantly higher than in the general population (Durcan and Zwemstra, 2014) and it has also been suggested that there are ten times more individuals with a mental disorder in jail than in mental hospitals in the United States (Torrey et al., 2014; Semenza & Grosholz, 2019). Instead of fulfilling a positive function, the prison impoverished environments could end up violating minimum human rights standards (Ligthart et al., 2019), and even become criminogenic factors (Vieraitis et al., 2007; Cid, 2009; Cullen et al., 2011; Meijers et al., 2018; Wallace and Wang, 2020).

These are significant findings that should be understood as an open invitation for researchers around the world to study the neuropsychological effects of prison. It is possible to advise, as a criminal policy, to start the reduction of imprisonment as a form of social control, while prioritizing restorative, conciliatory, civil, and therapeutic alternatives to punishment, to reach abolition in the long term. In the medium term, the humanization of the prison, the improvement of the infrastructure and the prison service is an effective way to promote mental health (Gabrysch et al., 2020).

NEUROCRIMINOLOGY AND NEUROSOCIOLOGY

Since the rise of neurolaw with Taylor et al. (1991), scientific evidence has shown that deviant behaviour has a neurobiological basis, and this has intensified judicial interest in the potential application of neuroscience to criminal law (Glenn and Raine, 2014). In line with this, neurocriminology combines multiple factors (Straiton and Lake, 2021) including genetics, parental influences, early life experiences, hormones, psychophysiology, brain structure, brain function, and neuroimaging to understand why certain individuals are driven to break the law (Glenn and Raine, 2014; Anderson, 2021; Straiton and Lake, 2021). Now that we are confident that neuroscience will have important implications for criminal justice systems (Greely and Farahany, 2019), research on the interaction between neuroscience and criminal law is booming.

Neurocriminology has identified structural and functional deficits in frontal, temporal and subcortical regions, as well as verbal, spatial, and executive dysfunction in antisocial behaviour, and these findings are largely supported by neurological studies of brain trauma in antisocial populations (Schug et al., 2015; Bellesi et al., 2019; van Dongen and Franken, 2019; Katzin et al., 2020). However, some criticize neurocriminology studies for being reductionist. Fallin et al. (2018) argue that most neuroscientists obfuscate legitimate social explanations, transforming complex socially situated behaviors into problems of neurocircuitry.

While this is a legitimate concern, we consider that it is possible to promote a collaboration of disciplines, instead of allowing them to become antagonistic towards each other. Understanding deviant behavior is complex, therefore the careful study of such behavior could benefit greatly from more constructive dialog and collaboration between sociological and neuroscientific disciplines (Aharoni et al., 2019).

Sociology has theoretically and empirically studied social facts such as extreme inequality, poverty, marginalization, and exclusion. In this context, neuroscience can explain how these supra-individual factors affect people's psychological well-being and leave traces on their neural structures. In addition, lack of nutrition, stress, physical and psychological aggression, stigmatization, and other risk factors might produce adverse neuropsychological effects that can interest criminological studies. With this in mind, it is possible to consider prevention programs that avoid the occurrence of problematic situations related to aggressiveness, impulsivity, lack of empathy, stress and others.

The more effective social programs are implemented, the less criminal law will be seen as a bitter necessity used to threaten individuals in a society. In this transition, institutions such as the prison, or the penal system itself, will be gradually replaced by restorative, community, conciliatory, civil, and therapeutic alternatives. This evolution, under the framework of a true abolitionist proposal, should be far from a dangerousness[1]

[1]We use the concept of dangerousness in the context of expansive proposals of the punitive power of the State under the narrative that there are dangerous individuals who must be arrested without even having committed a crime. In recent years the concept of Neuroprediction has become popular, which uses neurotechnologies to assess the risk of violence, crime, or recidivism. However, these technologies are still limited in accuracy, and are ethically problematic (Tortora et al., 2020).

perspective that would invade the mental privacy of offenders with neurotechnologies for predicting the risk of aggression or recidivism, which would be unnecessary, inaccurate and affect human dignity.

FREE WILL AS A NARRATIVE FOR SOCIAL CONTROL

At least in continental European criminal law, with deep Italian and German influences, criminal law has been built unequivocally on free will. The German scholar Claus Roxin maintains that there is an agreement that criminal law must start from free will, although free will cannot exactly be demonstrated (Roxin, 1997). Free will is the foundation of the culpability principle that implies a judgement of reproach to a free and conscientious person who could act according to the law but decided to act against it.

However, in recent decades, neuroscience has provided experiments that suggest that free will does not exist (Libet et al., 1983; Haggard and Eimer, 1999; Soon et al., 2008, 2013; Fried et al., 2011). These studies have not been far from controversy, as several academics also argue against the methodology and conclusions from these findings (Trevena and Miller, 2010; Glannon, 2011; Guggisberg and Mottaz, 2013; Mele, 2014). The truth is that, in general, in philosophy of free will there are two dominant positions: compatibilism and incompatibilism. Compatibilism assumes that even if determinism is true, we would still have free will, while incompatibilism,[2] excludes the possibility that free will exists if determinism is assumed to be true. (McKenna and Pereboom, 2016). It is also interesting to note that, within sociology, there is a strong debate around structure *versus* agency, which could imply that society determines human behavior (Stones, 2015).

In that sense, many scholars have pointed out the great challenges that criminal law must face. Jurists such as Gimbernat (1971) have affirmed that attempting to found criminal law on the unprovable free will is a battle lost beforehand; fighting it can only increase the irritation of empirical scientists. On the other hand, Winfried Hassemer (2011) argued that the consequences of human biology for criminal justice are obvious and that the only advisable approach is to avoid this discussion, or it will be the end of the criminal justice system.

In this brief commentary we will not deal with the question of whether criminal law can exist without free will. Several scholars such as Günther Jakobs (1992) and Morse (2015) have challenged the idea that the free will debate poses a real threat to criminal law. Rather, we want to point out that free will, despite not being a direct object of sociological questioning (Durkheim, 1966), is of interest in a transdisciplinary debate on penal abolitionism. Free will, in addition to being a metaphysically refutable concept, is a functional idea to achieve social control, as it serves as a justification for holding others morally responsible and facilitates punishment (Clark et al., 2014). This is not only applicable to criminal matters, Nietzsche (1968) argued that the idea of free will, despite being false, served as a narrative for Christianity and priests, for punishment, and therefore, for social control and the maintenance of the status quo. From this perspective, under the allegedly false narrative of free will in the penal system, the State ignores the causes of crime by holding the offender responsible and leaving the social structure intact. In that case, prisons would embody a hidden role in the wider field of political domination and general social control, which would be different from prison's declared objective of disciplining individuals (Foucault, 1977; Garland, 1991).

CONCLUSION

The new thesis of Penal Neuroabolitionism can be nourished by scientific findings. If neuroscience can show that voluntary decisions are not in fact consciously taken nor available to a responsible agent, and furthermore, if physics demonstrates that classical determinism and quantum indeterminism are true, then criminal law might lose its foundations. Without free will, it will be possible to stop simplifying criminal phenomenon and instead to scientifically understand the neurobiological, social, and cultural risk factors behind deviant behavior. With these inputs, it will be possible to offer more effective social programs and eliminate archaic concepts of moral or criminal responsibility. In addition, since it is possible to identify the adverse neuropsychological consequences of prisons, rigorous programs of humanization in the medium term, and of abolition in the long term, should be considered. In the future, neuroscience could even be useful to intervene in brains that clearly present severe pathologies related to deviant behavior. Penal Neuroabolitionism is a new approach, to invite researchers and academics to join in collective efforts to determine how we want to shape criminal policies of the future.

AUTHOR CONTRIBUTIONS

The author confirms being the sole contributor of this work and has approved it for publication.

ACKNOWLEDGMENTS

Some ideas of this manuscript have appeared previously in Spanish in Borbón (2021). The author would like to thank Laura Amy Daines for her kind comments that helped improve the paper.

[2]We have argued that Penal Neuroabolitionism as a criminal policy proposal should be based on an adaptation of hard incompatibilism (Borbón, 2021), which implies that our actions are either deterministic or truly random events and both possibilities exclude free will and moral responsibility (Pereboom, 2003). Now, in our vision, we should adopt a theoretical nuance that we have called humanistic incompatibilism, which would imply, in addition to the fact that free will does not exist and that we are not morally and criminally responsible, that human dignity must be a limit to the advancement of science and justice (Borbón, 2021).

REFERENCES

Aharoni, E., Anderson, N. E., Barnes, J. C., Allen, C. H., and Kiehl, K. A. (2019). Mind the gap: toward an Integrative Science of the Brain and Crime. *BioSocieties* 14, 463–468. doi:10.1057/s41292-019-00167-3

Anderson, N. E. (2021). "Neurocriminology," in *The Encyclopedia of Research Methods in Criminology and Criminal Justice, Volume II*. (New Jersey USA: Wiley-Blackwell), 633–641. doi:10.1002/9781119111931.ch122

Bellesi, G., Barker, E. D., Brown, L., and Valmaggia, L. (2019). Pediatric Traumatic Brain Injury and Antisocial Behavior: Are They Linked? A Systematic Review. *Brain Inj.* 33 (10), 1272–1292. doi:10.1080/02699052.2019.1641621

Borbón, D. (2021). Incompatibilismo humanista: Una contrapropuesta del neuroabolicionismo penal. *Cefd* 45, 46–72. doi:10.7203/CEFD.45.20713

Brinkley-Rubinstein, L. (2013). Incarceration as a Catalyst for Worsening Health. *Health Justice* 1 (1). doi:10.1186/2194-7899-1-3

Christie, N. (1981). *Limits to Pain*. Oxford: Martin Robertson & Company Ltd.

Cid, J. (2009). Is Imprisonment Criminogenic. *Eur. J. Criminology* 6 (6), 459–480. doi:10.1177/1477370809341128

Clark, C. J., Luguri, J. B., Ditto, P. H., Knobe, J., Shariff, A. F., and Baumeister, R. F. (2014). Free to Punish: A Motivated Account of Free Will Belief. *J. Pers Soc. Psychol.* 106 (4), 501–513. doi:10.1037/a0035880

Constantino, P., Assis, S. G., and Pinto, L. W. (2016). The impact of prisons on the mental health of prisoners in the state of Rio de Janeiro, Brazil. *Cien Saude Colet* 21 (7), 2089–2100. doi:10.1590/1413-81232015217.01222016

Cullen, F. T., Jonson, C. L., and Nagin, D. S. (2011). Prisons Do Not Reduce Recidivism. *Prison J.* 91 (3 Suppl. l), 48S–65S. doi:10.1177/0032885511415224

Davis, A. (2003). *Are Prisons Obsolete*. New York: Seven Stories Press.

Durcan, G., and Zwemstra, J. (2014). "Mental Health in Prison," in *Prisons and Health*. Editors S. Enggist, L. Møller., G. Galea., and C. Udesen (Copenhagen: World Health Organization).

Durkheim, E. (1966). *The Rules of Sociological Method*. New York: Free Press.

Edgemon, T. G., and Clay-Warner, J. (2019). Inmate Mental Health and the Pains of Imprisonment. *Soc. Ment. Health* 9 (1), 33–50. doi:10.1177/2156869318785424

Fair, H., and Walmsley, R. (2021). *World Prison Population List*. Thirteenth Edition. London: Institute for Crime & Justice Policy Research at Birkbeck University of London. https://www.prisonstudies.org/sites/default/files/resources/downloads/world_prison_population_list_13th_edition.pdf.

Fallin, M., Whooley, O., and Barker, K. K. (2018). Criminalizing the Brain: Neurocriminology and the Production of Strategic Ignorance. *BioSocieties* 14, 438–462. doi:10.1057/s41292-018-0135-y

Folter, R. S. (1986). On the Methodological Foundation of the Abolitionist Approach to the Criminal justice System. A Comparison of the Ideas of Hulsman, Mathiesen and Foucault. *Contemp. Crises* 10 (1), 39–62. doi:10.1007/BF00728495

Foucault, M. (1977). *Discipline and Punish*. London: Allen Lane.

Franks, D., and Turner, J. (2013). "Chapter 1: Introduction: Summaries and Comments," in *Handbook of Neurosociology*. Editors D. Franks and J. Turner (New York: Springer).

Fried, I., Mukamel, R., and Kreiman, G. (2011). Internally Generated Preactivation of Single Neurons in Human Medial Frontal Cortex Predicts Volition. *Neuron* 69, 548–562. doi:10.1016/j.neuron.2010.11.045

Gabrysch, C., Sepúlveda, C., Bienzobas, C., and Mundt, A. P. (2020). 'Maybe it Is Only in Prison that I Could Change like This' the Course of Severe Mental Illnesses during Imprisonment - A Qualitative 3-Year Follow-Up Study from Chile. *Front. Psychol.* 11, 1208. doi:10.3389/fpsyg.2020.01208

Garland, D. (1991). Sociological Perspectives on Punishment. *Crime and Justice* 14, 115–165. doi:10.1086/449185

Gimbernat, E. (1971). "Tiene un futuro la dogmática jurídicopenal," in *Problemas actuales de Derecho penal y procesal* (Salamanca: Universidad de Salamanca).

Glannon, W. (2011). *Brain, Body, and Mind: Neuroethics with a Human Face*. Oxford: Oxford Scholarship Online.

Glenn, A. L., and Raine, A. (2014). Neurocriminology: Implications for the Punishment, Prediction and Prevention of Criminal Behaviour. *Nat. Rev. Neurosci.* 15 (1), 54–63. doi:10.1038/nrn3640

Greely, H. T., and Farahany, N. A. (2019). Neuroscience and the Criminal Justice System. *Annu. Rev. Criminol.* 2 (1), 451–471. doi:10.1146/annurev-criminol-011518-024433

Guggisberg, A. G., and Mottaz, A. (2013). Timing and Awareness of Movement Decisions: Does Consciousness Really Come Too Late. *Front. Hum. Neurosci.* 7, 385. doi:10.3389/fnhum.2013.00385

Haggard, P., and Eimer, M. (1999). On the Relation between Brain Potentials and the Awareness of Voluntary Movements. *Exp. Brain Res.* 126, 128–133. doi:10.1007/s002210050722

Haney, C. (2012). "The Psychological Effects of Imprisonment," in *The Oxford Handbook of Sentencing and Corrections* (Oxford: Oxford University Press). doi:10.1093/oxfordhb/9780199730148.013.0024

Haney, C. (2017). "Madness" and Penal Confinement: Some Observations on Mental Illness and Prison Pain. *Punishment Soc.* 19 (3), 310–326. doi:10.1177/1462474517705389

Hassemer, W. (2011). *Neurociencias y culpabilidad en Derecho penal*. Barcelona, Spain: InDret V2. Available at: https://indret.com/neurociencias-y-culpabilidad-en-derecho-penal/.

Huey, M. P., and Mcnulty, T. L. (2005). Institutional Conditions and Prison Suicide: Conditional Effects of Deprivation and Overcrowding. *Prison J.* 85 (4), 490–514. doi:10.1177/0032885505282258

Hulsman, L. (1991). The Abolitionist Case: Alternative Crime Policies. *Isr. Law Rev.* 25 (3-4), 681–709. doi:10.1017/S0021223700010694

Jakobs, G. (1992). El Principio de Culpabilidad. *Anuario de derecho penal y ciencias penales* 45 (3), 1051–1084.

Katzin, S., Andiné, P., Hofvander, B., Billstedt, E., and Wallinius, M. (2020). Exploring Traumatic Brain Injuries and Aggressive Antisocial Behaviors in Young Male Violent Offenders. *Front. Psychiatry* 11, 507196. doi:10.3389/fpsyt.2020.507196

Libet, B., Gleason, C. A., Wright, E. W., and Pearl, D. K. (1983). Time of Conscious Intention to Act in Relation to Onset of Cerebral Activity (Readiness-potential). The Unconscious Initiation of a Freely Voluntary Act. *Brain* 106 (Pt 3), 623–642. doi:10.1093/brain/106.3.623

Ligthart, S., van Oploo, L., Meijers, J., Meynen, G., and Kooijmans, T. (2019). Prison and the Brain: Neuropsychological Research in the Light of the European Convention on Human Rights. *New J. Eur. Criminal L.* 10 (3), 287–300. doi:10.1177/2032284419861816

Mathiesen, T. (2006). *Prison on Trial*. Winchester: Waterside Press.

Mathiesen, T. (2015). *The Politics of Abolition Revisited*. New York: Routledge.

McKenna, M., and Pereboom, P. (2016). *Free Will a Contemporary Introduction*. New York: Routledge.

Meijers, J., Harte, J. M., Jonker, F. A., and Meynen, G. (2015). Prison Brain? Executive Dysfunction in Prisoners. *Front. Psychol.* 6, 43. doi:10.3389/fpsyg.2015.00043

Meijers, J., Harte, J. M., Meynen, G., Cuijpers, P., and Scherder, E. J. A. (2018). Reduced Self-Control after 3 Months of Imprisonment; A Pilot Study. *Front. Psychol.* 9, 69. doi:10.3389/fpsyg.2018.00069

Mele, A. (2014). *Free: Why Science Hasn't Disproved Free Will*. Oxford: Oxford University Press.

Morse, S. (2015). *Neuroscience, Free Will, and Criminal Responsibility*. Pennsylvania: Faculty Scholarship at Penn Law. 1604. https://scholarship.law.upenn.edu/faculty_scholarship/1604.

Nietzsche, F. (1968). *The Twilight of the Idols and the Anti-christ: Or How to Philosophize with a Hammer*. Harmondsworth: Penguin.

Nurse, J., Woodcock, P., and Ormsby, J. (2003). Influence of Environmental Factors on Mental Health within Prisons: Focus Group Study. *BMJ* 327 (7413), 480. doi:10.1136/bmj.327.7413.480

Pereboom, D. (2019). "Free Will Skepticism and Prevention of Crime," in *Free Will Skepticism in Law and Society: Challenging Retributive Justice*. Editors E. Shaw, D. Pereboom, and G. Caruso (Cambridge: Cambridge University Press), 99–115. doi:10.1017/9781108655583.005

Pereboom, D. (2003). *Living without Free Will*. Cambridge: Cambridge University Press.

Piper, A., and Berle, D. (2019). The Association between Trauma Experienced during Incarceration and PTSD Outcomes: a Systematic Review and Meta-Analysis. *J. Forensic Psychiatry Psychol.* 30, 854–875. doi:10.1080/14789949.2019.1639788

Reiter, K., Ventura, J., Lovell, D., Augustine, D., Barragan, M., Blair, T., et al. (2020). Psychological Distress in Solitary Confinement: Symptoms, Severity, and Prevalence in the United States, 2017-2018. *Am. J. Public Health* 110 (S1), S56–S62. doi:10.2105/ajph.2019.305375

Roxin, C. (1997). *Derecho Penal parte general, Tomo I: Fundamentos, la estructura de la teoría del delito*. Madrid: Civitas.

Schnittker, J., Massoglia, M., and Uggen, C. (2012). Out and Down: Incarceration and Psychiatric Disorders. *J. Health Soc. Behav.* 53 (4), 448–464. doi:10.1177/0022146512453928

Schug, R. A., Raine, A., Gao, Y., Glenn, A., and Yang, Y. (2015). "Neurocriminology," in *The Evolution of Forensic Psychiatry: History, Current Developments, Future Directions* (Oxford: Oxford University Press), 313–328. doi:10.1093/med/9780199393435.003.0029

Semenza, D. C., and Grosholz, J. M. (2019). Mental and Physical Health in Prison: How Co-occurring Conditions Influence Inmate Misconduct. *Health Justice* 7 (1), 1. doi:10.1186/s40352-018-0082-5

Soon, C. S., Brass, M., Heinze, H. J., and Haynes, J. D. (2008). Unconscious Determinants of Free Decisions in the Human Brain. *Nat. Neurosci.* 11, 543–545. doi:10.1038/nn.2112

Soon, C. S., He, A. H., Bode, S., and Haynes, J. D. (2013). Predicting Free Choices for Abstract Intentions. *Proc. Natl. Acad. Sci. U S A.* 110, 6217–6222. doi:10.1073/pnas.1212218110

Stones, R. (2015). *Structure and Agency. The Blackwell Encyclopedia of Sociology*. doi:10.1002/9781405165518.wbeoss293.pub2

Straiton, J., and Lake, F. (2021). Inside the Brain of a Killer: the Ethics of Neuroimaging in a Criminal Conviction. *Biotechniques* 70, 69–71. doi:10.2144/btn-2020-0171

Taylor, J. S., Harp, J. A., and Elliott, T. (1991). Neuropsychologists and Neurolawyers. *Neuropsychology* 5 (4), 293–305. doi:10.1037/0894-4105.5.4.293

Torrey, E. (2014). *The Treatment of Persons with Mental Illness in Prisons and Jails: A State Survey*. Arlington, VA: Treatment Advocacy Center.

Tortora, L., Meynen, G., Bijlsma, J., Tronci, E., and Ferracuti, S. (2020). Neuroprediction and A.I. In Forensic Psychiatry and Criminal Justice: A Neurolaw Perspective. *Front. Psychol.* 11, 220. doi:10.3389/fpsyg.2020.00220

Trevena, J., and Miller, J. (2010). Brain Preparation before a Voluntary Action: Evidence against Unconscious Movement Initiation. *Conscious. Cogn.* 19 (1), 447–456. doi:10.1016/j.concog.2009.08.006

van Dongen, J. D. M., and Franken, I. H. A. (2019). Neuroscience in Forensic Psychiatry and Psychology: An Introduction to the Special Issue. *Int. J. Forensic Ment. Health* 18 (3), 179–186. doi:10.1080/14999013.2019.1652708

Vegh, V. (2017). *Marxism and Criminology: A History of Criminal Selectivity*. Leiden: Brill.

Vieraitis, L. M., Kovandzic, T. V., and Marvell, T. B. (2007). The Criminogenic Effects of Imprisonment: Evidence from State Panel Data, 1974?2002. *Criminology Public Policy* 6 (3), 589–622. doi:10.1111/j.1745-9133.2007.00456.x

Wallace, D., and Wang, X. (2020). Does In-Prison Physical and Mental Health Impact Recidivism. *SSM Popul. Health* 11, 100569. doi:10.1016/j.ssmph.2020.100569

Conflict of Interest: The author declares that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

frontiers in Sociology

OPINION
published: 14 February 2022
doi: 10.3389/fsoc.2022.788447

Naturalness of Face-to-Face Medium and Video-Mediated Online Communication: Doubts About Evolutionary Mismatch

*Yulia Shkurko**

Department of Philosophy, Ulyanovsk State University, Ulyanovsk, Russia

Keywords: face-to-face communication, evolved adaptation, evolutionary mismatch, media naturalness theory, video-mediated communication, videoconferencing, computer-mediated communication, neurosociology

INTRODUCTION

This study was motivated by doubts about the idea of the natural superiority of face-to-face medium, which develops both at the conceptual level (e.g., Kock, 2004, 2005, 2012) and is taken as a reference point when testing or developing improvements in technological communication systems (e.g., Almeida et al., 2012; Chua et al., 2012; Kegel et al., 2012; Kimura et al., 2020). The idea of natural superiority of face-to-face communication is complementary to evolutionary mismatch hypothesis, according to which the evolved human nature is less consistent with all other types of device-mediated communication, which can be a source of negative social and cognitive consequences (undermine immediate interpersonal interactions, impairment in the development of the ability for theory of mind and role-taking, etc.; e.g., Sbarra et al., 2019; Kalkhoff et al., 2020).

With regard to video-mediated online communication (VMOC), with an explicit or implicit acceptance of the idea of evolutionary mismatch, it is often concluded that imitation of face-to-face interaction through technical means or through users' learning and training is a valid way to improve communication (more on this below).

The purpose of the article is to encourage a discussion about whether video-mediated online communication should be brought closer to face-to-face communication or whether we should look for other ways, in particular: (i) the validity of a reference to the evolutionary past of humanity (at least in the meaning of the absence of an evolved biological mechanism for VMOC) in improving VMOC, (2) problematic nature of taking the idea of the natural superiority of face-to-face communication for granted, (3) the need for search for alternatives for the development of VMOC systems.

THE NATURALNESS OF FACE-TO-FACE MEDIUM AND THE DIVERSIFIED NATURE OF THE BIOLOGICAL COMMUNICATION APPARATUS

The idea of the natural superiority of face-to-face communication underlies Kock's media naturalness hypothesis, which is quite popular in communication research (e.g., DeRosa et al., 2004; Simon, 2006; Vlahovic et al., 2012; Blau et al., 2017; Karl et al., 2021). According to this hypothesis, "the face-to-face medium is the most natural medium of all" (Kock, 2004, p. 124), arising from natural selection as the most efficient way of exchanging information in terms of the survival of our ancestors (Kock, 2004, 2005). Therefore, any forms of communication deviating from face-to-face interaction are considered as less suited to innate human communication capacities and as requiring greater cognitive efforts to exchange information, leads to an increasing communication ambiguity and a decreasing physiological arousal (Kock, 2004).

OPEN ACCESS

Edited by:
Vincenzo Auriemma, University of Salerno, Italy

Reviewed by:
Valeria Saladino, University of Cassino, Italy

***Correspondence:**
Yulia Shkurko
yulishkurko@gmail.com

Specialty section:
This article was submitted to Sociological Theory, a section of the journal Frontiers in Sociology

Received: *02 October 2021*
Accepted: *18 January 2022*
Published: *14 February 2022*

Citation:
Shkurko Y (2022) Naturalness of Face-to-Face Medium and Video-Mediated Online Communication: Doubts About Evolutionary Mismatch. Front. Sociol. 7:788447. doi: 10.3389/fsoc.2022.788447

The media naturalness hypothesis is inherently complementary to the evolutionary mismatch hypothesis, central to evolutionary analysis (Lloyd et al., 2011) and fruitfully applied in different disciplines. According to the hypothesis, behavioral, mental and other adaptations, rigidly tied to the structure and functioning of the brain, which were useful for the survival of our ancestors in the past, may not be so in the new changed conditions. The evolutionary mismatch can be a source of negative social, psycho-emotional and other consequences; for example, affect the performance of organizations, lead to chronic psychological stress, be a source of low level of well-being, and so forth (Van Vugt and Ronay, 2013; Brenner et al., 2015; Kanazawa and Li, 2015; Li et al., 2017).

Kock proceeds from the fact that in the process of evolution our ancestors developed a biological apparatus tuned to the properties of face-to-face communication, such as colocation, synchronicity, facial expression, the ability to convey and observe body language, and speech language (Kock, 2005, p. 125; Kock, 2012, p. 386). Accordingly, there is a mismatch between the biological communication apparatus and the characteristics of modern means of communication. Fixing this evolutionary mismatch is used by Kock to argue the position about the need to approximate e-communications in business to the properties of natural face-to-face communication (Kock, 2005).

The statement that in the process of evolution humans have formed a single biological apparatus associated with face-to-face communication is insufficiently substantiated. Evidence from anthropology, evolutionary psychology and evolutionary sociology (e.g., Dunbar, 1997; Buss, 2019; Turner, 2021) suggests that our ancestors participated in communication, which (1) is characterized by varying degrees of representation of the above properties of face-to-face communication, (2) is connected with solving various adaptation problems. Accordingly, (3) neurobiological mechanisms associated with communication of various kind have evolved.

It is likely that our ancestors during scavenging or hunting (it is believed that our ancestors began to hunt since the time of Homo erectus, perhaps earlier; however, this point of view is not accepted by everyone, e.g., Nitecki and Nitecki, 1987) communicate with each other without being able to read non-verbal information, see the face of a fellow tribesman, and this kind of communication in an evolutionary sense is no less natural than face-to-face communication. In addition, by participating in face-to-face interactions, our ancestors solved various problems, for example, detecting social alliances, managing long-term pair-bonding, attaining and maintaining social rank, etc. (e.g., Kurzban et al., 2001; Fletcher et al., 2015; Maner and Case, 2016). Solving these adaptation problems can be considered in the context of maintaining strong or weak social ties and the corresponding development of cognitive abilities with the rewiring of the human brain (Turner and Maryanski, 2013; Turner, 2021).

As Turner and Maryanski (2013) demonstrated, originally to our ancestors (the last common ancestor to all the great apes who lived in the first half of the Neogene period until about 12–18 million years ago, when the orangutans split from other great apes) were characterized by weak social ties, low sociality, and organization (Turner, 2021). The changes took place about 5–6 million years ago, when solving the problem of survival in open areas of the African savanna led to the development of primary, first and second order emotions, large volume of neocortex, enhanced cognitive capacities, capacity for speech, capacity to produce and use cultural symbols that allowed them to become better organized (Turner, 2021, p. 239). Moreover, "at our genetic core, it is not likely that the ape in us disappeared; rather, it is more likely that new behavioral propensities were layered over the more ancient ways of behaving and organizing (...)" (Turner, 2021, p. 38). Other researchers also pay attention to the evolutionary layering of the modern human brain, for example, Dunbar when considering the evolution of language though transition of mankind from social grooming to telling of gossip (Dunbar, 1997, p. 61–62).

DYSFUNCTIONAL EFFECTS OF APPROACHING VIDEO-MEDIATED ONLINE COMMUNICATION TO THE PROPERTIES OF FACE-TO-FACE MEDIUM AND EVOLUTIONARY MISMATCH

One approach to the problem of improving VMOC is to approximate it to the properties of face-to-face interaction (see the references below). In the terms of evolutionary analysis, the implementation of this approach can be described as: (1) the desire to bring the environment (technologies) in line with the evolved biological communication apparatus associated with face-to-face medium, (2) humans' adaptation to a novel environment through learning, training and/or the process of habituating.

A technological strategy for simulating face-to-face communication in an online environment is implemented (or justified for subsequent implementation) by creating the illusion of physical co-presence (telepresence), tracking of the person's face, body language and gestures, improving the quality of video and sound, maximum synchronization, using Virtual Reality technology, system for eye contact, realization of the function of tactile sensations, neurostimulation, using Augmented Reality technologies, and so forth (e.g., Almeida et al., 2012; Chua et al., 2012; Kimura et al., 2020).

An adaptive approach to improving VMOC is expressed in recommendations for learning users certain rules of interaction through video-mediated online platforms (gaze direction, camera and microphone mute, voice volume, "hide self" view, using an external webcam, virtual proxemics rules, interactions to enhance the sense of group belongingness, and so forth; e.g., Bailenson, 2021; Bennett et al., 2021) and training in the use of VMOC systems (e.g., Rivet et al., 2021) to enable users to perform their social functions in a similar way to how it is done using a face-to-face medium. In addition, this approach postulates the possibility of achieving an optimum in social interactivity mediated by new technologies through self-organization (e.g., Paradisi et al., 2021).

The authors of the above and similar studies consider the lack of face-to-face communication properties in the online environment as the causes of the negative psychological and other

consequences, decrease in the effectiveness of communication and/changes in the habitual performance of social roles. For example, non-verbal overload is considered as a cause of fatigue during long-term participation in videoconferences (Bailenson, 2021), the reduced visual and tactile/smell senses as a factor that can reduce the effectiveness of dance movement therapy (Paradisi et al., 2021), a low level of social presence (caused by incomplete view, lack of eye contact and life-size scaling, etc.) as a decrease in involvement in communication, mutual understanding and satisfaction with communication (Almeida et al., 2012; Chua et al., 2012; Kimura et al., 2020).

Without questioning that technological and learning/training ways of approaching VMOC to face-to-face interaction can improve the quality of communication, at least for some users, I would like to draw the attention of readers to the non-obviousness of considering the properties of face-to-face interaction as a guideline in this kind of search.

In the terms of evolutionary analysis (previous section) the technological strategy does not eliminate the evolutionary mismatch, but rather may exacerbate it. Evolutionary mismatch captures a moment of dysfunctional consequences as a result of mental and other human traits that were evolved in one environment being placed in another (Lloyd et al., 2011). The environment in the considered case should be understood as the social context in which communication was carried out to solve a certain adaptation problem.

Some of these dysfunctional effects are inherent in face-to-face communication environments and could potentially be eliminated in an online environment by keeping the VMOC properties in a standard form, for example, by maintaining the benefits of not having direct physical presence on cognitive and affective processes and by giving priority to speech (an idea of prioritizing the ability to convey and listen to speech over facial expressions, body language for the effectiveness of communication and proximity to face-to-face communication is also indicated in the media naturalness hypothesis in "speech imperative proposition," Kock, 2004, p. 335). Spoken language as an adaptation for the transmission of information (Pinker, 1994/2007) is a later human evolutionary aacquisition than the cognitive abilities associated with reading and communicating non-verbal information (in particular, emotions; e.g., Turner and Maryanski, 2013; Turner, 2014)[1]. Saturation of video-online communication with non-verbal social cues through technical improvements can lead to the activation of more ancient mechanisms of social cognition and perception. These mechanisms may interfere with the implementation of the mechanisms associated with the speech aspect of communication, which is the most important in many areas of human activity. To illustrate, this can lead to an increase in forms of behavior inappropriate for the professional sphere, such as harassment, flirting, intrigue, aggression, etc. and interfering with work performance (e.g., Blackwell et al., 2019 indicates that embodiment and presence can intensify harassment in VR social reality).

[1]The capacity for speech arose about 2 million years ago, accompanied by the growth of the neocortex, while human emotional abilities developed 10–12 million years ago, associated with an increase in the subcortical areas (Turner, 2014).

Other consequences are specific to VMOC and not inherent in face-to-face communication in the traditional form; for example, the appearance of asymmetry in obtaining information about the interlocutor due to different technical means (AI-based emotion detection technologies, predictive technologies, automatic data capture and data analysis technologies, masking and deepfake technologies, etc.) that users have at their disposal, inequality and technological escalation associated with it. In addition, the technological and ideological legitimization of the idea of normativity and natural superiority of face-to-face communication may have negative consequences both for the development of the VMOC systems (we set limits in advance) and people (stress, anxiety, frustration, impaired well-being, etc.), since this ideal is unlikely to be achieved.

Thus, as follows from the above idea of the diversified nature of the biological communication apparatus and how the adaptive approach leads to this, VMOC generates its own sociality (see also works on the theory of social presence, Cui et al., 2013 for a review), which is (or becomes over time) no less natural than sociality associated with face-to-face medium. Therefore, the reference to the naturalness of face-to-face medium and evolutionary mismatch in the context of discussing the problems of modern VMOC systems requires at least concretization, depending on the goals and features of the users, allowing to identify specific evolved adaptations and adaptation problems. Otherwise, we face one-sided and potentially misleading interpretations of data indicating differences of face-to-face communication compared to VMOC, referring to our brain's unpreparedness for this kind of communication; for example, the results of such studies, which recorded partial activation of mirror neurons in video-mediated online circumstances (e.g., Dickerson et al., 2017), or data concerning other emotionality (intensity, valence, etc.) of video-mediated online compared to face-to-face communication in different categories of people (e.g., Riby et al., 2012; Schaarschmidt and Koehler, 2021).

INSTEAD OF CONCLUSION: THE NEED TO STUDY ALTERNATIVE WAYS TO IMPROVE VIDEO-MEDIATED ONLINE COMMUNICATION

An alternative way is to move away from considering the problem of improving VMOC as a task to bridge the gap between VMOC and face-to-face medium. One approach involves focusing on the development of alternative institutions through the implementation of such VMOC systems that level the imperfections of social interactions such as excessive ritualization, particularism, prejudice, biased perceptions, etc. generated, among other things, by the properties of face-to-face communication. Orientation to the functional tasks of institutions, may help us to justify and accept the possibility for "non-natural" VMOC systems; for instance, neurotechnological invasive or non-invasive interventions in the human brain and other alternatives to enhancing cognitive abilities and customizing VMOC are worth exploring.

AUTHOR CONTRIBUTIONS

The author confirms being the sole contributor of this work and has approved it for publication.

ACKNOWLEDGMENTS

The author thanks to Valeria Saladino for constructive criticism and extremely informative comments.

REFERENCES

Almeida, I. D. S., Oikawa, M. A., Carres, J. P., Miyazaki, J., Kato, H., and Billinghurst, M. (2012). "AR-based video-mediated communication: a social presence enhancing experience," in *14th Symposium on Virtual and Augmented Reality* (Rio de Janeiro). pp. 125–130. doi: 10.1109/SVR.2012.4

Bailenson, J. N. (2021). Nonverbal overload: a theoretical argument for the causes of zoom fatigue. *Technol. Mind Behav.* 2. doi: 10.1037/tmb0000030

Bennett, A. A., Campion, E. D., Keeler, K. R., and Keener, S. K. (2021). Videoconference fatigue? Exploring changes in fatigue after videoconference meetings during COVID-19. *J. Appl. Psychol.* 106, 330–344. doi: 10.1037/apl0000906

Blackwell, L., Ellison, N., Elliott-Deflo, N., and Schwartz, R. (2019). Harassment in social virtual reality: challenges for platform governance. *Proc. ACM Hum. Comput. Interact*. 3:100. doi: 10.1145/3359202

Blau, I., Weiser, O., and Eshet-Alkalai, Y. (2017). How do medium naturalness and personality traits shape academic achievement and perceived learning? An experimental study of face-to-face and synchronous e-learning. *Res. Learn. Technol.* 25. doi: 10.25304/rlt.v25.1974

Brenner, S. L., Jones, J. P., Rutanen-Whaley, R. H., Parker, W., Flinn, M. V., and Muehlenbein, M. P. (2015). Evolutionary mismatch and chronic psychological stress. *J. Evolut. Med.* 30, 32–44. doi: 10.4303/jem/235885

Buss, D. M. (2019). *Evolutionary Psychology. The New Science of the Mind. 6th Edn.* New York, NY; London: Routledge.

Chua, Y., Tee, K. P., Yan, R., Li, L., and Huang, Z. (2012). "Towards more engaging telepresence by face tracking," in *Proceedings of the Workshop at SIGGRAPH Asia (WASA '12)* (New York: Association for Computing Machinery), 137–141.

Cui, G., Lockee, B., and Meng, C. (2013). Building modern online social presence: a review of social presence theory and its instructional design implications for future trends. *Educ. Inf. Technol.* 18, 661–685. doi: 10.1007/s10639-012-9192-1

DeRosa, D. M., Hantula, D. A., Kock, N., and D'Arcy, J. (2004). Trust and leadership in virtual teamwork: a media naturalness perspective. *Hum. Resour. Manag.* 43, 219–232. doi: 10.1002/hrm.20016

Dickerson, K., Gerhardstein, P., and Moser, A. (2017). The role of the human mirror neuron system in supporting communication in a digital world. *Front. Psychol.* 8, 698. doi: 10.3389/fpsyg.2017.00698

Dunbar, R. (1997). *Grooming, Gossip and the Evolution of Language, 6th Edn*. London: Faber and Faber Limited.

Fletcher, G. J. O., Simpson, J. A., Campbell, L., and Overall, N. C. (2015). Pair-bonding, romantic love, and evolution: the curious case of homo sapiens. *Perspect. Psychol. Sci.* 10, 20–36. doi: 10.1177/1745691614561683

Kalkhoff, W., Serpe, R. T., and Pollock, J. (2020). *Is Video Chat a Sufficient Proxy for Face-to-Face Interaction? Biosociological Reflections on Life during the COVID-19*. Available online at: https://thisviewoflife.com/is-video-chat-a-sufficient-proxy-for-face-to-face-interaction-biosociological-reflections-on-life-during-the-covid-19-pandemic/

Kanazawa, S., and Li, N. P. (2015). Happiness in modern society: why intelligence and ethnic composition matter. *J. Res. Pers.* 59, 111–120. doi: 10.1016/j.jrp.2015.06.004

Karl, K. A., Peluchette, J. V., and Aghakhani, N. (2021). Virtual work meetings during the COVID-19 pandemic: The good, bad, and ugly. *Small Group Res.* 10464964211015286. doi: 10.1177/10464964211015286

Kegel, I., Cesar, P., Jansen, J., Bulterman, D., Stevens, T., Kort, J., et al. (2012). "Enabling 'togetherness' in high-quality domestic video conferencing," in *Proceedings of the 20th ACM international conference on Multimedia (MM '12). Association for Computing Machinery* (New York, NY), 159–168.

Kimura, S., Ooseki, E., Aburakawa, Y., and Yamaguchi, M. (2020). Evaluation and formulation of the sense of social telepresence in video-mediated communication systems: contribution of eye contact to enhancing social telepresence. *J. Soc. Inf. Display* 29, 1–17. doi: 10.1002/jsid.976

Kock, N. (2004). The psychobiological model: towards a new theory of computer-mediated communication based on darwinian evolution. *Organ. Sci.* 15, 327–348. doi: 10.1287/orsc.1040.0071

Kock, N. (2005). Media Richness or Media Naturalness? The evolution of our biological communication apparatus and its influence on our behavior toward e-communication tools. *IEEE Trans. Profess. Commun.* 48, 117–130. doi: 10.1109/TPC.2005.849649

Kock, N. (2012). "Media naturalness theory: human evolution and behaviour towards electronic communication technologies," in *Applied Evolutionary Psychology,* ed S. Craig Roberts (Oxford: Oxford University Press).

Kurzban, R., Tooby, J., and Cosmides, L. (2001). Can race be erased? Coalitional computation and social categorization. *Proc. Natl. Acad. Sci. U.S.A.* 98, 15387–15392. doi: 10.1073/pnas.251541498

Li, N. P., van Vugt, M., and Colarelli, S. M. (2017). The Evolutionary Mismatch Hypothesis: Implications for Psychological Science. *Curr. Dir. Psychol. Sci.* 27, 38–44. doi: 10.1177/0963721417731378

Lloyd, E. A., Wilson, D. S., and Sober, E. (2011). *Evolutionary Mismatch and What to Do About It: A Basic Tutorial.* Available online at: https://evolution-institute.org/wp-content/uploads/2015/08/Mismatch-Sept-24-2011.pdf

Maner, J. K., and Case, C. R. (2016). "Dominance and prestige: dual strategies for navigating social hierarchies," in *Advances in Experimental Social Psychology*, *Vol. 54*, eds J. L. Olson and M. P. Zanna (London: Elsevier), 129–180.

Nitecki, M. N., and Nitecki, D. V. (Eds.). (1987). *The Evolution of Human Hunting*. New York, NY; London: Plenum Press.

Paradisi, P., Raglianti, M., and Sebastiani, L. (2021). Online communication and body language. *Front. Behav. Neurosci.* 16:709365. doi: 10.3389/fnbeh.2021.709365

Pinker, S. (1994/2007). *The Language Instinct*. New York, NY: Harper Perennial Modern Classics.

Riby, D. M., Whittle, L., and Doherty-Sneddon, G. (2012). Physiological reactivity to faces via live and video-mediated communication in typical and atypical development. *J. Clin. Exp. Neuropsychol.* 34, 385–395. doi: 10.1080/13803395.2011.645019

Rivet, E. B., Cholyway, R., Edwards, C., Wishnoff, M., Raza, O., Haynes, S., et al. (2021). Video-mediated breaking bad news simulation. *Clin. Teach.* 18, 424–430. doi: 10.1111/tct.13387

Sbarra, D. A., Briskin, J. L., and Slatcher, R. B. (2019). Smartphones and close relationships: the case for an evolutionary mismatch. *Perspect. Psychol. Sci.* 14, 596–618. doi: 10.1177/1745691619826535

Schaarschmidt, N., and Koehler, T. (2021). Experiencing emotions in video-mediated psychological counselling versus to face-to-face settings. *Societies* 11, 20. doi: 10.3390/soc11010020

Simon, A. F. (2006). Computer-mediated communication: task performance and satisfaction. *J. Soc. Psychol.* 146, 349–379. doi: 10.3200/SOCP.146.3.349-379

Turner, J. (2021). *On Human Nature. The Biology and Sociology of What Made Us Human*. New York, NY: Routledge.

Turner, J. H. (2014). "The evolution of human emotions," in *Handbook of the Sociology of Emotions. Vol. II. Handbooks of Sociology and Social Research*, eds J. E. Stets and J. H. Turner (Dordrecht: Springer Science+Business Media), 11–31.

Turner, J. H., and Maryanski, A. (2013). "The evolution of the neurological basis of human sociality," in *Handbook of Neurosociology*, eds D. D. Franks and J. H. Turner (New York, NY; London: Springer Science+Business Media B.V.).

Van Vugt, M., and Ronay, R. (2013). The evolutionary psychology of leadership: theory, review, and roadmap. *Organ. Psychol. Rev.* 4, 74–95. doi: 10.1177/2041386613493635

Vlahovic, T. A., Roberts, S., and Dunbar, R. (2012). Effects of duration and laughter on subjective happiness within different modes of communication.

J. Comput. Mediated Commun. 17, 436–45. doi: 10.1111/j.1083-6101.2012.01584.x

Conflict of Interest: The author declares 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: All claims expressed in this article are solely those of the authors and do not necessarily represent those of their affiliated organizations, or those of the publisher, the editors and the reviewers. Any product that may be evaluated in this article, or claim that may be made by its manufacturer, is not guaranteed or endorsed by the publisher.

frontiers in Behavioral Neuroscience

SYSTEMATIC REVIEW
published: 08 March 2022
doi: 10.3389/fnbeh.2022.815811

A Domain-General Developmental "Do-GooD" Network Model of Prosocial Cognition in Adolescence: A Systematic Review

*Benjamin S. Sipes[1], Tony T. Yang[2], Kendall C. Parks[1], Namasvi Jariwala[1] and Olga Tymofiyeva[1]**

[1] Department of Radiology and Biomedical Imaging, University of California, San Francisco, San Francisco, CA, United States, [2] Department of Psychiatry and Behavioral Sciences, The Langley Porter Psychiatric Institute, Division of Child and Adolescent Psychiatry, Weill Institute for Neurosciences, University of California, San Francisco, San Francisco, CA, United States

OPEN ACCESS

Edited by:
Gennaro Iorio, University of Salerno, Italy

Reviewed by:
Valeria Saladino, University of Cassino, Italy
Olga Maslova, Neurosciences Research Institute of Samara State Medical University, Russia

***Correspondence:**
Olga Tymofiyeva
olga.tymofiyeva@ucsf.edu

Specialty section:
This article was submitted to Individual and Social Behaviors, a section of the journal Frontiers in Behavioral Neuroscience

Received: *15 November 2021*
Accepted: *10 February 2022*
Published: *08 March 2022*

Citation:
Sipes BS, Yang TT, Parks KC, Jariwala N and Tymofiyeva O (2022) A Domain-General Developmental "Do-GooD" Network Model of Prosocial Cognition in Adolescence: A Systematic Review. Front. Behav. Neurosci. 16:815811. doi: 10.3389/fnbeh.2022.815811

Adolescence is a period of substantial neural and social development, and prosocial decisions are beneficial to personal well-being, the well-being of others, and the functioning of society. Advances in network neuroscience call for a systematic synthesis and reappraisal of prosocial neural correlates during adolescent development. In this systematic review, we aim to outline the progress made in this field, identify the similarities between study results, and propose a model for prosocial cognition in adolescents to young adults. A total of 25 articles were included in this review. After reviewing and synthesizing the literature, we propose a DOmain-General Developmental "Do-GooD" network model of prosocial cognition that aligns with the reviewed literature, accounts for development, and combines elements of the value-based decision-making model with distinct value contributions from the default mode network, salience network, and control network. We offer predictions to test the "Do-GooD" model and propose new future directions for studying prosocial behavior and its development during adolescence, which in turn may lead to improving education and the development of better health interventions for adolescents.

Keywords: prosocial, adolescence, networks, theory of mind, MRI, domain general cognitive processes

INTRODUCTION

Adolescence is a period of substantial neural and social development. Prosocial behavior, defined as voluntary behavior intended to benefit another individual (Eisenberg et al., 2007), is a key element to human cooperation in society, it relates to health benefits for the giver (Inagaki and Eisenberger, 2016; Moieni et al., 2019), and it is thought to be causally related to improved well-being [for reviews, see Helliwell et al. (2017) and Aknin et al. (2019)]. While prosocial behavior is multi-dimensional with many possible incentives, altruistic prosociality is dominated by motivations to benefit others without obvious self-benefit (Batson, 1991), and thus it may reflect intrinsically motivated helping behavior. Consolidating magnetic resonance imaging (MRI) research on

altruistic prosocial behavior could elucidate prosocial decision-making mechanisms significant to adolescence, which could inform the development of interventions aimed at improving prosocial development in youth.

Prosocial behavior in childhood predicts adulthood prosociality (Eisenberg et al., 2001), and prosocial development during early adolescence appears highly influenced by the social-cultural environment (House et al., 2013). Both childhood prosocial behavior and social-cultural environment highlight adolescence as a critical period for healthy prosocial development. Competencies related to prosocial behavior are known to develop during adolescence, such as decision-making (Mann et al., 1989) and interpersonal relationships (Smetana et al., 2006). The adolescent brain also undergoes substantial structural remodeling in the gray matter, white matter, and functional activity related to social-cognition [see for review Blakemore (2012)].

Neural mechanisms of prosocial behavior and cognition are under active investigation. MRI neuroimaging has an advantage over other imaging modalities by providing excellent spatial resolution and whole-brain coverage. Functional MRI (fMRI) in particular is able to identify regions with greater blood oxygen level dependence (BOLD) signal during prosocial tasks compared to control tasks. Bellucci et al. (2020) conducted a recent meta-analysis on this neuroimaging literature, showing that brain regions associated with prosociality included the ventromedial prefrontal cortex (VMPFC), left dorsolateral prefrontal cortex (DLFPC), middle cingulate cortex (MCC), and the posterior cingulate cortex (PCC). The authors also noted that prosocial brain regions had significant overlap with mentalizing (or Theory of Mind) regions in the VMPFC and PCC, as well as with an empathy region in the MCC (Bellucci et al., 2020).

To our knowledge, no models have been developed to explicitly describe prosocial decision-making during development. Research on Theory of Mind (ToM), which is the ability to attribute mental states to self and others (Goldman, 2012), has been often suggested to underly prosocial behavior through greater involvement in other-oriented brain regions that facilitate empathy and develop during adolescence (Cassidy et al., 2003; Decety and Jackson, 2004; Carter and Huettel, 2013; Slaughter et al., 2015; Meinhardt-Injac et al., 2020). Value-based decision-making as a general model for decision-making in the brain has also been speculated to describe altruism (Brosch and Sander, 2013). One neuroeconomic model proposed by Declerck et al. (2013) uses a value-based decision-making framework to characterize prosocial behavior in adulthood, proposing that different brain systems are responsible for different prosocial motivations: that altruism primarily involves social brain regions, while selfish incentives (e.g., money or reputation) drive prosocial behavior through cognitive control brain regions (Declerck et al., 2013). Yet none of these models synthesize findings into a general understanding of prosocial neurodevelopment.

Recent advances in human neuroscience research emphasize the importance of brain networks for describing general cognitive processes (Bassett and Sporns, 2017). Domain-general networks such as the medial frontoparietal "default-mode" network (DMN), the midcingulo-insular "salience" network (SN), and the lateral frontoparietal "control" network (CN) are identified in resting state brain activations and during task-evoked cognition (Uddin et al., 2019), which may suggest their role in facilitating cognitive processes such as prosocial behavior. Each network's functionality is varied, but a few broad patterns have emerged. The DMN is likely involved in generating predictions (Dohmatob et al., 2017), consolidating social information (Meyer et al., 2019), and theory of mind (Hyatt et al., 2015). The SN is strongly connected to deep-brain structures involved in bodily sensation (Kleckner et al., 2017), empathy (Fan et al., 2011), and evaluating fairness (Gabay et al., 2014). The CN is generally implicated in self-control (Berkman et al., 2017), but it also is involved in understanding social norms (Hackel et al., 2020) and evaluating moral preferences (Crockett et al., 2017). Moreover, accumulating evidence has highlighted significant development both within and between the DMN, SN, and CN during adolescence (Uddin et al., 2011; Ryali et al., 2016). Yet to current scientific knowledge, no accounts of prosocial behavior in terms of such domain-general networks exist.

This present work systematically reviews the literature on prosocial cognition spanning adolescent development with three goals. Our first aim is to summarize the common findings on the neural correlates of adolescent prosocial behavior grouped by domain-general networks. That review informs our second aim in which we propose a **DO**main-**G**eneral **D**evelopmental "Do-GooD" model of prosocial cognition that synthesizes many of the previously described models into a domain-general network framework that can explain the reviewed results and some of their heterogeneity. Our third and final aim is to offer new predictions based on the "Do-GooD" model to guide advances in the field of adolescent prosocial neural development.

METHODS

We reviewed and synthesized the literature on MRI neural correlates of prosocial development in typically developing adolescents from three electronic databases as described by the following sections. We conducted this systematic review following PRISMA recommendations (Moher et al., 2009).

Search Strategy

We conducted our search on 16th April 2021 in three databases: PubMed, PsychINFO, and Web of Science. An updated search was conducted on 8th November 2021.

The following search terms with Boolean operators queried the databases' titles and abstracts: [(adolescen* OR "young adults") AND (fMRI OR DTI OR MRI OR "magnetic resonance") AND (prosocial OR pro-social OR altruis* OR coop* OR trust OR "trust game" OR recipro*) AND (behavior* OR behaviour*)]. To ensure search results from recently published work, we searched Google Scholar using the terms [adolescent AND

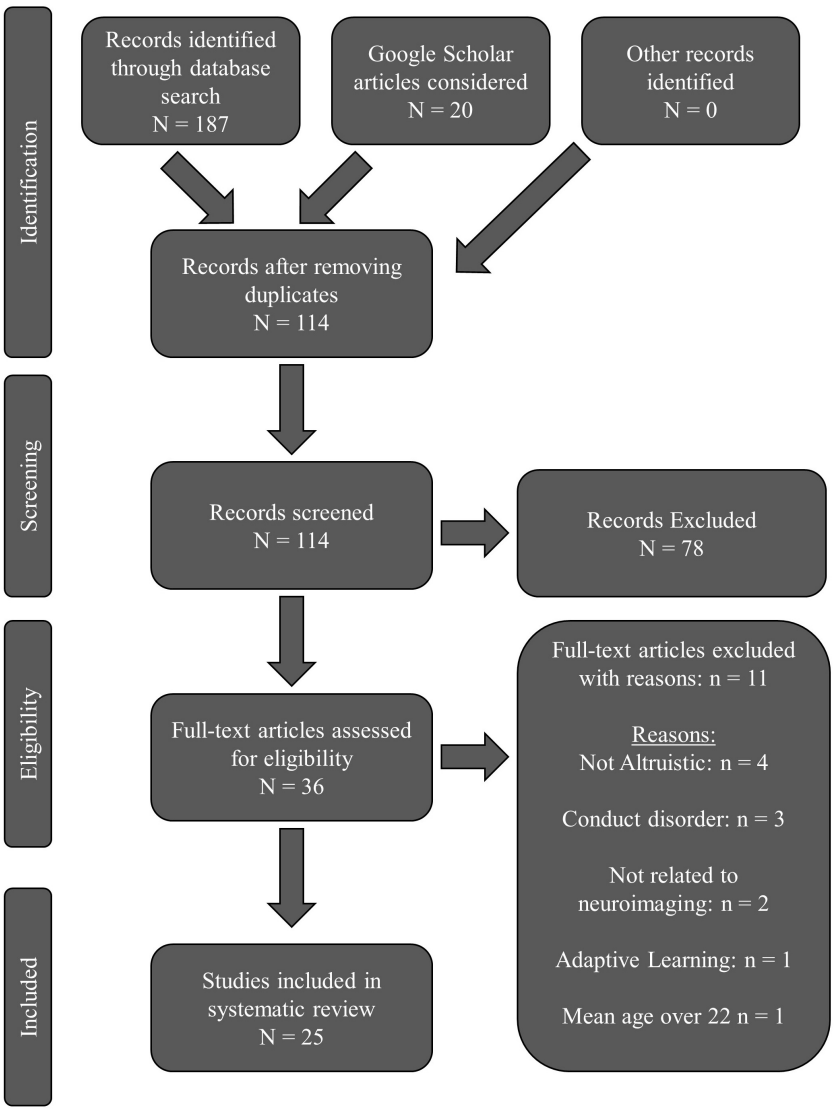


FIGURE 1 | PRISMA flow chart for the systematic review literature search.

prosocial AND mri] published since the year 2020, and evaluated the first twenty most relevant results for eligibility.

Screening, Eligibility and Data Extraction

We removed duplicate results, then screened abstracts and methods sections for all articles. The following criteria were considered a reason for exclusion: not a full research paper, not peer-reviewed, the publication was not in English, assessed a strictly adult (over 22) or childhood (under 10) population, no MRI imaging, animal studies, case studies, no prosocial measures relating to MRI. Our age criterion was based on past work and reviews on adolescence (Steinberg, 2008; Van Hoorn et al., 2019), and we included studies with subjects ages 10 to 22 years. We excluded studies where the mean subject age was below 10- and above 22-years-old. Full-text articles were then assessed for eligibility. Studies upon closer inspection that did not have a clear relationship between prosocial decisions and neural correlates were further excluded from the analysis. Since we focused on the altruistic dimension of prosocial behavior, we excluded studies with tasks where adolescents' optimal strategy to maximize self-payoff was to be prosocial, which does not reflect altruistic choices. Lastly, we excluded atypical populations because the aim was to review healthy prosocial decision-making and development.

The remaining studies were reviewed, and their data were extracted. Extracted information included the following: the first author's name, year published, a general summary of study aims, study sample sizes, population ages, MRI modality, any tasks performed by the subjects during/after the MRI, the study's measure of prosociality, the resulting neural correlates in their experiment, and any correlations/effect-sizes corresponding to those neural correlates.

RESULTS

The PRISMA flow chart is presented in **Figure 1**. Our database search revealed 187 total articles: PubMed returned 60 results; PsychINFO returned 35 results; Web of Science returned 92 results. Twenty articles were assessed from Google Scholar. After removing all duplicates, 114 articles remained. Thirty-six articles remained after initial screening for eligibility. Eleven full-text articles were excluded: four were not altruistic; three focused on conduct disorder; two did not relate prosocial findings to neuroimaging; one focused on adaptive learning; one had young adults with a mean age over 22-years-old. Twenty-five total articles were reviewed.

The 25 included studies are summarized in **Table 1**. In the following, we describe the types of methodologies used to study prosocial behavior. We then describe neural correlates related to prosociality in sections focusing on reward and valuation regions, the default mode network, the salience network, the control network, and visual/somatosensory networks. We close each section with a summary of the main findings.

Methodological Strategies to Study Prosociality in Adolescents

Among the 25 included articles, seven reported prosocial neural correlates related to behaviors that were not imaged directly (see **Table 1**, column "Prosocial Measure"). Two of these used the self-report Strengths and Difficulties Questionnaire's (SDQ) prosocial subscale related to cortical thickness changes (Ferschmann et al., 2019) and resting state functional connectivity (Okada et al., 2019). The other five studies used a prosocial behavioral task after neuroimaging and related prior neural activations to subsequent prosociality (Masten et al., 2010; Overgaauw et al., 2014; Tashjian et al., 2018; Tousignant et al., 2018; Spaans et al., 2020).

Nineteen studies reported prosocial neural correlates concurrently with a prosocial decision-making task. Seven of these used the Dictator Game (Moor et al., 2012; Güroğlu et al., 2014; Will et al., 2016, 2018; Schreuders et al., 2018, 2019; Duell et al., 2021), and five used close variations on the Dictator Game, including either the Allocation Game (Do and Telzer, 2019; Do et al., 2019), the Family Assistance Task (Telzer et al., 2011, 2013), or the Charity of Self Yield Task (Spaans et al., 2020; Brandner et al., 2021). The seven remaining studies used various games that also involved resource distribution: the Socially Mindful task (Lemmers-Jansen et al., 2018), the Altruism Antisocial Game (Sakai et al., 2017), the Trust Game (van den Bos et al., 2009, 2011), the Public Goods Game (Van Hoorn et al., 2016), and Cyberball (van der Meulen et al., 2016; Tousignant et al., 2018).

In addition to the methodological differences described above, the reviewed studies focused on three different aspects of the decision-making process (see **Table 1**, column "Aspect of Prosociality"). Eight studies compared (pro)social decision-making in general (i.e., the deliberation phase) to neutral/non-prosocial control conditions (hereafter, "prosocial decision-making") (van den Bos et al., 2011; Moor et al., 2012; Van Hoorn et al., 2016; Sakai et al., 2017; Lemmers-Jansen et al., 2018; Tousignant et al., 2018; Will et al., 2018; Duell et al., 2021). Eleven studies contrasted prosocial decision-making trials based on the actual prosocial *choice* such that decision-making with prosocial outcomes were compared to decision-making with non-prosocial outcomes (hereafter, "prosocial choices") (Telzer et al., 2011, 2013; Güroğlu et al., 2014; Lemmers-Jansen et al., 2018; Schreuders et al., 2018, 2019; Do and Telzer, 2019; Do et al., 2019; Spaans et al., 2020; van der Meulen et al., 2016; Brandner et al., 2021). Twelve studies analyzed neural activation during prosocial decision-making that correlated with the *frequency* of making prosocial choices, and therefore accounts for between-person differences (hereafter, "giving frequency" or "behavior frequency") (van den Bos et al., 2009, 2011; Masten et al., 2010; Moor et al., 2012; Güroğlu et al., 2014; Overgaauw et al., 2014; Will et al., 2016; Schreuders et al., 2018; Tashjian et al., 2018; Tousignant et al., 2018; Ferschmann et al., 2019; Okada et al., 2019).

Reward and Valuation Regions

The reviewed studies often identified the striatum as related to prosociality in adolescents. Studies that analyzed prosocial decision-making found activation in the bilateral striatum (Will et al., 2018) including the dorsal striatum (van den Bos et al., 2011) and the caudate (Sakai et al., 2017; Tousignant et al., 2018; Duell et al., 2021). Prosocial choices across adolescence frequently implicated the ventral striatum (VS) (van den Bos et al., 2009; Telzer et al., 2013; Güroğlu et al., 2014) including the nucleus accumbens (Spaans et al., 2020; van der Meulen et al., 2016; Brandner et al., 2021), with greater VS activation when decisions were prosocial. The VS also had significant functional connectivity relating to prosocial choices in other regions, including the posterior superior temporal sulcus (pSTS) adolescents behaved equitably with outgroups (Do and Telzer, 2019), and the left ventrolateral prefrontal cortex (VLPFC), left dorsomedial prefrontal cortex (DMPFC), and right medial prefrontal cortex (mPFC) in young adults making costly donations (Telzer et al., 2011). The putamen also activated in adolescents (Schreuders et al., 2019) and young adults (Schreuders et al., 2018) while making prosocial choices toward friends more than to disliked peers. The midbrain was also identified during both decision-making (Sakai et al., 2017) and prosocial choices (Telzer et al., 2013). Lastly, the VMPFC was identified in youth during prosocial decision-making (Güroğlu et al., 2014; Tousignant et al., 2018; Will et al., 2018; Duell et al., 2021), its activation during decision-making interacted with pubertal hormone changes (Duell et al., 2021), and its activation was greater for prosocial choices (Güroğlu et al., 2014; Spaans et al., 2020; Brandner et al., 2021). One study additionally found a correlation between nucleus accumbens and VMPFC activation during prosocial choices (Brandner et al., 2021).

Summary

In the reviewed literature, brain regions involved in reward and value processing were related to prosocial behavior. Both

TABLE 1 | This table summarizes all results from the reviewed studies.

Author (Year)	Total N	Age range(s)	Prosocial measure	MRI measure	Aspect of prosociality	Analytic approach	Contrast	Regions implicated
Brandner et al., 2021	142 (88 female)	8 to 19	Donation observation	Charity or Self Yield Task (task-based fMRI)	Prosocial Choice	Region of Interest	Mother Gain > No Gain & Father Gain > No Gain & Stranger Gain > No Gain	Nucleus accumbens (mother/father) > stranger
						Region of Interest Correlation	Mother Gain > No Gain & Father Gain > No Gain	nucleus accumbens (positive association with pleasure) Mother Gain (r = 0.25), Father Gain (r = 0.28)
						Region of Interest	Father Gain > No Gain & Stranger Gain > No Gain	VMPFC (Father) > VMPFC (Stranger)
						Region(s) of Interest Correlation	Mother Gain > No Gain & Father Gain > No Gain & Stranger Gain > No Gain Correlation of nucleus accumbens and VMPFC	Mother Gain (r = 0.61) Father Gain (r = 0.66) Stranger Gain (r = 0.47)
Do et al., 2019	51 (28 female)	8 to 16	Donation behavior	Allocation Task (task-based fMRI)	Prosocial Choice	Whole-Brain Contrast	Costly Giving > Non-costly Giving	B-pSTS, L-Prec, L-inferior temporal gyrus, L-IFG, L-DLPFC, R-DMPFC
					Prosocial Choice/Frequency	Whole-Brain Regression	Costly Giving > Costly Reward	dACC (negative association)
Do and Telzer, 2019	51 (28 female)	8 to 16	Donation behavior	Allocation Task (task-based fMRI)	Prosocial Choice	Region of Interest	Give Out-Group > Give In-Group	FC between VS and R-pSTS
Duell et al., 2021	97 (51% female)	11 to 14	Donation behavior	Charity time donation (task-based fMRI)	Decision-Making	Whole-Brain Contrast	Decisions Post > Pre-observation	B-insula, B-inferior temporal gyrus, L-middle occipital gyrus, R-dACC, R-FFG, R-postcentral gyrus, R-cuneus
				hormone interaction with task activation	Decision-Making	Whole-Brain Regression	Post > Pre-obs * cortisol * Testosterone	B-OFC, PCC, B-cerebellum, L-TPJ, L-insula, L-DLPFC, L-precentral gyrus, R-caudate, R-MTG, R-superior orbital gyrus
Ferschmann et al., 2019	169 (92 female)	12 to 26	SDQ (prosocial)	Cortical Thinning	Frequency	Whole-Brain Regression	N/A	L-DLPFC, R-pMTG, R-IFG, R-mPFC, R-IPS, R-TPJ, R-dACC
Masten et al., 2010	20 (10 female)	12 to 13	Prosocial writing (post-task)	Cyberball Observation (task-based fMRI)	Frequency	Whole-Brain Regression	Exclusion > Inclusion	R-AI (r = 0.71), R-PCC (r = -0.68), R-Prec (r = -0.69)

(Continued)

TABLE 1 | Continued

Author (Year)	Total N	Age range(s)	Prosocial measure	MRI measure	Aspect of prosociality	Analytic approach	Contrast	Regions implicated
Moor et al., 2012	53 (13 female)	10 to 12 14 to 16 19 to 21	% forgiving offers	Dictator Game (task-based fMRI)	Frequency	Whole-Brain Regression	Excluders > Includers	dACC (positive association)
					Decision-Making	Whole-Brain Contrast	Excluders > Includers (19-21)	dACC, L-TP, R-insula
Güroğlu et al., 2014	10	μ = 20.7	Donation behavior	Dictator Game (task-based fMRI)	Prosocial Choice	Whole-Brain Contrast	Prosocial Inequity > Equity	VMPFC, VS, R-insula
	28 (17 female)				Frequency	Whole-Brain Regression	Decision-making	Prec, VMPFC, R-DLPFC (positive associations)
Lemmers-Jansen et al., 2018	47 (22 female)	16 to 27 (μ = 21)	Social Mindfulness	SoMi Task (task-based fMRI)	Decision-Making	Whole-Brain Contrast	Decision-Making Prosocial > Control	B-DMPFC, B-middle frontal gyrus, B-IFG, B-TPJ, L-ACC, L-IPL, R-MCC, R-PCC, R-Prec
					Prosocial Choice	Conjunction Analysis	Prosocial Decisions	L-IPL, L-Prec, R-DLPFC, R-IFG, R-TPJ, R-MTG, R-cuneus
Okada et al., 2019	271 (129 female)	10 to 13	SDQ (prosocial)	RS-FC in ACC	Frequency	Region of Interest	RS-FC with ACC correlating with SDQ	B-MCC, B-PCC, R-precentral gyrus (all positive associations)
				MRS on ACC	Frequency	Region of Interest	metabolites with SDQ	GABA (ρ = -0.15)
Overgaauw et al., 2014	37 (23 female)	12 to 19	Donation behavior	Dictator Game (task-based fMRI)	Frequency	Whole-Brain Regression	Negative > Positive social scenes correlation with giving	R-IPL (r = -0.35)
Sakai et al., 2017	45 (0 female)	15 to 16	Donation behavior	AIAn Game (task-based fMRI)	Decision-Making	Whole-Brain Contrast	Decision > Control	mPFC, ACC, caudate, thalamus, VTA, B-insula, B-IFG, R-DLPFC, R-SPL, R-IPL, R-TPJ, R-postcentral gyrus
Schreuders et al., 2018	27 (12 female)	μ = 21.25	Donation behavior	Dictator Game (task-based fMRI)	Frequency	Whole-Brain Regression	Decision-making Friend > Disliked Peer	SMA, L-lingual gyrus, L-precentral gyrus, R-insula, R-DLPFC, R-calcarine gyrus (all negative associations)
					Prosocial Choice/Frequency	Whole-Brain Regression	% prosocial Friend > Disliked peer	SMA (r = -0.6), R-insula (r = -0.62)
					Prosocial Choice	Whole-Brain Contrast	Prosocial Friends > Disliked Peers	B-TPJ/IPL, L-putamen, R-IFG
					Prosocial Choice	Whole-Brain Contrast	Prosocial Friends > Unknown Peers	B-TPJ/IPL, L-SPL, L-Prec

(Continued)

TABLE 1 | Continued

Author (Year)	Total N	Age range(s)	Prosocial measure	MRI measure	Aspect of prosociality	Analytic approach	Contrast	Regions implicated
Schreuders et al., 2019	50 (21 female)	μ = 14.6	Donation behavior	Dictator Game (task-based fMRI)	Prosocial Choice	Whole-Brain Contrast	Prosocial Friends > Disliked Peers	B-SPL, R-postcentral/precentral gyri, R-MTG, R-insula, R-TPJ, R-middle occipital gyrus, R-putamen
					Prosocial Choice	Whole-Brain Contrast	Prosocial Friends > Unknown Peers	B-SPL, B-IPL, L-middle occipital gyrus, L-precentral gyrus
Spaans et al., 2020	160 (84 females)	11 to 21	Donation observation	Charity or Self Yield Task (task-based fMRI)	Prosocial Choice	Whole-Brain Contrast	Charity-Gain > Both-No-Gain	B-TPJ, VMPFC, L-mPFC, L-DLPFC, R-Prec
			Donation behavior (post-task)	Charity or Self Yield Task (task-based fMRI)	Prosocial Choice	Region of Interest	Charity-Gain > Both-No-Gain	nucleus accumbens (positive association)
Tashjian et al., 2018	20 (7 female)	13 to 15	Donation behavior (post-task)	Prosocial, Social, or Neutral scene observation (task-based fMRI)	Frequency	Conjunction based Regression Analysis	Prosocial > Neutral&Social scenes	B-TPJ (positive association)
Telzer et al., 2011	25 (13 female)	μ = 20.2	Donation behavior	Family Assistance Task (task-based fMRI)	Prosocial Choice	Whole-Brain Contrast	Costly Donation > Non-costly Reward	B-IPL, L-DPLFC, R-DMPFC
					Prosocial Choice	Whole-Brain Regression	Costly Donation > Non-costly Reward WBR family obligation	B-pSTS, R-TPJ, R-ACC, L-DLPFC
					Prosocial Choice	Region of Interest	Costly Donation > Non-costly Reward FC	FC between VS and L-VLPFC, L-DMPFC, R-mPFC
Telzer et al., 2013	32 (18 female)	15 to 16	Donation behavior	Family Assistance Task (task-based fMRI)	Prosocial Choice	Whole-Brain Contrast	Costly Donation > Non-costly Reward	dACC, cuneus, ventral midbrain, L-insula
					Prosocial Choice	Whole-Brain Regression	Costly Donation > Non-costly Reward WBR family obligation	B-VS
Tousignant et al., 2018	20 adolescents (10 female) & 20 adults (10 female)	μ adoles = 14.25 μ adult = 24.25	Cyberball inclusion	Cyberball Observation (task-based fMRI)	Frequency	Regression on significant whole-brain regions	Observation Exclusion > Inclusion correlated with behavior in young adults	insula (r = 0.46), amygdala (r = 0.47)

(Continued)

TABLE 1 | Continued

Author (Year)	Total N	Age range(s)	Prosocial measure	MRI measure	Aspect of prosociality	Analytic approach	Contrast	Regions implicated
				Cyberball Play (task-based fMRI)	Decision-Making	Whole-Brain Contrast	Play Exclusion > Inclusion	PCC, B-TPJ, B-TP (extending to insula and VMPFC), R-mPFC, R-DMPFC, R-DLPFC, R-lateral temporal cortex, R-caudate
				Cyberball Play (task-based fMRI)	Decision-Making	Whole-Brain Contrast	Play Exclusion > Inclusion adults > adolescence	R-TPJ, R-DMPFC/mPFC, R-fusiform face area
van den Bos et al., 2009	22 (11 female)	18 to 22	Reciprocity	Trust Game (task-based fMRI)	Prosocial Choice	Whole-Brain Contrast	Reciprocate > Defect	B-visual cortex
					Frequency	Whole-Brain Regression	Defect > Reciprocate% reciprocate	dACC, B-insula, L-Prec, R-TPJ, R-thalamus (positive associations); R-VS (negative association)
van den Bos et al., 2011	62 (30 female)	12 to 14 15 to 17 18 to 22	Reciprocity	Trust Game (task-based fMRI)	Prosocial Choice	Whole-Brain Contrast	Reciprocate > Defect	B-visual cortex
					Prosocial Choice	Whole-Brain Contrast and *post hoc* correlation	Reciprocate > Control (age correlation)	mPFC (r = -0.56)
					Frequency	Whole-Brain Regression	Defect > Reciprocate WBR%reciprocate	dACC, B-insula (positive association)
					Decision-Making	Whole-Brain Contrast	Decision-making > Control	B-dorsal striatum, L-Prec, R-SPL, R-DLPFC, R-DMPFC, R-ACC
					Decision-Making	Whole-Brain Contrast	Decision-making (older > younger)	L-TPJ, R-DLPFC
van der Meulen et al., 2016	23 (all female)	18 to 19	Cyberball inclusion	Cyberball play (task-based fMRI)	Prosocial Choice	Whole-Brain Contrast	Prosocial > Control	B-TPJ, B-cuneus, B-insula, L-nucleus accumbens, R-IFG, R-superior temporal gyrus
Van Hoorn et al., 2016	61 (31 female)	12 to 13 15 to 16	Donation behavior	Public Goods Game (task-based fMRI)	Decision-Making	Whole-Brain Contrast	Decision-making Observation > Alone	B-TPJ/STS, B-Prec, B-DMPFC
					Decision-Making	Region of Interest based on significant whole-brain activation	Age*Condition interaction	DMPFC, L-STS
Will et al., 2016*	43 (17 female)	μ = 14.1	Donation behavior	Dictator Game (task-based fMRI)	Frequency	Whole-Brain Regression	% Forgiveness Excluders > Includers	DMPFC

(Continued)

TABLE 1 | Continued

Author (Year)	Total N	Age range(s)	Prosocial measure	MRI measure	Aspect of prosociality	Analytic approach	Contrast	Regions implicated
Telzer et al., 2010 and Will et al., 2018*	47 (18 female)	μ = 14	Donation behavior	Dictator Game (task-based fMRI)	Decision-Making	Whole-Brain Contrast	Decision-making Costly equity > (Non-costly equity + non-costly giving)	B-striatum , B-pre-SMA, B-VMPFC, L-pSTS/TPJ, L-calcarine gyrus, L-MTG, L-SMA, L-IFG, L-ACC, R-PCC, R-fusiform gyrus
					Decision-Making	Whole-Brain Contrast	Decision-making Non-costly giving > (Non-costly equity + Costly equity)	B-middle occipital gyrus

*B- (bilateral-); L- (left-lateralized-); R- (right-lateralized-); Prec (precuneus) mPFC (medial prefrontal cortex); DMPFC (dorsal medial prefrontal cortex); DLPFC (dorsolateral prefrontal cortex); VLPFC (ventrolateral prefrontal cortex); IFG (inferior frontal gyrus); ACC (anterior cingulate cortex); dACC (dorsal ACC); MCC (middle cingulate cortex); PCC (posterior cingulate cortex); SPL (superior parietal lobule); IPL (inferior parietal lobule); TPJ (temporoparietal junction); STS (superior temporal sulcus); pSTS (posterior STS); STG (superior temporal gyrus); MTG (middle temporal gyrus); pMTG (posterior MTG); TP (temporal pole); VS (ventral striatum); VTA (ventral tegmental area); GABA (gamma-aminobutyric acid); WBR (whole-brain regression); AIAn (Altruism Antisocial Game); SoMi (Socially Mindful Task); MRS (magnM,etic resonance spectroscopy); *Will et al. (2016, 2018) had overlapping (non-independent) adolescent samples.*

the striatum and VMPFC were involved in prosocial decision-making, and they had greater activation when youth made prosocial choices. Some striatal subregions may be more involved in (pro)social decision-making generally, while others were involved specifically in making prosocial choices.

Default Mode Network Regions

The reviewed studies identified default mode network (DMN) regions as related to prosociality in adolescence. Gray matter cortical thinning rate was greater in the mPFC, temporoparietal junction (TPJ), inferior frontal gyrus (IFG), and medial temporal gyrus (MTG) for adolescents who scored as highly prosocial on the SDQ compared to those who scored as low prosocial (Ferschmann et al., 2019). While only one study showed changes in the brain's structure, many others showed DMN activation and developmental differences during prosocial tasks.

The mPFC, and specifically the DMPFC, both activated during prosocial decision-making, and most frequently activation was right-lateralized (Telzer et al., 2011; van den Bos et al., 2011; Tousignant et al., 2018; Do et al., 2019) or bilateral (Van Hoorn et al., 2016; Sakai et al., 2017; Lemmers-Jansen et al., 2018). Four studies also found prosocial choices related to D/MPFC activation that was left-lateralized (Spaans et al., 2020), right-lateralized (Telzer et al., 2011; Do et al., 2019), or bilateral (Will et al., 2016). Some studies suggest that adolescent development relates to activation changes during prosocial tasks, where young adults had greater activation in the right DMPFC (Telzer et al., 2011; Tousignant et al., 2018) but decreasing activation in the mPFC (van den Bos et al., 2011).

The PCC and precuneus had activation that predicted prosocial frequency occurring after a non-prosocial fMRI task (Masten et al., 2010). The PCC and precuneus were identified bilaterally active during both prosocial decision-making and prosocial choices in adolescents (Van Hoorn et al., 2016; Tousignant et al., 2018; Will et al., 2018; Do et al., 2019; Spaans et al., 2020) and young adults (van den Bos et al., 2009; Güroğlu et al., 2014; Lemmers-Jansen et al., 2018; Schreuders et al., 2018).

The TPJ/STS was frequently identified relating to adolescent prosocial decision-making (Van Hoorn et al., 2016; Sakai et al., 2017; Tousignant et al., 2018; Will et al., 2018) and prosocial choices (Tashjian et al., 2018; Do et al., 2019; Schreuders et al., 2019; Spaans et al., 2020). Young adults continued showing activation in the TPJ/STS (van den Bos et al., 2009; Telzer et al., 2011; Lemmers-Jansen et al., 2018; Schreuders et al., 2018; van der Meulen et al., 2016), and there was additional evidence that activation during prosocial tasks in this region increases with age bilaterally (van den Bos et al., 2011; Van Hoorn et al., 2016; Tousignant et al., 2018). The IFG bilaterally was less often related to prosocial cognition, but it was consistently identified with studies that also found activation in the TPJ (Sakai et al., 2017; Lemmers-Jansen et al., 2018; Schreuders et al., 2018; Will et al., 2018; Do et al., 2019; van der Meulen et al., 2016).

Lastly, Duell et al. (2021) found that DMN regions, including the PCC, TPJ, and MTG, had activation relating to prosocial

decision-making that interacted with adolescent testosterone and cortisol levels.

Summary

Twenty-one studies found DMN regions related to prosocial cognition during adolescence, and several found evidence suggesting developmental increases in DMPFC and TPJ activation during prosocial tasks. In general, the mPFC and TPJ regions were commonly identified across both prosocial decision-making and prosocial choices, but other regions including the PCC, precuneus, and IFG may be significant in certain contexts.

Salience Network Regions

In the reviewed literature, the salience network, consisting of the anterior cingulate cortex (ACC) and bilateral insula, had increased activation to prosocial decision-making relative to a calculation control (Sakai et al., 2017), had greater activation in prosocial decision-making after observing highly prosocial peers relative to low prosocial peers (Duell et al., 2021), and had greater activation in young adults compared to younger adolescents when making forgiveness decisions (Moor et al., 2012). Increased dorsal (d)ACC and bilateral insula activation also positively related to prosocial giving frequency when youth made *antisocial* choices, such that greater activation while behaving antisocial related to greater giving frequency in both adolescents (van den Bos et al., 2011) and young adults (van den Bos et al., 2009).

Activation in the dACC showed a relationship with overall giving frequency, although in one study this relationship was positive (Moor et al., 2012), while in another it was negative (Do et al., 2019). Studies also identified the ACC without the insula during prosocial decision-making (van den Bos et al., 2011; Lemmers-Jansen et al., 2018; Will et al., 2018), prosocial choices (Telzer et al., 2013), and prosocial choices when regressed with a prosocial questionnaire in young adults (Telzer et al., 2011). Prosocial inclination also related to greater cortical thinning in the dACC across adolescent development (Ferschmann et al., 2019) and greater resting state functional connectivity between the ACC and the bilateral PCC, middle cingulate cortex, and right precentral gyrus (Okada et al., 2019). This same study also used magnetic resonance spectroscopy and found that gamma-aminobutyric acid (GABA) was the only neurotransmitter in the ACC to relate to prosocial inclination (Okada et al., 2019).

Insula activation during social observation tasks positively related to prosocial behavior frequency following the task in both adolescence (Masten et al., 2010) and young adults (Tousignant et al., 2018), as well as prosocial decision-making across development (Tousignant et al., 2018). Interestingly, the right insula had greater activation while subjects behaved prosocially to friends more than disliked peers in early adolescence (Schreuders et al., 2019), but in young adults, right insula activation was negatively related to prosocial giving frequency to friends compared to disliked peers (Schreuders et al., 2018). Yet other studies still found that when young adults made prosocial choices, they had greater insula activation when distributing money (Güroğlu et al., 2014) and when playing Cyberball (van der Meulen et al., 2016).

Summary

Seventeen studies reviewed here found that the salience network was involved in prosocial behavior across adolescent development, but its exact relationship to enacting prosocial behavior remains unclear. Some studies found that salience network regions positively related to prosocial decisions, while others indicated the opposite. Overall, this network appears most related to prosocial cognition when accounting for the frequency of prosocial decisions across an entire task rather than activation specific to adolescent prosocial choices.

Control Network Regions

The control network, consisting of the bilateral LPFC and inferior parietal lobule (IPL), related to prosociality in adolescence and more so in young adulthood. Right-lateralized DLPFC and IPL were related to prosocial decision-making compared to non-prosocial calculation in adolescents (Sakai et al., 2017), and the bilateral DLPFC and left IPL related to socially mindful decision-making in young adults, with the right DLPFC and left IPL specifically relating to prosocially mindful choices (Lemmers-Jansen et al., 2018). Both the left DLPFC and right inferior parietal sulcus related to greater cortical thinning in high prosocial compared to low prosocial adolescents (Ferschmann et al., 2019).While both adolescents and young adults showed activation in the bilateral IPL when making prosocial choices to friends more than disliked peers (Schreuders et al., 2018, 2019), only young adults showed increased activation in the right DLPFC to this contrast, and its activation negatively correlated with giving inequity that favored friends more than disliked peers (Schreuders et al., 2018). Similarly, young adults had greater activation in the left DLPFC and bilateral IPL when making prosocial choices, and they had activation in the left DLPFC that positively related to prosocial feelings toward one's family (Telzer et al., 2011). The right IPL related to prosocial giving frequency in adolescents and young adults while playing the Dictator Game after viewing social scenes (Overgaauw et al., 2014). The right DLPFC related to decision-making across adolescents and young adults (Tousignant et al., 2018) and prosocial choices in young adults (Güroğlu et al., 2014), and one study found greater activation in young adults compared to adolescents during decision-making (van den Bos et al., 2011). The left DLPFC showed activation across adolescence in response to prosocial choices (Spaans et al., 2020), left DLPFC activation during prosocial choices changed across early to mid-adolescence (Do et al., 2019), and its activation during decision-making was modulated by testosterone and cortisol concentrations (Duell et al., 2021).

Summary

Thirteen studies found CN regions relating to prosocial decision-making, choices, and choice frequency. In general, these findings suggest that DLPFC activation is more pronounced in young adults, especially during choices, and most findings suggest that

greater DLPFC activation is related to greater prosocial and equitable choices.

Visual and Somatosensory Regions

Ten studies found that visual regions such as the middle occipital gyrus (Will et al., 2018; Schreuders et al., 2019; Duell et al., 2021), cuneus (Telzer et al., 2013; Lemmers-Jansen et al., 2018; van der Meulen et al., 2016; Duell et al., 2021), fusiform gyrus (Tousignant et al., 2018; Will et al., 2018; Duell et al., 2021), calcarine gyrus (Schreuders et al., 2018; Will et al., 2018), and visual cortex generally (van den Bos et al., 2009, 2011) were involved in both prosocial decision-making and choices across adolescence and young adults, and across tasks including the Dictator Game, the Trust Game, the Socially Mindful task, and Cyberball. One study also found that adults recruited more activation in the right fusiform face area than adolescents during prosocial decision-making while playing Cyberball (Tousignant et al., 2018).

Six studies found somatosensory regions related to prosocial behavior in the precentral gyri (Schreuders et al., 2018, 2019; Okada et al., 2019; Duell et al., 2021), the right postcentral gyrus (Sakai et al., 2017; Schreuders et al., 2019; Duell et al., 2021), and the supplementary motor area (Schreuders et al., 2018; Will et al., 2018). These findings were in both adolescents and young adults, and in studies focusing on prosocial decision-making, choices, frequency, and prosocial inclination from resting state functional connectivity.

Summary

Although not often hypothesized, both visual and somatosensory regions were implicated in eleven prosocial cognition studies from early adolescence to young adulthood and relating both to the prosocial decision-making process in general as well as making prosocial choices.

DISCUSSION

In the following, we propose a synthesis of the above findings in terms of domain-general brain networks (Uddin et al., 2019). Our proposed Domain-General Developmental "Do-GooD" Network Model of Prosocial Cognition in Adolescence is shown schematically in **Figure 2**. Specifically, we propose that the general mechanism of prosociality in adolescents follows value-based decision-making, with three domain-general networks contributing computations as follows: the default mode network computes value predictions for both the self and other, the salience network assesses fairness to modulate value accrual, and the control network develops throughout adolescence to compute value for upholding social rules and norms. The contributions of these three networks are integrated in the VMPFC and striatum, as described below.

Ventromedial Prefrontal Cortex and Striatum

Value-based decision-making is a framework for general decision-making in the brain, and it is thought to be especially suited for describing both altruism (Brosch and Sander, 2013) and adolescent development (Pfeifer and Berkman, 2018). This framework proposes that the VMPFC integrates value computations from other brain regions (Brosch and Sander, 2013). Prior work demonstrates that VMPFC activation reflects the relative subjective value of selected options (Boorman et al., 2009; Nicolle et al., 2012) together with the VS (Lim et al., 2011). Work by Juechems et al. (2019) helps disentangle the role of the striatum from the VMPFC, showing that the striatum encodes the outcome's value receipt independent of goals, while the VMPFC encodes a "representation of cumulative assets in a way that maximizes a specific goal" (pg. 984). However, an exact understanding of the VMPFC and striatum's roles in value-based decision making remains unclear.

Neurocomputational research may help provide further evidence for the differing roles of the VMPFC and VS during prosocial cognition. Hutcherson et al. (2015) developed a neurocomputational model that predicted altruistic decision-making in adults using activation in the VMPFC, VS, and TPJ with strikingly accurate results within and across subjects. In their model, behavior was executed once VMPFC activation representing the decision's relative value exceeded a decision-threshold. TPJ activation accounted for computations regarding the value of giving to others whereas the VS had greater activation during selfish decisions, and the VMPFC responded to both selfish and prosocial decisions (Hutcherson et al., 2015). Other neurocomputational work on prosocial *learning* suggests that the VS and VMPFC activations were also related to prediction error (PE) signals in adolescents, where the VS represents PE while learning for oneself while the VMPFC represents PE while learning for others (Westhoff et al., 2021). However, in a previous adult study using the same experiment, PE in the VS was impartial to self- versus other, and the subgenual ACC contributed to prosocial PE (Lockwood et al., 2016). While the VMPFC, subgenual ACC, and VS are all anatomically close and may partially overlap, these discrepancies could also reflect subtle differences between adult and adolescent prosocial learning mechanisms related to value encoding. Overall, these results align well with and expand the value-based decision-making framework for prosocial behavior, with value accrual taking place in the VMPFC, value outcome in the striatum, and value computation in the TPJ (and possibly other regions/networks, as we discuss below).

Studies reviewed here supported and expanded on these findings into the adolescent age range. The VMPFC and VS had greater activation during prosocial behavior, and the VS had significant functional connectivity with both mentalizing (pSTS, medial PFC) and control regions (VLPFC) during prosocial decision-making (van den Bos et al., 2009; Telzer et al., 2011, 2013; Güroğlu et al., 2014; van der Meulen et al., 2016; Lemmers-Jansen et al., 2018; Tousignant et al., 2018; Do and Telzer, 2019; Spaans et al., 2020; Brandner et al., 2021; Duell et al., 2021). Furthermore, adolescent reaction times for making prosocial choices in the Dictator Game were longer than selfish choices

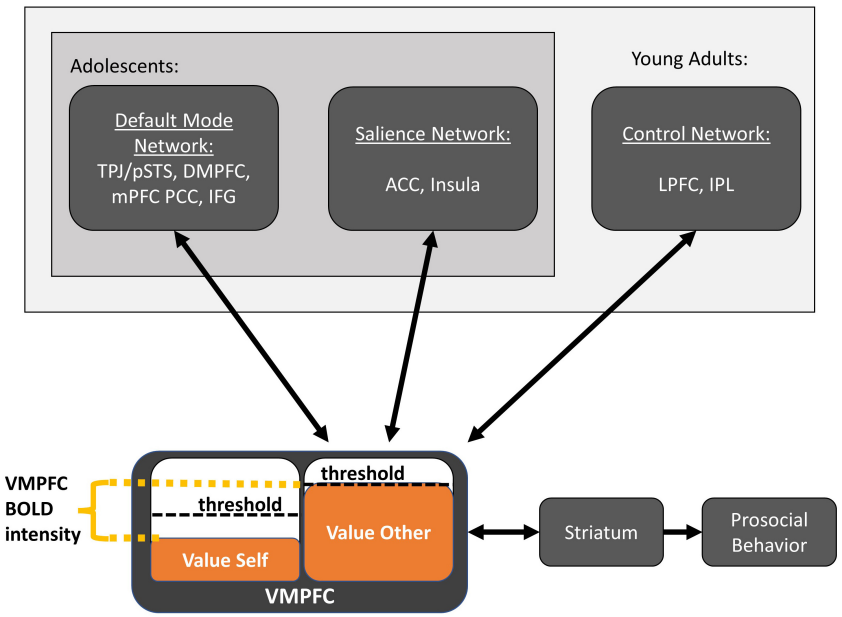


FIGURE 2 | The domain-general developmental "Do-GooD" network model of prosocial cognition. Three domain-general networks contribute value computations for prosocial decisions, which are integrated in the ventromedial prefrontal cortex. Activation in the ventromedial prefrontal cortex and striatum corresponds to the relative value between available options. Once the prosocial option reaches the decision-threshold, prosocial behavior is enacted. The default mode network predominantly computes value for self and other, and these value computations can be influenced by events that occur before the prosocial decision and may reflect general prosocial disposition. The salience network may contribute at least two types of information, one is value attributed to affect while another is self-monitoring for fairness norms, the latter of which may suppress value accrual to uphold perceived fairness. The control network computes the value for abstract desires and learned social norms and contributes this value in ways that align with those desires and norms. The control network is involved across adolescence, but importantly, it further develops through young adulthood with greater activation that increases the weight of these social norm values during decision-making. This model proposes a bidirectional process between value computation and value accrual that unfolds over many cycles in time, and where response time is proportional to the decision threshold in the ventromedial prefrontal cortex.

(Will et al., 2016; Do et al., 2019), which aligns well with a bidirectional mechanism involving both value computation and accrual over time.

Default Mode Network

The default mode network (DMN) subsumes the mentalizing regions of the brain (Lombardo et al., 2010; Hyatt et al., 2015). The DMN's involvement in prediction (Dohmatob et al., 2017), social information consolidation (Meyer et al., 2019), and goal orientation (Spreng et al., 2014) makes it a likely candidate for a system that computes both self- and other-value. Most studies reviewed here identified key mentalizing and DMN nodes relating to prosocial behavior, and activation of DMN regions outside of direct prosocial decision-making also predicted subsequent prosocial behavior (Masten et al., 2010; Tashjian et al., 2018). Evidence suggests that some DMN regions have specificity for self-processing, such as the PCC and mPFC (Blakemore et al., 2007; van Schie et al., 2018), with others being more specific for other-processing, such as the DMPFC and TPJ (Mason and Just, 2009; Sabbagh et al., 2009; Carter and Huettel, 2013). However, these associations are not always the case and vary based on context (Nicolle et al., 2012) and subregional functionalization (Molnar-Szakacs and Uddin, 2013). We propose instead that the computation for self- and other-value occurs throughout the DMN and that the resulting information accumulates in the VMPFC for value integration. It should be noted that the VMPFC is also considered to be a key DMN region (Uddin et al., 2019), so while we differentiate our discussion of the VMPFC from the DMN for clarity, it is likely meaningful that a value accrual mechanism is integrated with the value computation mechanisms so postulated.

The mirror neuron system may also act as a neural substrate upon which mentalizing regions simulate others (Gallese and Goldman, 1998), and thus may be relevant to computing other-value. The mirror neuron system consists of some DMN regions, such as the IFG and STS, as well as other regions, including the primary motor and occipital cortices (Rajmohan and Mohandas, 2007). The mirror-neuron system involvement helps explain why regions such as the motor cortex (Sakai et al., 2017; Okada et al., 2019; Schreuders et al., 2019; Duell et al., 2021) and occipital cortex (van den Bos et al., 2009, 2011; Telzer et al., 2011, 2013; van der Meulen et al., 2016; Lemmers-Jansen et al., 2018; Duell et al., 2021) had activation relating to prosocial behavior. Supporting this relationship between mirroring and prosocial decision-making, the electroencephalography (EEG) signal from adult subject's dorsal somatosensory cortex while observing another's hand being struck (by a belt) accounted for the amount of money donated to reduce subsequent strike intensity, and transcranial magnetic stimulation (TMS) disruption of the same region accordingly impaired that prosocial giving (Gallo et al., 2018).

The mirror neuron system has a rich functional relationship with the DMN that has been shown to contribute to embodied simulation for both self and other processing (Lombardo et al., 2010), constituting a likely module leveraged by core DMN regions to compute self- and other-value.

Salience Network

While the DMN plays a significant role in computing the value for both self and other, it needs not be the only system that contributes value. The salience network (SN) may also contribute to value computations in emotional contexts such as giving to friends (Schreuders et al., 2019), to family (Telzer et al., 2013), to previous exclusion (Moor et al., 2012; van der Meulen et al., 2016), or self-chosen charities (Spaans et al., 2020; Duell et al., 2021). The reviewed literature and other research also highlight another special involvement of the SN in prosocial decision-making: it appears to assess *fairness imbalance* to modulate value accrual.

Most neuroimaging studies on adolescent altruistic prosociality implement the Dictator Game or one of its many variations. The key element is that "Dictator" decides how to distribute a resource (usually money) between two people, generally themselves and/or some other person/player(s). Prosocial behavior can be operationalized in terms of the *fairness* in the resource distribution, where the distribution can favor the Dictator (selfish choices), the other player (prosocial inequity), or both evenly (prosocial equity). Prior work on the Dictator Game has shown that the amount of money that a Dictator keeps and gives was based on the *entire experimental session* according to what that Dictator determined to be a "fair" distribution, even if that Dictator played with a new recipient each trial (Bolton et al., 1998). Thus, determining fairness across all trials is an integral part of prosocial decision-making in this context.

The SN consists primarily of the ACC and insula (Uddin et al., 2019), and a meta-analysis found the SN regularly active when processing unfair offers (Gabay et al., 2014). In a study with ages ranging from 10- to 20-years-old, all ages showed dACC and bilateral insula activation when processing unfairness, and specifically when the adolescent themselves deviated from their own sense of fairness (Güroğlu et al., 2011). That is, the SN was self-monitoring unfairness in their own behavior, and activation in the SN was strongest to personal-norm fairness violations in those adolescents who mostly behaved fairly (Güroğlu et al., 2011). Therefore, strong activation in the SN during prosocial decision-making suggests an experience that one's actions are not aligned with their personal sense of fairness. The ACC in particular has also been shown to have significant functional connectivity with the VMPFC to provide information about task switching that optimizes long-term payoff (Economides et al., 2014). This could be especially relevant to fairness considerations, as a signal that payoffs are unfair demands switching one's strategy in subsequent trials to optimize fairness. This may additionally indicate that VMPFC and ACC connectivity is an important source of feedback both within and across prosocial task trials.

Some of the reviewed studies on adolescent prosocial behavior found the dACC positively related to giving (van den Bos et al., 2009, 2011; Moor et al., 2012; Duell et al., 2021), yet another found the dACC negatively related to giving (Do et al., 2019); however, considering the dACC as encoding personal unfairness can resolve this discrepancy. van den Bos et al. (2009, 2011) found that dACC activation while choosing to act Selfish > Prosocial related to greater overall giving, suggesting that processing selfish behavior as unfair conferred greater prosocial behavior throughout the experimental session. Similarly, Do et al. (2019) found that dACC activation during the prosocial choice contrast Costly Giving > Costly Reward negatively related to overall prosocial giving; that is, feeling that costly giving was unfair led to decreases in overall giving. Moor et al. (2012) found that dACC activation during decision-making positively related to more "forgiving" offers to players who had previously Excluded > Included them. Because the adolescents were previously excluded, most offers were highly unequal and punishing, but those who had greater dACC activation possibly found that punishment overly unfair and subsequently gave more prosocial offers. Lastly, Duell et al. (2021) found the dACC had increased activation when behaving prosocially after having just observed a highly prosocial peer donate to charity. Observing a highly prosocial peer may have increased fairness self-monitoring in subsequent giving that increased dACC activation and conferred more prosocial decisions. In some of these studies, activation in the dACC during either prosocial or selfish contrasts could predict overall prosocial behavior. Fairness considerations are based on the entire experimental session, not trial-by-trial, so it could be that the dACC modulates the ongoing value accrual in the VMPFC to suppress unfair options. Supporting this possible mechanism, Okada et al. (2019) found that the only neurotransmitter in the ACC that related to a prosocial questionnaire was GABA, responsible for neuronal inhibition.

Control Network

The control network (CN) consists of the LPFC and the IPL (Uddin et al., 2019). The LPFC structurally and functionally develops during adolescence (Sowell and Jernigan, 1998; Dumontheil, 2014), which suggests its role in prosocial decisions may also develop during this time. The LPFC represents abstract and multi-dimensional values (Dixon and Christoff, 2014), such as delayed-discounting (Guo and Feng, 2015), social norms (Hackel et al., 2020), and moral attitudes (Crockett et al., 2017). Prosocial decision-making is frequently multi-dimensional, it includes social other recognition, understanding goals related to context specific social norms, and the cost-benefit-analysis for different options. The CN within a value-based decision-making framework may contribute value reflecting abstract goals and social rules rather than strictly suppressing selfishness (Berkman et al., 2017). Thus, the CN develops to contribute value that accounts for these contextual goals and learned moral norms in the decision-making process to support prosocial decisions.

In the reviewed literature, the DLPFC and IPL were frequently engaged in prosocial decision-making and choices, and the DLPFC specifically showed evidence for development across adolescence relating to prosocial behavior, both in brain structure (Ferschmann et al., 2019) and function (van den Bos et al.,

2011; Do et al., 2019). Interestingly, the right DLPFC showed activation in young adults when the recipient of their prosocial behavior was unknown and not depicted (van den Bos et al., 2011; Güroğlu et al., 2014; Lemmers-Jansen et al., 2018; Tousignant et al., 2018), whereas the left DLPFC showed activation in young adults when giving prosocially to their families (Telzer et al., 2011), to a visible other (Do et al., 2019), or to a charity of their choosing (Spaans et al., 2020; Duell et al., 2021). The DLPFC accounting for abstract social values also resolves a discrepancy between most studies finding greater activation to prosocial choices, but Schreuders et al. (2018) finding that greater activation during decision-making to friends compared to disliked peers *negatively* related to giving inequity that favored friends more than disliked peers. It could be that giving equally to disliked peers requires more value for abstract social norms than does giving only to close friends, and thus giving to a disliked peer would necessitate greater recruitment in regions that account for this abstract virtue of "giving despite disliking the peer." The IPL overall had less frequent activation related to prosocial behavior; it was bilaterally active when mid-adolescents gave money to Friends > Unknown peers (Schreuders et al., 2019) and when young adults gave to their family compared to receiving a reward (Telzer et al., 2011). While evidence suggests that the CN was more involved in older adolescents and young adults, it is unclear what exactly this network contributes to prosocial neural mechanisms; however, because previous work shows that the CN represents abstract values, its involvement could be illuminated through individual differences in social values and behavior.

Most individual differences in brain activation in response to social norms were demonstrated in the CN, DMN, and reward regions. When adolescents decided to give prosocially to their family, those with a greater sense of family obligation had more activation in the striatum (Telzer et al., 2013), greater activation in the right TPJ, bilateral pSTS, right ACC, and left DLPFC, as well as greater functional connectivity between the VS and the left VLPFC, left DMPFC, and right mPFC (Telzer et al., 2011). Culture likely plays a role, as evidenced by a study finding that adolescents from a communalist culture had greater striatum activation when giving to their family than those from an individualist culture (Telzer et al., 2010). The LPFC contributes value regarding social rules and expectations, especially when they are different from one's disposition. In adults, greater right DLPFC connectivity to the VMPFC occurred when abiding by prosocial or selfish norms different from the individual's prosocial disposition (Hackel et al., 2020). Furthermore, transcranial magnetic stimulation of the DLPFC in adults increased prosociality (Balconi and Canavesio, 2014). Prosocial giving toward in-groups versus out-groups also shows individual differences, where functional connectivity between the VS and pSTS can either indicate greater bias or lesser bias depending on which group the individuals are giving when the functional connectivity is greatest (Do and Telzer, 2019). Yet not many studies investigating adolescent prosocial behavior manipulate social norms or relate brain activation to cultural values, both of which may better elucidate how neural correlates relate to individual perceptions of social norms and how one could leverage this relationship to increase prosociality.

Limitations

This review has several limitations. First, substantial study heterogeneity precluded a meta-analysis of this literature. Such a meta-analysis would greatly assist in the interpretation of this work, including the discussion of the TPJ, which has unclear and disputed anatomical boundaries (Carter and Huettel, 2013; Geng and Vossel, 2013; Schurz et al., 2014). However, meta-analyses cannot currently accommodate functional connectivity or magnetic resonance spectroscopy findings, both of which contribute to the current review and model proposed here. Second, while our model proposes a domain-general network framework, there are not enough connectivity studies to make strong claims about the networks as a whole, and not about which brain regions definitively constitute those networks. Given this limitation, our aim is to present a network-informed model aligned with the current evidence to drive brain connectivity hypotheses for future work on prosocial development. Third, most studies reviewed here investigated prosocial neural correlates during a task that involved sharing or keeping money, namely the Dictator Game (or a variation). While monetary giving may be a convenient operationalization for prosocial decision-making, it limits the scope and generalizability of these findings, as it may be only one dimension of prosocial behavior in adolescent lives. Evidence also shows that introducing monetary transactions during social decisions can change the social context of that situation (Gneezy and Rustichini, 2000; Mellström and Johannesson, 2008). Indeed, while our model suggests the role of fairness detection in prosocial decision-making, this may be specific to economic prosocial contexts rather than prosociality in general. An important direction for new research would be to compare prosocial neural correlates in situations that involve resource distribution with neural correlates observed in situations that, for example, involve prosocial emotional consolation.

Future Directions

Methodological Advances

Future studies could benefit from new methodological approaches to study neural correlates of prosociality. As previously mentioned, prosocial paradigms thus far use games in which adolescents distribute a resource (usually monetary) between themselves and others. However, everyday life includes prosocial behavior that does not incorporate resource distribution, such as empathetic listening, playing cooperative games, or expressing love and kindness for friends and family. Future studies on prosocial behavior could adapt this real-life game observation during moments of cooperation or selfishness to investigate questions about prosocial cognition in ecologically valid contexts for adolescents. On the MRI methodological side, connectivity studies have been sparse. The reviewed literature on prosocial cognition implicates many brain regions, yet it remains unclear how these regions coactivate in networks during tasks to support prosocial behavior. Furthermore, only one study we reviewed had considered resting state functional

connectivity, which may be especially useful to understand individual differences in prosocial disposition. The brain's structural connectivity may also offer insights into prosocial disposition and one's change in prosociality with development.

Model Predictions

The "Do-GooD" model predicts that greater activation of key other-value computing regions (e.g., the TPJ) through TMS could increase prosocial giving, as was similarly demonstrated in the DLPFC, which also resulted in increased prosociality (Balconi and Canavesio, 2014). With respect to developmental changes, we expect both prosociality and its associated brain network connectivity to increase during adolescent development. Specifically, we expect prosociality to increase in tandem with functional within- and between-network connectivity development in the DMN, SN, and CN, which has previously been shown in Ryali et al. (2016), and which may be associated with changes in myelination. Furthermore, because studies find that resting state functional connectivity shows relationships similar to those during tasks (Smith et al., 2009), it may be fruitful to test whether individual prosocial tendencies are associated with differences in resting state connectivity. The proposed model could also help develop new targets for interventions and for monitoring changes. Specifically, we may expect that interventions aimed at increasing prosociality, such as love and kindness meditation, will increase functional and structural connectivity within the DMN and between it and the mirror neuron system, thus improving the computation of other-value. Furthermore, interventions that promote prosociality as an intrinsically good or "fair" option, which would *decrease* SN activation while giving and *increase* SN activation while behaving selfishly, each correlating with the intervention's effectiveness. SN activation toward prosocial versus selfish decisions as well as functional connectivity between the DMN, mirror neuron system, and CN all could be used to assess adolescents with challenges relating to low prosocial behavior, such as conduct disorder or the early development of a potential antisocial personality disorder, and inform treatment planning. For example, the intervention could emphasize communal responsibility in those with strong SN activation to the (un)fairness of prosocial options or instead emphasize human shared experiences to enhance other-value computations between the DMN and mirror neuron system.

CONCLUSION

In this review, we summarize and synthesize the current neuroimaging findings on prosocial behavior during adolescence. We propose that prosocial decision-making is a form of value-based choice carried out by domain-general networks. In particular, we suggest that overall value accrues in the ventromedial prefrontal cortex and reward regions, value for self and others is computed in the default mode network, fairness imbalance is monitored in the salience network, and abstract values for social norms develops during adolescence in the control network. Ultimately, understanding the neural basis and development of prosocial behavior is crucial to understanding how cooperation can be promoted in a society. This neuroscientific understanding may help illuminate the underlying neural development of psychiatric disorders, such as conduct disorder or antisocial personality disorder, and aid in the development and evaluation of improved and innovative treatments for these conditions.

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/s.

AUTHOR CONTRIBUTIONS

BS did the conceptualization, performed the methodology, carried out the formal analysis and data curation, investigated the data, wrote the original draft, reviewed, and edited the manuscript. TY did the conceptualization, performed the methodology, wrote, reviewed, and edited the manuscript, and carried out the funding acquisition. KP and NJ performed the methodology, and wrote, reviewed, and edited the manuscript. OT did the conceptualization, performed the methodology, wrote, reviewed, and edited the manuscript, and carried out the project administration and funding acquisition. All authors contributed to the article and approved the submitted version.

FUNDING

This work was supported by the National Center for Complementary and Integrative Health (NCCIH) R21AT009173 and R61AT009864; the National Center for Advancing Translational Sciences (CTSI), National Institutes of Health, through UCSF-CTSI UL1TR001872; the American Foundation for Suicide Prevention (AFSP) SRG-1-141-18; and UCSF Weill Institute for Neurosciences to OT and TY.

REFERENCES

Aknin, L. B., Whillans, A. V., Norton, M. I., and Dunn, E. W. (2019). *Happiness and Prosocial Behavior: An Evaluation of the Evidence*. Boston, MA: Harvard Business School, 20.

Balconi, M., and Canavesio, Y. (2014). High-frequency rTMS on DLPFC increases prosocial attitude in case of decision to support people. *Soc. Neurosci.* 9, 82–93. doi: 10.1080/17470919.2013.861361

Bassett, D. S., and Sporns, O. (2017). Network neuroscience. *Nat. Neurosci.* 20, 353–364. doi: 10.1038/nn.4502

Batson, C. D. (1991). *The altruism question: Toward a social-psychological answer (pp. ix, 257)*. Mahwah, NJ: Lawrence Erlbaum Associates, Inc.

Bellucci, G., Camilleri, J. A., Eickhoff, S. B., and Krueger, F. (2020). Neural signatures of prosocial behaviors. *Neurosci. Biobehav. Rev.* 118, 186–195. doi: 10.1016/j.neubiorev.2020.07.006

Berkman, E. T., Hutcherson, C. A., Livingston, J. L., Kahn, L. E., and Inzlicht, M. (2017). Self-Control as Value-Based Choice. *Curr. Direct. Psychol. Sci.* 26, 422–428. doi: 10.1177/0963721417704394

Blakemore, S.-J. (2012). Imaging brain development: The adolescent brain. *NeuroImage* 61, 397–406. doi: 10.1016/j.neuroimage.2011.11.080

Blakemore, S.-J., den Ouden, H., Choudhury, S., and Frith, C. (2007). Adolescent development of the neural circuitry for thinking about intentions. *Soc. Cognit. Affect. Neurosci.* 2, 130–139. doi: 10.1093/scan/nsm009

Bolton, G. E., Katok, E., and Zwick, R. (1998). Dictator game giving: Rules of fairness versus acts of kindness. *Int. J. Game Theory* 27, 269–299. doi: 10.1007/s001820050072

Boorman, E. D., Behrens, T. E. J., Woolrich, M. W., and Rushworth, M. F. S. (2009). How Green Is the Grass on the Other Side? Frontopolar Cortex and the Evidence in Favor of Alternative Courses of Action. *Neuron* 62, 733–743. doi: 10.1016/j.neuron.2009.05.014

Brandner, P., Gürouglu, B., van de Groep, S., Spaans, J. P., and Crone, E. A. (2021). Happy for Us not Them: Differences in neural activation in a vicarious reward task between family and strangers during adolescent development. *Dev. Cognit. Neurosci.* 51:100985. doi: 10.1016/j.dcn.2021.100985

Brosch, T., and Sander, D. (2013). Neurocognitive mechanisms underlying value-based decision-making: From core values to economic value. *Front. Hum. Neurosci.* 7:398. doi: 10.3389/fnhum.2013.00398

Carter, R. M., and Huettel, S. A. (2013). A Nexus Model of the Temporal-Parietal Junction. *Trends Cognit. Sci.* 17, 328–336. doi: 10.1016/j.tics.2013.05.007

Cassidy, K. W., Werner, R. S., Rourke, M., Zubernis, L. S., and Balaraman, G. (2003). The Relationship Between Psychological Understanding and Positive Social Behaviors. *Soc. Dev.* 12, 198–221. doi: 10.1111/1467-9507.00229

Crockett, M. J., Siegel, J. Z., Kurth-Nelson, Z., Dayan, P., and Dolan, R. J. (2017). Moral transgressions corrupt neural representations of value. *Nat. Neurosci.* 20, 879–885. doi: 10.1038/nn.4557

Decety, J., and Jackson, P. L. (2004). The Functional Architecture of Human Empathy. *Behav. Cognit. Neurosci. Rev.* 3, 71–100. doi: 10.1177/1534582304267187

Declerck, C. H., Boone, C., and Emonds, G. (2013). When do people cooperate? The neuroeconomics of prosocial decision making. *Brain Cognit.* 81, 95–117. doi: 10.1016/j.bandc.2012.09.009

Dixon, M. L., and Christoff, K. (2014). The lateral prefrontal cortex and complex value-based learning and decision making. *Neurosci. Biobehav. Rev.* 45, 9–18. doi: 10.1016/j.neubiorev.2014.04.011

Do, K. T., and Telzer, E. H. (2019). Corticostriatal connectivity is associated with the reduction of intergroup bias and greater impartial giving in youth. *Dev. Cognit. Neurosci.* 37:100628. doi: 10.1016/j.dcn.2019.100628

Do, K. T., McCormick, E. M., and Telzer, E. H. (2019). The neural development of prosocial behavior from childhood to adolescence. *Soc. Cognit. Affect. Neurosci.* 14, 129–139. doi: 10.1093/scan/nsy117

Dohmatob, E., Dumas, G., and Bzdok, D. (2017). Dark Control: Towards a Unified Account of Default Mode Function by Markov Decision Processes. *Neuroscience* [Preprint]. doi: 10.1101/148890

Duell, N., van Hoorn, J., McCormick, E. M., Prinstein, M. J., and Telzer, E. H. (2021). Hormonal and neural correlates of prosocial conformity in adolescents. *Dev. Cognit. Neurosci.* 48:100936. doi: 10.1016/j.dcn.2021.100936

Dumontheil, I. (2014). Development of abstract thinking during childhood and adolescence: The role of rostrolateral prefrontal cortex. *Dev. Cognit. Neurosci.* 10, 57–76. doi: 10.1016/j.dcn.2014.07.009

Economides, M., Guitart-Masip, M., Kurth-Nelson, Z., and Dolan, R. J. (2014). Anterior cingulate cortex instigates adaptive switches in choice by integrating immediate and delayed components of value in ventromedial prefrontal cortex. *J. Neurosci.* 34, 3340–3349. doi: 10.1523/JNEUROSCI.4313-13.2014

Eisenberg, N., Fabes, R. A., and Spinrad, T. L. (2007). "Prosocial Development," in *Handbook of Child Psychology*, eds W. Damon and R. M. Lerner (Atlanta: American Cancer Society), doi: 10.1002/9780470147658.chpsy0311

Eisenberg, N., Zhou, Q., and Koller, S. (2001). Brazilian Adolescents' Prosocial Moral Judgment and Behavior: Relations to Sympathy, Perspective Taking, Gender-Role Orientation, and Demographic Characteristics. *Child Dev.* 72, 518–534. doi: 10.1111/1467-8624.00294

Fan, Y., Duncan, N. W., de Greck, M., and Northoff, G. (2011). Is there a core neural network in empathy? An fMRI based quantitative meta-analysis. *Neurosci. Biobehav. Rev.* 35, 903–911. doi: 10.1016/j.neubiorev.2010.10.009

Ferschmann, L., Vijayakumar, N., Grydeland, H., Overbye, K., Sederevicius, D., Due-Tønnessen, P., et al. (2019). Prosocial behavior relates to the rate and timing of cortical thinning from adolescence to young adulthood. *Dev. Cognit. Neurosci.* 40:100734. doi: 10.1016/j.dcn.2019.100734

Gabay, A. S., Radua, J., Kempton, M. J., and Mehta, M. A. (2014). The Ultimatum Game and the brain: A meta-analysis of neuroimaging studies. *Neurosci. Biobehav. Rev.* 47, 549–558. doi: 10.1016/j.neubiorev.2014.10.014

Gallese, V., and Goldman, A. (1998). Mirror neurons and the simulation theory of mind-reading. *Trends Cognit. Sci.* 2, 493–501. doi: 10.1016/S1364-6613(98)01262-5

Gallo, S., Paracampo, R., Müller-Pinzler, L., Severo, M. C., Blömer, L., Fernandes-Henriques, C., et al. (2018). The causal role of the somatosensory cortex in prosocial behaviour. *Elife* 7:e32740. doi: 10.7554/eLife.32740.001

Geng, J. J., and Vossel, S. (2013). Re-evaluating the role of TPJ in attentional control: Contextual updating? *Neurosci. Biobehav. Rev.* 37, 2608–2620. doi: 10.1016/j.neubiorev.2013.08.010

Gneezy, U., and Rustichini, A. (2000). A fine is a price. *J. Legal Stud.* 29, 1–17.

Goldman, A. I. (2012). Theory of mind. *Oxford Handb. Philosop. Cognit. Sci.* 1, 402–424.

Moor, B. G., Gürouglu, B., Op de Macks, Z. A., Rombouts, S. A. R. B., Van der Molen, M. W., and Crone, E. A. (2012). Social exclusion and punishment of excluders: Neural correlates and developmental trajectories. *NeuroImage* 59, 708–717. doi: 10.1016/j.neuroimage.2011.07.028

Guo, Y., and Feng, T. (2015). The mediating role of LPFC–vmPFC functional connectivity in the relation between regulatory mode and delay discounting. *Behav. Brain Res.* 292, 252–258. doi: 10.1016/j.bbr.2015.06.035

Güroğlu, B., van den Bos, W., van Dijk, E., Rombouts, S. A. R. B., and Crone, E. A. (2011). Dissociable brain networks involved in development of fairness considerations: Understanding intentionality behind unfairness. *NeuroImage* 57, 634–641. doi: 10.1016/j.neuroimage.2011.04.032

Güroğlu, B., Will, G.-J., and Crone, E. A. (2014). Neural Correlates of Advantageous and Disadvantageous Inequity in Sharing Decisions. *PLoS One* 9:e107996. doi: 10.1371/journal.pone.0107996

Hackel, L. M., Wills, J. A., and Van Bavel, J. J. (2020). Shifting prosocial intuitions: Neurocognitive evidence for a value-based account of group-based cooperation. *Soc. Cognit. Affect. Neurosci.* 15, 371–381. doi: 10.1093/scan/nsaa055

Helliwell, J., Aknin, L., Shiplett, H., Huang, H., and Wang, S. (2017). Social Capital and Prosocial Behaviour as Sources of Well-Being (No. w23761; p. w23761). *Natl. Bureau Econom. Res.* 2017:w23761. doi: 10.3386/w23761

House, B. R., Silk, J. B., Henrich, J., Barrett, H. C., Scelza, B. A., Boyette, A. H., et al. (2013). Ontogeny of prosocial behavior across diverse societies. *Proc. Natl. Acad. Sci.* 110, 14586–14591. doi: 10.1073/pnas.1221217110

Hutcherson, C. A., Bushong, B., and Rangel, A. (2015). A Neurocomputational Model of Altruistic Choice and Its Implications. *Neuron* 87, 451–462. doi: 10.1016/j.neuron.2015.06.031

Hyatt, C. J., Calhoun, V. D., Pearlson, G. D., and Assaf, M. (2015). Specific default mode subnetworks support mentalizing as revealed through opposing network recruitment by social and semantic FMRI tasks. *Hum. Brain Mapp.* 36, 3047–3063. doi: 10.1002/hbm.22827

Inagaki, T. K., and Eisenberger, N. I. (2016). Giving support to others reduces sympathetic nervous system-related responses to stress. *Psychophysiology* 53, 427–435. doi: 10.1111/psyp.12578

Juechems, K., Balaguer, J., Herce Castañón, S., Ruz, M., O'Reilly, J. X., and Summerfield, C. (2019). A Network for Computing Value Equilibrium in the Human Medial Prefrontal Cortex. *Neuron* 101, 977.e–987.e. doi: 10.1016/j.neuron.2018.12.029

Kleckner, I. R., Zhang, J., Touroutoglou, A., Chanes, L., Xia, C., Simmons, W. K., et al. (2017). Evidence for a Large-Scale Brain System Supporting Allostasis and Interoception in Humans. *Nat. Hum. Behav.* 1:69. doi: 10.1038/s41562-017-0069

Lemmers-Jansen, I. L. J., Krabbendam, L., Amodio, D. M., Van Doesum, N. J., Veltman, D. J., and Van Lange, P. A. M. (2018). Giving others the option of choice: An fMRI study on low-cost cooperation. *Neuropsychologia* 109, 1–9. doi: 10.1016/j.neuropsychologia.2017.12.009

Lim, S.-L., O'Doherty, J. P., and Rangel, A. (2011). The Decision Value Computations in the vmPFC and Striatum Use a Relative Value Code That is Guided by Visual Attention. *J. Neurosci.* 31, 13214–13223. doi: 10.1523/JNEUROSCI.1246-11.2011

Lockwood, P. L., Apps, M. A. J., Valton, V., Viding, E., and Roiser, J. P. (2016). Neurocomputational mechanisms of prosocial learning and links to empathy. *Proc. Natl. Acad. Sci.* 113, 9763–9768. doi: 10.1073/pnas.1603198113

Lombardo, M. V., Chakrabarti, B., Bullmore, E. T., Wheelwright, S. J., Sadek, S. A., Suckling, J., et al. (2010). Shared Neural Circuits for Mentalizing about the Self and Others. *J. Cognit. Neurosci.* 22, 1623–1635. doi: 10.1162/jocn.2009.21287

Mann, L., Harmoni, R., and Power, C. (1989). Adolescent decision-making: The development of competence. *J. Adolesc.* 12, 265–278. doi: 10.1016/0140-1971(89)90077-8

Mason, R. A., and Just, M. A. (2009). The Role of the Theory-of-Mind Cortical Network in the Comprehension of Narratives. *Lang. Linguist. Compass* 3, 157–174. doi: 10.1111/j.1749-818X.2008.00122.x

Masten, C. L., Eisenberger, N. I., Pfeifer, J. H., and Dapretto, M. (2010). Witnessing peer rejection during early adolescence: Neural correlates of empathy for experiences of social exclusion. *Soc. Neurosci.* 5, 496–507. doi: 10.1080/17470919.2010.490673

Meinhardt-Injac, B., Daum, M. M., and Meinhardt, G. (2020). Theory of mind development from adolescence to adulthood: Testing the two-component model. *Br. J. Dev. Psychol.* 38, 289–303. doi: 10.1111/bjdp.12320

Mellström, C., and Johannesson, M. (2008). Crowding Out in Blood Donation: Was Titmuss Right? *J. Eur. Economic Associat.* 6, 845–863. doi: 10.1162/JEEA.2008.6.4.845

Meyer, M. L., Davachi, L., Ochsner, K. N., and Lieberman, M. D. (2019). Evidence That Default Network Connectivity During Rest Consolidates Social Information. *Cereb. Cortex* 29, 1910–1920. doi: 10.1093/cercor/bhy071

Moher, D., Liberati, A., Tetzlaff, J., and Altman, D. G. (2009). Preferred Reporting Items for Systematic Reviews and Meta-Analyses: The PRISMA Statement. *PLoS Med.* 6:1000097. doi: 10.1371/journal.pmed.1000097

Moieni, M., Irwin, M. R., Haltom, K. E. B., Jevtic, I., Meyer, M. L., Breen, E. C., et al. (2019). Exploring the role of gratitude and support-giving on inflammatory outcomes. *Emotion* 19, 939–949. doi: 10.1037/emo0000472

Molnar-Szakacs, I., and Uddin, L. Q. (2013). Self-Processing and the Default Mode Network: Interactions with the Mirror Neuron System. *Front. Hum. Neurosci.* 7:00571. doi: 10.3389/fnhum.2013.00571

Nicolle, A., Klein-Flügge, M. C., Hunt, L. T., Vlaev, I., Dolan, R. J., and Behrens, T. E. J. (2012). An Agent Independent Axis for Executed and Modeled Choice in Medial Prefrontal Cortex. *Neuron* 75, 1114–1121. doi: 10.1016/j.neuron.2012.07.023

Okada, N., Yahata, N., Koshiyama, D., Morita, K., Sawada, K., Kanata, S., et al. (2019). Neurometabolic and functional connectivity basis of prosocial behavior in early adolescence. *Sci. Rep.* 9:732. doi: 10.1038/s41598-018-38355-z

Overgaauw, S., Güroglu, B., Rieffe, C., and Crone, E. A. (2014). Behavior and Neural Correlates of Empathy in Adolescents. *Dev. Neurosci.* 36, 210–219. doi: 10.1159/000363318

Pfeifer, J. H., and Berkman, E. T. (2018). The Development of Self and Identity in Adolescence: Neural Evidence and Implications for a Value-Based Choice Perspective on Motivated Behavior. *Child Dev. Perspect.* 12, 158–164. doi: 10.1111/cdep.12279

Rajmohan, V., and Mohandas, E. (2007). Mirror neuron system. *Ind. J. Psychiatry* 49, 66–69. doi: 10.4103/0019-5545.31522

Ryali, S., Supekar, K., Chen, T., Kochalka, J., Cai, W., Nicholas, J., et al. (2016). Temporal Dynamics and Developmental Maturation of Salience, Default and Central-Executive Network Interactions Revealed by Variational Bayes Hidden Markov Modeling. *PLoS Computat. Biol.* 12:e1005138. doi: 10.1371/journal.pcbi.1005138

Sabbagh, M. A., Bowman, L. C., Evraire, L. E., and Ito, J. M. B. (2009). Neurodevelopmental Correlates of Theory of Mind in Preschool Children. *Child Dev.* 80, 1147–1162. doi: 10.1111/j.1467-8624.2009.01322.x

Sakai, J. T., Dalwani, M. S., Mikulich-Gilbertson, S. K., Raymond, K., McWilliams, S., Tanabe, J., et al. (2017). Imaging decision about whether to benefit self by harming others: Adolescents with conduct and substance problems, with or without callous-unemotionality, or developing typically. *Psychiat. Res. Neuroimaging* 263, 103–112. doi: 10.1016/j.pscychresns.2017.03.004

Schreuders, E., Klapwijk, E. T., Will, G.-J., and Gürouglu, B. (2018). Friend versus foe: Neural correlates of prosocial decisions for liked and disliked peers. *Cognit. Affect. Behav. Neurosci.* 18, 127–142. doi: 10.3758/s13415-017-0557-1

Schreuders, E., Smeekens, S., Cillessen, A. H. N., and Gürouglu, B. (2019). Friends and foes: Neural correlates of prosocial decisions with peers in adolescence. *Neuropsychologia* 129, 153–163. doi: 10.1016/j.neuropsychologia.2019.03.004

Schurz, M., Radua, J., Aichhorn, M., Richlan, F., and Perner, J. (2014). Fractionating theory of mind: A meta-analysis of functional brain imaging studies. *Neurosci. Biobehav. Rev.* 42, 9–34. doi: 10.1016/j.neubiorev.2014.01.009

Slaughter, V., Imuta, K., Peterson, C. C., and Henry, J. D. (2015). Meta-Analysis of Theory of Mind and Peer Popularity in the Preschool and Early School Years. *Child Dev.* 86, 1159–1174. doi: 10.1111/cdev.12372

Smetana, J. G., Campione-Barr, N., and Metzger, A. (2006). Adolescent Development in Interpersonal and Societal Contexts. *Annu. Rev. Psychol.* 57, 255–284. doi: 10.1146/annurev.psych.57.102904.190124

Smith, S. M., Fox, P. T., Miller, K. L., Glahn, D. C., Fox, P. M., Mackay, C. E., et al. (2009). Correspondence of the brain's functional architecture during activation and rest. *Proc. Natl. Acad. Sci.* 106, 13040–13045. doi: 10.1073/pnas.0905267106

Sowell, E. R., and Jernigan, T. L. (1998). Further MRI evidence of late brain maturation: Limbic volume increases and changing asymmetries during childhood and adolescence. *Dev. Neuropsychol.* 14, 599–617. doi: 10.1080/87565649809540731

Spaans, J. P., Peters, S., and Crone, E. A. (2020). Neural reward related-reactions to monetar gains for self and charity are associated with donating behavior in adolescence. *Soc. Cognit. Affect. Neurosci.* 15, 151–163. doi: 10.1093/scan/nsaa027

Spreng, R. N., DuPre, E., Selarka, D., Garcia, J., Gojkovic, S., Mildner, J., et al. (2014). Goal-Congruent Default Network Activity Facilitates Cognitive Control. *J. Neurosci.* 34, 14108–14114. doi: 10.1523/JNEUROSCI.2815-14.2014

Steinberg, L. (2008). A social neuroscience perspective on adolescent risk-taking. *Dev. Rev.* 28, 78–106. doi: 10.1016/j.dr.2007.08.002

Tashjian, S. M., Weissman, D. G., Guyer, A. E., and Galván, A. (2018). Neural response to prosocial scenes relates to subsequent giving behavior in adolescents: A pilot study. *Cognit. Affect. Behav. Neurosci.* 18, 342–352. doi: 10.3758/s13415-018-0573-9

Telzer, E. H., Fuligni, A. J., Lieberman, M. D., and Galván, A. (2013). Ventral striatum activation to prosocial rewards predicts longitudinal declines in adolescent risk taking. *Dev. Cognit. Neurosci.* 3, 45–52. doi: 10.1016/j.dcn.2012.08.004

Telzer, E. H., Masten, C. L., Berkman, E. T., Lieberman, M. D., and Fuligni, A. J. (2010). Gaining while giving: an fMRI study of the rewards of family assistance among white and Latino youth. *Soc. Neurosci.* 5, 508–518. doi: 10.1080/17470911003687913

Telzer, E. H., Masten, C. L., Berkman, E. T., Lieberman, M. D., and Fuligni, A. J. (2011). Neural regions associated with self control and mentalizing are recruited during prosocial behaviors towards the family. *NeuroImage* 58, 242–249. doi: 10.1016/j.neuroimage.2011.06.013

Tousignant, B., Eugène, F., Sirois, K., and Jackson, P. L. (2018). Difference in neural response to social exclusion observation and subsequent altruism between adolescents and adults. *Neuropsychologia* 116, 15–25. doi: 10.1016/j.neuropsychologia.2017.04.017

Uddin, L. Q., Supekar, K. S., Ryali, S., and Menon, V. (2011). Dynamic Reconfiguration of Structural and Functional Connectivity Across Core Neurocognitive Brain Networks with Development. *J. Neurosci.* 31, 18578–18589. doi: 10.1523/JNEUROSCI.4465-11.2011

Uddin, L. Q., Yeo, B. T. T., and Spreng, R. N. (2019). Towards a Universal Taxonomy of Macro-scale Functional Human Brain Networks. *Brain Topogr.* 32, 926–942. doi: 10.1007/s10548-019-00744-6

van den Bos, W., van Dijk, E., Westenberg, M., Rombouts, S. A. R. B., and Crone, E. A. (2009). What motivates repayment? Neural correlates of reciprocity in the Trust Game. *Soc. Cognit. Affect. Neurosci.* 4, 294–304. doi: 10.1093/scan/nsp009

van den Bos, W., van Dijk, E., Westenberg, M., Rombouts, S. A., and Crone, E. A. (2011). Changing brains, changing perspectives: the neurocognitive development of reciprocity. *Psychol. Sci.* 22, 60–70. doi: 10.1177/0956797610391102

van der Meulen, M., van IJzendoorn, M. H., and Crone, E. A. (2016). Neural Correlates of Prosocial Behavior: Compensating Social Exclusion in a Four-Player Cyberball Game. *PLoS One* 11:e0159045. doi: 10.1371/journal.pone.0159045

Van Hoorn, J., Shablack, H., Lindquist, K. A., and Telzer, E. H. (2019). Incorporating the social context into neurocognitive models of adolescent decision-making: A neuroimaging meta-analysis. *Neurosci. Biobehav. Rev.* 101, 129–142. doi: 10.1016/j.neubiorev.2018.12.024

Van Hoorn, J., Van Dijk, E., Gürouglu, B., and Crone, E. A. (2016). Neural correlates of prosocial peer influence on public goods game donations during adolescence. *Soc. Cognit. Affect. Neurosci.* 11, 923–933. doi: 10.1093/scan/nsw013

van Schie, C. C., Chiu, C.-D., Rombouts, S. A. R. B., Heiser, W. J., and Elzinga, B. M. (2018). When compliments do not hit but critiques do: An fMRI study into self-esteem and self-knowledge in processing social feedback. *Soc. Cognit. Affect. Neurosci.* 13, 404–417. doi: 10.1093/scan/nsy014

Westhoff, B., Blankenstein, N. E., Schreuders, E., Crone, E. A., and van Duijvenvoorde, A. C. K. (2021). Increased ventromedial prefrontal cortex activity in adolescence benefits prosocial reinforcement learning. *Neuroscience* [Preprint]. doi: 10.1101/2021.01.21.427660

Will, G.-J., Crone, E. A., van Lier, P. A. C., and Gürouglu, B. (2016). Neural correlates of retaliatory and prosocial reactions to social exclusion: Associations with chronic peer rejection. *Dev. Cognit. Neurosci.* 19, 288–297. doi: 10.1016/j.dcn.2016.05.004

Will, G.-J., Crone, E. A., van Lier, P. A. C., and Güroğlu, B. (2018). Longitudinal links between childhood peer acceptance and the neural correlates of sharing. *Dev. Sci.* 21:e12489. doi: 10.1111/desc.12489

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: All claims expressed in this article are solely those of the authors and do not necessarily represent those of their affiliated organizations, or those of the publisher, the editors and the reviewers. Any product that may be evaluated in this article, or claim that may be made by its manufacturer, is not guaranteed or endorsed by the publisher.

frontiers in Psychology

ORIGINAL RESEARCH
published: 08 March 2022
doi: 10.3389/fpsyg.2022.792580

Tears of Joy as an Emotional Expression of the Meaning of Life

Bernardo Paoli[1], Rachele Giubilei[2] and Eugenio De Gregorio[3]*

[1] Accademia Delle Tecniche Psicologiche, Turin, Italy, [2] Istituto per lo Studio Delle Psicoterapie, Rome, Italy, [3] Link Campus University, Rome, Italy

This article describes a research project in which a qualitative research was carried out consisting of 24 semi-structured interviews and a subsequent data analysis using the MAXQDA software in order to investigate a particular dimorphic emotional expression: tears of joy (TOJ). The working hypothesis is that TOJ are not only an atypical expression due to a "super joy," or that they are only an attempt by the organism to self-regulate the excess of joyful emotion through the expression of the opposite emotion (sadness), but that it is an emotional experience in its own right—not entirely overlapping with joy—with a specific adaptive function. Through the interviews, conducted in a cross-cultural context (mainly in India and Japan), we explored the following possibility: what if the adaptive function of crying for joy were to signal, to those experiencing it, the meaning of their life; the most important direction given to their existence? The material collected provided positive support for this interpretation.

Keywords: dimorphous emotional expressions, tears of joy, meaning of life, semi-structured interviews, narrative analysis

OPEN ACCESS

Edited by:
Vincenzo Auriemma, University of Salerno, Italy

Reviewed by:
Ester Miranda, Ordine Degli Psicologi Della Regione Campania, Italy
Inga Dóra Sigfúsdóttir, Reykjavík University, Iceland
Caine Meyers, Reykjavík University, Iceland, in collaboration with reviewer IS

****Correspondence:***
Bernardo Paoli
bernardo.paoli.492@gmail.com

Specialty section:
This article was submitted to Cognitive Science, a section of the journal Frontiers in Psychology

Received: *10 October 2021*
Accepted: *03 February 2022*
Published: *08 March 2022*

Citation:
Paoli B, Giubilei R and De Gregorio E (2022) Tears of Joy as an Emotional Expression of the Meaning of Life. Front. Psychol. 13:792580. doi: 10.3389/fpsyg.2022.792580

INTRODUCTION

The emotions we experience and express have an adaptive function. They allow us to live better in the surrounding environment and respond accordingly to specific circumstances (e.g., fleeing from danger in response to feeling fear). They are the result of a process, of a largely unconscious process of self-regulation, which modulates their nature, intensity and manifestations. Responses to emotions are almost never as violent and powerful as they could be; as such, it happens rarely that a person "loses their mind" completely ignoring internal and external feedback signals. Emotions are also involved in automatic regulation (Matarazzo and Zammuner, 2009). We make conscious attempts to modify our emotions in order to align them with our goals and interests by asking ourselves whether it is useful to feel fear when facing a certain difficulty. Thus, we can cope with fear by changing the perspective we use to observe the situation. Emotional regulations mean that one is able to modulate their form or mitigate their urgency. More generally, it means that one is able to assess demands from the environment and one's own resources, and to respond to them in a flexible and adaptive way. Emotions, properly modulated and regulated, improve social interaction and individual wellbeing. Crying is an emotional expression that has both a self-regulatory goal (decreasing tension and recovering psychological balance) and the purpose of attracting the attention of others and requesting their help and support. Crying can also be the emotional expression of the "opposite" emotion: it can occur in situations in which a person experiences great joy. The dimorphous

expression of tears of joy (TOJ) is a unique, non-mixed experience: the person experiences only joy, and not joy mixed with sadness. TOJ occurs in very significant situations in people's lives, especially in correspondence with the perception of a deep connection with others and with episodes of personal success.

These are the findings from the literature, and the starting point for our qualitative research. This research, which started in an unusual way—due to a journey in India and in Japan taken by one of the authors—sought to explore the cultural influence on emotions and emotional expression, and, above all, on the possible links between TOJ and people's definition of the meaning of life (MOL). Regarding the first point, we know from the literature that there are cultural differences that regulate emotional expression. In collectivist cultures (which exalt "the good of the group before the good of the individual") social rules seem to lead people to avoid the direct expression of emotions, especially negative ones, which can undermine group harmony; on the other hand, the rules of individualistic cultures (which exalt "the good of the individual before the good of the group") seem to be more tolerant of the expression of strong emotions (e.g., anger), because of values such as self-affirmation. Interestingly, the emotional expression of crying tends to occur more frequently in democratic countries with individualistic cultures, where there is greater wealth and political freedom. As for the second point—the pivot of the research—the literature says that people who experience a higher level of meaningfulness in their lives are more likely to experience positive moods and greater wellbeing. So, what if the adaptive function of TOJ were to signal the MOL to those experiencing it? In the literature, these two themes have never been related to each other. The present study aims to investigate a possible connection.

The Adaptive Function of Emotions

From an evolutionary perspective, emotions help humans cope with and adapt to different situations in life (cf. Lazarus, 1991; Plutchik, 2001). When triggered, emotions simultaneously activate different systems—such as perceptual, attentional, and neurophysiological systems—that predispose people to certain behaviors (Tooby and Cosmides, 2008). For example, anger stimulates the activation of the sympathetic nervous system and triggers a flow of energy adequate to support a dynamic response to the situation, which may be self-defense or decompression; fear, on the other hand, induces a state of neurophysiological activation that allows the individual to respond to the initial stimulus through attack, avoidance, or escape. In the literature (Fredrickson, 1998; Ruini, 2017) it has been found that "positive" emotions play important adaptive functions,on par with "negative" ones. Specifically, emotions such as joy, interest, or satisfaction have the ability to modify styles of thought and action, and may expand and improve people's cognitive, behavioral, and social skills, which will in turn become lasting resources for the future. Fredrickson (1998) further argues that the important adaptive functions of positive emotions lie in their ability to counteract negative emotions and their consequences, leading to improved mental and physical health and motivation to work for one's wellbeing.

The Regulatory Function of Emotions: Emotional Self-Regulation

It has been widely attested in the literature that an individual's ability to self-regulate their emotions is a key feature in maintaining social functioning, physical wellbeing, and mental health (cf. Gross and John, 2003). Emotional regulation can be defined as the ability to cope with, monitor, and modulate one's own emotional experiences, and refers to behavioral and cognitive processes that coordinate the intensity, duration, and expression of emotions in response to internal and external stimuli (Gross, 1998; Gross, 2007). For example, when we find ourselves in circumstances that trigger fear, we can divert our attention away from those elements of the situation that most disturb us and focus instead on other aspects we perceive as less dangerous in order to regulate the intensity of the emotion felt in that moment. Gross (2001) distinguishes between antecedent-focused and response-focused strategies: antecedent-focused strategies refer to what individuals do before the emotional response tendencies are fully activated (e.g., choosing not to frequent places or people perceived as disturbing in order to avoid the onset of unpleasant emotions); response-focused strategies refer to what people do when the emotional response is in progress (e.g., striving to appear calm rather than angry, thus suppressing the expression of the emotion felt). The different strategies can down-regulate or up-regulate emotional experiences: while down-regulation strategies tend to attenuate the emotional response, up-regulation strategies contribute to enhancing and prolonging it, whether it be a positive emotion triggered by a pleasant event, or a negative emotion generated by an unpleasant event.

Many works in the literature have focused on the regulation of negative emotions, while few studies have focused on understanding how people regulate positive emotions, such as happiness or pride. Positive emotion regulation refers to how humans modulate responses to stimuli in order to enhance and maintain the positive emotional experiences experienced at a given time (Bryant and Veroff, 2007). Some studies (cf. Langston, 1994) show that, when experiencing very positive situations (e.g., victory in a competition; achievement of an important goal) people can implement behaviors designed to protect their state of happiness: for example, sharing good news with friends or relatives is a way to prolong the positive experience (capitalization). Positive emotional regulation strategies include savoring (Bryant, 1989), which is the ability of humans to enhance and intensify positive experiences in their lives (Bryant and Veroff, 2007). Bryant et al. (2005) theorizes three types of savoring: savoring in relation to an impending positive situation (e.g., anticipatory excitement before an enjoyable event); savoring that prolongs and reinforces the positive event experienced in the present moment (e.g., sharing the experience with people important to us); and savoring intense memories of positive experiences in order to relive the emotions associated with them (e.g., remembering the best moments of an event). Bryant and Veroff (2007), identified several strategies that people use to enhance their savoring ability and that are expressed at cognitive, behavioral, and interpersonal levels. These include: memory building, which

consists in creating a lasting memory of an event (for example, taking a mental picture of an event, or taking a diary); self-congratulation every time we manage to achieve something important in our lives in order to amplify positive feelings; sharing positive emotion with others; comparing the experience lived with a worse one, to appreciate it more; attentional absorption, which means to stay focused and engaged in the present moment and in experience that we are living, without turning our thoughts to the past or future; sensory-perceptual sharpening, which consists in focusing on the sensory aspects that are stimulated in a certain experience (e.g., smells or sounds); behavioral expression, which covers all those physical expressions of happiness (laughing, jumping, clapping) that contribute to generating a positive cycle of pleasure; temporal awareness, for example, reminding ourselves that the experience will not last forever may spur us to enjoy it even more; counting blessings, i.e., experiencing gratitude for having had the opportunity to experience something positive; avoidance of kill-joy thinking, which refers to not focusing exclusively on negative aspects when we go through a difficult time. Use of savoring strategies is positively associated with variables related to individual wellbeing (e.g., self-esteem, life satisfaction, self-reported optimism), whereas lack of savoring skills is linked to depressive feelings, hopelessness, and anhedonia (Bryant, 2003; Joormann and Stanton, 2016).

Interpersonal Emotion Regulation

Humans often seek to moderate their emotional states through the comfort and support of other individuals, thus engaging in a process referred to as interpersonal emotional regulation (Zaki and Williams, 2013). When people listen to and support someone's feelings by showing empathy, solidarity, and sharing, they are actually helping them to regulate the intensity of the emotions they experience. Zaki and Williams (2013) identify two different processes that can support interpersonal emotional regulation: response-independent and response-dependent. The latter is based on the quality of feedback received from the person with whom the emotion is shared; in other words, when people express their sadness or joy to another person, they are only satisfied if that person responds favorably to the request to share. If the interlocutor shows indifference, then emotional regulation does not succeed. Response-independent processes, meanwhile, do not imply that the person with whom emotional states are shared must respond in a particular way: the fact of having talked with someone about one's emotions, giving them a label and identifying their source, is enough in itself to allow people to feel regulated. As is the case in self-regulation, different strategies can be used in interpersonal regulation, depending on the goal one wants to achieve for a given emotional state. We refer to down-regulation processes when people respond in a way that attenuates and minimizes the intensity of the emotional experience shared by the communicative partner, while also weakening behavioral responses (Krompinger et al., 2008). In an experimental study, Pauw et al. (2019) asked participants to watch a video of a man crying over his partner's cheating and asked them to record a supportive video message for him. Analysis revealed that when the situation required immediate emotional down-regulation (such as having to be ready to face an upcoming job interview), participants attempted to regulate the other through disengagement from the emotional experience by implementing distraction and suppression strategies. For example, by saying "Try not to think about her for now," or "Don't let your emotions take over."

When, on the other hand, a person shares positive events with significant others (relatives, friends, partners) and they respond in a way that maximizes and prolongs the positive feelings and benefits experienced, we refer to the phenomenon of capitalization (Gable et al., 2004; Gable and Reis, 2010; Reis et al., 2010). Gable et al. (2004) found that communicating positive situations with significant others is associated with increased wellbeing and daily positive affect. The authors also showed that if significant others respond actively and constructively to capitalization attempts, benefits increase: in couples, this translates into greater wellbeing in some important aspects of the relationship, such as daily marital satisfaction and intimacy.

Crying in Literature

Crying is one of the most common and universally recognized forms of expression through which people manifest and share their emotions. Crying results from the interaction between psychobiological, cognitive, and social processes (cf. Vingerhoets et al., 2000) and serves several functions. It has been suggested in the literature that crying may lead to a decrease in tension (cf. Vingerhoets et al., 2009) and promote the recovery of psychological balance (Rottenberg et al., 2003; Hendriks et al., 2007), although the empirical evidence supporting these hypotheses is conflicting. Some authors have investigated the interpersonal effects of this emotional expression. For example, Hendriks et al. (2008) conducted a survey with the purpose of studying how individuals respond when faced with a crying person, and had participants read six short vignettes depicting social situations. Specifically, three vignettes depicted unpleasant situations (e.g., talking to someone at a funeral or causing a car accident), while the other three depicted pleasant situations (e.g., meeting someone who had just become a parent). In each vignette there was a main character for participants to identify with, and another person who may or may not be crying. In most cases, participants reported that if they were faced with a crying interlocutor, they would exhibit more emotional support and fewer negative feelings toward him or her. Crying could therefore serve as a means of attracting attention, conveying requests for help and support, stimulating others to provide emotional support and thereby facilitating social bonding (Frijda, 1997; Kottler and Montgomery, 2001).

Cultural Differences in Emotional Expression

Several studies (cf. Matsumoto, 1989, 1990; Safdar et al., 2009) have investigated cultural differences that may influence the display of emotions. In this regard, Ekman and Friesen (1969); Ekman (1972) proposed the existence of social rules, referred to as display rules, which govern the manifestation of emotions within

different cultural groups, and which are learned by individuals through the socialization process. These rules direct emotional expression based on whether it is more or less acceptable within a given culture (Matsumoto et al., 1999) and establish how, and in what context, a person should express their emotions. The studies by Ekman (1972) and Friesen (1972) provided the first, which has become a milestone in the history of psychology, provided the first evidence of the existence of the "display rules." The authors highlighted how American and Japanese people have a different way of expressing their emotions depending on the context: if a stranger was present during the viewing of a movie with the participants, the Japanese (unlike Americans) tended not to express negative emotions, disguising them with smiles. The presence of a stranger activated a set of unwritten, culturally learned rules in Japanese participants that regulated the expression of negative emotions. Ekman and Friesen's study was later resumed by Matsumoto (1992), who compared the responses of American and Japanese people in reference to a task of facial expression recognition, finding results in keeping with those of previous studies. In the same research, Matsumoto found that Japanese participants were less able to recognize negative emotions than American subjects, while he found no significant differences in the recognition of positive emotions. To account for these differences, the author investigated cultural differences between the United States and Japan, focusing specifically on the concepts of individualism and collectivism. In cultures with an individualistic features (like most Western cultures), the primary values are those of individual autonomy, self-interest and success; it can be hypothesized that this is why levels of conformity to the group are lower and independence is greater instead: emotions can be experienced primarily as personal experiences, the expression of which is an individual's right. In these cultures, for example, the manifestation of anger is tolerated and considered functional for the individual, as long as it is expressed in socially appropriate ways (Eid and Diener, 2001). Collectivistic cultures, on the other hand, would foster a greater level of conformity within the group, and collective needs would tend to take precedence over individual needs. In general, these cultures seem to urge the individual to maintain cohesion and harmony in the group, rather than to foster individual affirmation (Matsumoto, 1991; Noon and Lewis, 1992); where emotions are experienced as interactive experiences, reflecting the social context, their expression needs to be controlled. In particular, negative emotions may threaten group cohesion and are therefore discouraged. The expression of emotions such as anger or contempt would not be considered acceptable, as they threaten authority and harmony in the group (Miyake and Yamazaki, 1995). Regarding positive emotions, in individualistic cultures there would be a great attention to the pursuit of happiness and its individual expression: not expressing positive emotions could be considered a failure, and unhappiness would tend to have a strongly negative connotation. Conversely, in collectivist cultures, display rules might also filter out the expression of positive emotions, as expression is sometimes considered undesirable (see Eid and Diener, 2001).

A study by Safdar et al. (2009) examined the display rules of seven basic emotions in three different populations: American, Canadian, and Japanese. The goal of the research was to compare the display rules of emotional expression, both across and within cultures. The authors hypothesized that Canadians and Americans showed more approval toward the expression of both negative emotions such as anger and disgust, as well as positive emotions such as happiness and surprise, than Japanese participants, and that all three populations did not show particular differences regarding the expression of emotions such as sadness or fear. In keeping with the first hypothesis, the results showed that Japanese subjects expressed fewer negative emotions than Americans and Canadians, and showed significantly lower mean scores in the expression of positive emotions than Canadians. It was also found that there was no difference between Japanese and North Americans in the expression of emotions of sadness or fear.

Regarding the emotional expression of crying, some authors have conducted cross-cultural studies (see Kraemer and Hastrup, 1986; Vingerhoets and Becht, 1997). Williams and Morris (1996) investigated the crying behaviors of 448 participants from Great Britain and Israel, and the results showed that Britons cried more frequently than Israelis and that women cried more intensely and more often than men. Van Hemert et al. (2011) conducted a study to examine the tendency to cry in 37 countries, including Africa, Asia, the Caribbean, Europe, the Middle East, North America, Oceania, and South America. Analyses showed that crying is not significantly related to perceived distress, but is related to subjective wellbeing; that is, happier countries report more expressions of crying. At for the frequency, the results also showed that crying occurs more frequently in democratic countries, with an individualistic culture, where there is greater wealth and political freedom.

Tears of Joy

TOJ is a special form of crying which can occur when a person is completely involved in situations in which they experience great joy. TOJ is an emotional experience that has been little researched to date, so much so that it is not even mentioned in an atlas of 156 human emotions (Watt Smith, 2015), and in the study conducted by Cowen and Keltner (2017) at the University of California at Berkeley—which identified 27 different interconnected emotions—it is not explicitly mentioned; it is shown in a video (this study made use of video recordings of different emotional expressions) within the category of the emotion of joy. The main studies in the literature that have focused on TOJ consider it as a dimorphous expression of positive emotions (cf. Aragón et al., 2015; Aragón, 2017; Aragón and Clark, 2017): the strong emotion felt (joy) is manifested through an expressive mode (crying) that refers to a different, or even opposite, emotional state (sadness, pain). An example of this is the tears shed by Olympic athletes after winning a gold medal: their joy is so enormous and uncontrollable that it triggers a crying reaction. The hypothesis put forward by the authors is that dimorphous expressions perform a regulatory function of emotional states: when individuals feel overwhelmed by positive feelings—so intense that they are perceived as unmanageable—they may respond through the expression of an emotion that has opposite

value to the one experienced in order to compensate for its excess. In this regard, Aragón and Clark (2017) hypothesize that TOJ also function as a model of interpersonal emotional regulation. Through six experimental studies, the authors found that, when faced with joy expressed in a dimorphic way by significant others, people tend to provide down-regulation responses, thus dampening the intensity of the emotion and attempting to bring it to a level perceived as more manageable. Aragón (2017) again argues that dimorphous expressions cannot be identified with mixed expressions of emotion: as shown in their study, dimorphic expressions derive from a single evaluation of the event experienced, for which there is a single corresponding emotional experience, yet manifested through two recognized expressions, one with positive valence (smiling) and one with negative valence (crying). In contrast, mixed emotion expressions arise when an event stimulates positive and negative evaluations and emotions simultaneously (e.g., joy and sadness), which might then manifest in two emotional expressions of opposite meaning (Larsen et al., 2001; Larsen and McGraw, 2014). For example, Aragón in their study (ibid.) shows participants a video of of a generous man willing to help others; the video also informs viewers that the man died young in a tragic accident. From the analyses performed, the researcher finds that those who watched this video reported paired positive and negative appraisals, emotions, and expressions (joy/sadness, smiling/crying), in contrast with participants who watched the same video but were informed that the man had lived a long time; these latter participants reported primarily positive appraisals and positive emotions. Aragón and Bargh (2018) also suggest that dimorphous expressions may represent certain motivational orientations: in particular, happiness expressed through expressions of anger may communicate experiences of appetitive nature, characterized by the drive toward a desired end state; happiness manifested through expressions of sadness (such as tears) may communicate consummatory states, characterized by the hedonic experience of pleasure when the desired state has been achieved. For example, a basketball player may manifest happiness through aggressive expressions while he is playing a game and scores a point (appetitive state); the same athlete may manifest joy through tears when the desired state has been achieved, or when the game has been won (consummatory state).

An initial taxonomy of experiences in which TOJ occurs was developed by Hoffman et al. (2013). Through a systematic study using a sample of Indian adults, the researchers came to identify 15 main types of situations in which TOJ may occur: non-romantic affection; personal achievements; birth of a child; reunion; romantic love; identification with a movie/other medium; observing a child; reflection on one's life; recovery of a loved one from illness/injury; personal recovery from illness/injury; aesthetic delight; material gain; individual religious experience; interpersonal laughter; witnessing an act of goodness. The research also found that the most frequently reported categories were those related to non-romantic affection and personal success, while religious experiences were reported less frequently. Subsequently, a more nuanced study conducted by Zickfeld et al. (2020) distinguished between four different macro-categories of positive tears: tears of affection (e.g., those shed during a wedding), tears of success (e.g., those shed for a sporting victory), tears of beauty (when one perceives something as extraordinarily beautiful), and tears of amusement (shed in situations in which one laughs so hard that one begins to cry). A number of international studies have investigated whether tears provoked by negative emotions show a different impact on mood compared to those stimulated by positive feelings, and have also tried to identify the possible functions of positive emotional crying. According to Ishii and Shinya (2021), positive crying is more effective in calming one's mood than crying triggered by negative feelings, while Hoffman et al. (2016) find that the frequency of joyful tears is significantly associated with reduced self-perceived transitory stress, physical wellbeing following joyful crying, and self-reported health perceptions.

The Meaning of Life in Literature

We conclude the literature review section by addressing the topic of MOL; the authors' clinical experience has shown that patients tend to associate TOJ with the meaning of their lives. The literature (cf. King et al., 2006; Datu, 2015) shows that having a clear idea of the meaning of one's own life is linked to people's propensity to experience greater wellbeing and positive affect. In this regard, King et al. (2006) believe that it is the daily frequency of positive emotional states that may give meaning to a day or not. Other authors (Emmons, 2003; McDonald et al., 2012; Machell et al., 2015) relate MOL to the achievement of one's own goals: individuals attach great value to these activities, and their accomplishment gives meaning to one's actions, thus also increasing the sense of self-efficacy and promoting the development and maintenance of wellbeing (cf. Diener, 1984; Emmons, 1986). Machell et al. (2015) investigated how people's everyday events are able to influence their perception of meaning on a daily basis. The researchers asked 162 college students to complete daily reports in which they provided measures of: meaning in life, positive and negative social events and achievements, and positive and negative affects. The results showed that social events and positive achievements were correlated with higher perceptions of meaning, whereas social events and negative achievements were correlated with lower perceptions of meaning. Existence may also be infused with meaning through social relationships and contact with others. In this regard, Lambert et al. (2013) investigated which element of social relationships was most likely to promote a sense of MOL. In one study, which included American and Indian participants (the latter in smaller numbers), four methodologically different studies were conducted that found that a strong sense of belonging correlated with higher levels of perceiving life as meaningful, much more so than social support and social worth.

Methodological Background: Narratives and Narrative Psychology

Before describing the methodological approach of the research, we consider it useful to make a brief reference to the use of narratives, narrative psychology, and the biographical approach to the study of emotions and actions related to emotional manifestations. In recent years, the use of narratives in social

research has become a popular and widely used approach in the humanities. Various models of narrative analysis have been developed from materials and research data based on biographies, biographical and narrative interviews, diaries, and—more recently—blogs and other web sources. Broadly speaking, narrative analyses are based on the philosophical assumptions of ontological relativism and constructionism (Smith, 2013); these models imply a continuous interaction between the researcher and the external environment and view knowledge (including scientific knowledge) as a co-constructed and culturally-characterized product. Narratives are methods rooted in people and contexts, situations and cultures; in this sense, using narratives has theoretical implications, both regarding theory of method (how to use narratives) and theoretical elaboration resulting from the analysis of results (what to do with narratives). The reference to narrative constructionism here recalls a socio-culturally oriented approach that understands human beings as "meaning makers" who make use of narratives to interpret, mediate, and share their experience in story form (Smith and Monforte, 2020); in this sense, a narrative is a story told by tracing cultural canons. The stories each of us tell about our experiences (including those elaborated from biographical experience) are based on a narrative structure (Sarbin, 1986a; Murray, 1995). The relationship between biography and self-narration is so close that real streams of study (such as narrative psychology) and research tools (such as biographical interviews) have become widespread in the history of psychology and psychological research. Mancuso and Sarbin (1983) argue that human beings think, perceive, imagine, and dream according to a narrative structure; each individual gives events an order and confers on them a plot which together lay the foundation for a narrative description of reality. Bruner (1990, 2002) states that every narrative can be considered a mental model, a way of perceiving and organizing reality; in order to understand human behavior, it is necessary to bring out the individual's ability to narrate. Our experience takes a narrative form because actions and thought (cognitive processes such as, for example, planning and memory) are guided by narrative structures: the narrative, in short, is our way of organizing social episodes, actions and their stories, as is widely attested by autobiographical studies (Sarbin, 1986b; McAdams et al., 1996).

Given these premises, in the present article we decided to use a qualitative and narrative approach to explore, through the interviews, the psychological and cultural factors that influence the emotional representation of joy in a particular circumstance, that is, when it is expressed through unstoppable crying: TOJ. The guidelines for analysis of the interviews were shared among the three authors of this article; two coded the texts and extrapolated the results; one acted as a supervisor. The entire work was guided by the qualitative research validity criteria described by Tracy (2010), namely: (a) worthy topic (the topic of the research is relevant, timely, significant and interesting), (b) rich rigor (the study relies on sufficient, abundant, appropriate, and complex theoretical constructs, context issues and data collection and analysis processes), (c) sincerity (the study is characterized by a clear positioning of the researcher(s) in the field, transparency about the methods and challenges), (d) credibility (the research is marked by a thick description, concrete detail, and multivocality, (e) resonance (the research influences or moves particular readers or a variety of audiences through evocative representation of processes under investigation and shows transferable findings), (f) significant contribution (the research provides a significant contribution to the field), (g) ethics (the research considers situational and culturally specific ethical factors), and (h) meaningful coherence (the study achieves what it purports to be about, uses methods and procedures that fit its stated goals and meaningfully interconnects literature, research questions and findings, interpretations). The process of analysis, which leads to the elaboration of results from a qualitative study, is cyclical and iterative: the work of the researcher resembles a moving back and forth between each interview, between pieces of the same interview, giving greater emphasis to some linguistic forms and content today and to others tomorrow, once again under the banner of the complexity of qualitative work (Smith and Monforte, 2020).

RESEARCH: IS THERE A CONNECTION BETWEEN TEARS OF JOY AND THE MEANING OF LIFE?

In the present research we wondered whether TOJ could be considered not merely an emotional expression, and therefore a sort of subcategory of joy, but a phenomenon with its own specific qualities; whether it was not merely an automatic emotional self-regulation but also fulfilled a specific adaptive function. The research hypothesis is that TOJ is an emotion that is not entirely superimposable with joy but that it accompanies and signals the most significant experiences in people's lives, whereby the meaning of their lives is understood; its attainment constitutes the most ambitious goal that a human being can establish for themself in the orientation of their entire existence. To investigate this hypothesis we chose to use a qualitative method, through semi-structured interviews, to facilitate a free narrative of emotional experience in the respondents and to bring out potentially new aspects not yet investigated in the literature.

Participants and Interviews

Our qualitative approach was based on the collection of in-depth, semi-structured interviews with 24 participants, of which 17 were from India, 6 from Japan, and 1 from England. The recruitment of participants may seem atypical. In fact, the entire research begun with interpersonal and friendly contacts with two cultural mediators who put one of the authors in contact with some interviewees (the interviews took place during a 6-month trip to India and Japan by one of the authors). At a later stage, the recruitment of the other interviewees followed a snowball principle, a strategy now recognized in qualitative research (Heckathorn, 1997; Morgan, 2008). The recruitment has, therefore, followed a mix of snowball-like organization and casual encounters; both solutions are accepted in qualitative research and mixed methods. Specifically: 8 chance encounters (5 Indian, 2 Japanese, 1 English), 12 encounters organized by a professor of Periyar University (Salem, Tamil Nadu, India)

with students from the Faculty of Psychology, and 4 encounters organized by a cultural mediator from Tokyo. Although not belonging to the two cultures Indian and Japanese, we decided to keep the interview with an English man within the group because of his interesting contribution to the topic of research. All interviews were audio-recorded and conducted in English. If the interviewee was unable to speak English, the presence of a language mediator was requested (5 interviews were conducted with the presence of a mediator). An informed consent form was signed by each interviewee. In order to respect ethical and privacy issues we decided to anonymize all participants, so that the parts of the interview reported in this article are attributed to interviews and not to specific individuals; moreover, male personal pronouns are used everywhere, regardless of the gender of the interviewees. Regarding the demographic characteristics of the respondents: 15 women (11 Indian and 4 Japanese) and 9 men (6 Indian, 2 Japanese, 1 English) participated. The average age of the respondents was 29.2. The mean age of the Indians was 23.2; that of the Japanese was 42.5. This difference is consistent with the different overall mean age of the two populations: in India 28.7; in Japan 48.6[1].

Interviews were conducted following a semi-structured protocol. The interview guide can be found in **Appendix**. As can be read in the interview guide text, the questions about TOJ were placed at the beginning of the interview, while those about the MOL were placed at the end, in order to reduce the possibility the interviewee associated the two topics only because they were treated one after the other. The interview was conducted in a style open to dialogue and following the narratives of the interviewees, so that it was possible to better understand the specificity of the socio-cultural context in which they lived. The approach used made it possible to co-construct a shared narrative between interviewee and interviewer while adhering to the cultural and local context in which the emotional expression was taking place. The value of co-construction in the data collection phase described by Bruner (1990) constitutes the main theoretical-methodological reference for the research.

Qualitative Data Analysis

The semi-structured interviews were subjected to a qualitative content analysis through a coding procedure for narrative themes (Ryan and Russell Bernard, 2003; Braun and Clarke, 2006). Prior to content analysis, each interview was transcribed, and the interviewees' transcripts reviewed by a language facilitator. Next, in each of the transcribed interviews, an attempt was made to identify emergent themes. In the tradition of the qualitative approach, a theme is important because it captures something significant about the data as it relates to the research questions (Braun and Clarke, 2006). We used MAXQDA software to perform computer-supported qualitative content analysis (Kuckartz, 2013; Kuckartz and Rädiker, 2019) to filter the structure of our transcripts and then code them. In the first step, major themes were identified through reading the interviews. This led to the identification of the main content analysis categories (codes and code sets):

1. Tears of joy (TOJ);
2. Meaning of life (MOL);
3. Personal characteristics.

After identifying the parts of the interview pertaining to each of these three thematic areas, we proceeded to extend the analysis, extrapolating segments of text from the transcripts which had specific, recognizable contents relating to the main topics:

1. TOJ: frequency, trigger events, description, situations in which it happened, situations in which it didn't occur, tensions before, family/friends/social conflict, inner conflict.
2. MOL: whether life has a meaning or not, trigger events, what is the MOL, related concepts, connection between TOJ and MOL.
3. Personal characteristics: self-description (hard or soft), ways of experiencing emotions (whether they can or can't control their emotions), whether they speak about themself in the third person, personal/professional realization.

Each interview segment featuring the above-described topics was (re)coded so as to detect, with greater precision, the specific narrative theme around which the discourse of the interviewees was built; for each theme the corresponding segment was identified and defined (coded). More dense segments (articulate, complex, polysemic) were coded with more than one code.

RESULTS

A first reflection concerns the different responses to the project among Indian and Japanese participants. A certain ease in recruiting Indian interviewees was contrasted by a greater difficulty in recruiting people that were happy to be interviewed by a foreigner in the Japanese context. In Japan, on several occasions the initial openness to the project was followed by disinvestment; during the interviews—due also to the difficulty of communicating in English—even those most open to dialogue showed some resistance to talking about emotional issues. What we observed is consistent with established findings in the literature about Japanese people's reticence in expressing their emotions with strangers (Nakane, 1970; Matsumoto, 1991). The different emotional investment in the interviews between Indian and Japanese participants can also be seen through the different richness of the codes attributed during the qualitative analysis: the interviews of the Indian participants have an average of 34.9 codes attributed to each interview (limited to the themes of TOJ and the MOL); in the case of the Japanese participants the average number of codes per interview is 13.5. Another interesting finding is that almost all Japanese interviewees, specifically all those from a predominantly mountainous prefecture bordering Tokyo, initially confused the interviewer's description of TOJ with a different type of emotional experience that they claimed they had experienced many times: feeling sadness inside and showing joy externally (the exact opposite of what happens with TOJ). This cultural duty to repress one's negative emotions in favor of preserving group harmony is a finding consistent with

[1] www.cia.gov/the-world-factbook/

what has been described in cultural anthropology texts (cft. Nakane, 1970).

Tears of Joy

The interviews indicate that the Indian participants have generally experienced TOJ a few times, while the Japanese participants report that it has happened to them only once. In general, however, TOJ is a known experience, but not one experienced it with particular frequency; this could be due to the young age of most of the interviewees (**Table 1**). It is also significant to note that the participants who said they had never cried for joy were also more likely to describe themselves in a "hard" and confident way (e.g., "I have a different set of priorities," "I'm very good at deleting people," "I have been able to shield my personal ambitions. I'm very ambitious"). The reported contexts in which TOJ have been experienced are: with relatives, during a birthday, at university/school, during a competition, receiving news, doing hard work/solving a problem, at the birth of a child, in a religious building, in nature, during a political election, during a wedding, helping someone, cooking, watching a video, alone. The main triggers recognized by respondents were: achieving a result, pride for others, birth, positive surprise, acceptance by the family, a child being given his/her name, spiritual wonder, wedding, solving a critical situation, feeling part of a group (**Table 2**). Consistent with findings in the literature (Hoffman et al., 2013), the achievement of a personal success (winning a school or a sport competition, gaining access to a university or a job) is a major trigger of TOJ. Again, the fact that there is no co-prevalence of TOJ experiences associated with family life moments may depend on the young age of many of the respondents. The terms used to describe the TOJ experience were: instantaneous, instinctive, unexpected, incomprehensible, significant, powerful, emotional, shocking, overwhelming, relevant, with a big impact; experience of greatness, of change, of ecstasy, of victory, of achievement; insight, deep understanding, sense of responsibility; feeling loved, happy, proud, alive, free, important, special, on the right track. The three terms that stand out the most are "happiness," "unexpected," and "achievement": the triggering event was unexpected, just as the strength of the reaction upon the achievement of an important goal for their life and career was also unexpected. Consistent with this, the main emotional tensions that the interviewees experienced before the TOJ were related to not knowing if they would be able (or if their family members would be able) to achieve a certain goal ("When you decide to participate in something, especially a competition, you always want to win, you know, there is always this ambition, desire behind. But you also know that you doubt yourself"), but also a sense of constraint due to a commitment made to oneself or one's family ("I was feeling so stuck"), which was followed by a sense of liberation (**Table 3**).

TABLE 1 | Frequencies of coded category "Tears of joy".

TOJ: Frequencies	
Sometimes	9
Once	6
Never	6
Many times	2
I don't remember	1

TABLE 2 | Frequencies of coded category "Triggering events".

TOJ: triggering events	Frequencies
Achieving a result	12
Pride for others	4
Birth	3
Positive surprise	3
Acceptance by the family	2
To a child is given his/her name	2
Spiritual wonder	2
Wedding	1
Solving a critical situation	1
Feeling part of a group	1

TABLE 3 | Frequencies of coded category "Tension before tears of joy".

TOJ: tension before	Frequencies
I didn't know if I/he/she would be able to	7
I had to, but I didn't want to	7
I/he/she had worked so hard	5
I didn't know if it would be possible	3
I suffered for family pressure	3
I waited it for a long time	2
I was unhappy	2
I felt uncomfortable with others	1

Achievement of Goals as the Main Cause of Tears of Joy

In particular, a strong correspondence was found between TOJ at the achievement of an important goal and the tension of not knowing if one would be able to achieve it; it is also curious to note that the three full words that appeared together most frequently in the interview texts are "[I] don't know." We might advance the hypothesis that the unexpected happiness of TOJ becomes more easily accessible to those who strongly desire to achieve a goal but are not fully sure of their abilities. We also found a co-presence of codes between TOJ caused by the realization of an important goal and the presence of an internal conflict ("So I tried to get some job, but mentally I am not in a normal stage"), the description of oneself as able to control one's emotions ("I told you that I don't cry very easily. So if I do get good news in front of people, I am just happy"), and the description of the meaning of one's own life as "helping/having a good impact on others" ("So it's our duty to live the life to the fullest and have a good life if possible helping others. Being good with others").

Meaning of Life: Connection With Tears of Joy

"Does life have meaning? If yes, what is the meaning of your life? Do you think life has meaning in and of itself, or are we the ones

TABLE 4 | Frequencies of coded category "Life has a meaning or not".

MOL: Life has a meaning or not?	
Yes	20
Yes and no	2
I don't know	2

TABLE 5 | Frequencies of coded category "Connection between TOJ and MOL".

Is there a connection between TOJ and MOL?	
Yes	12
I don't know	1

TABLE 6 | Shared segments between tears of joy and meaning of life.

		Life has a meaning or not			
		Yes	**Yes and no**	**I don't know**	
Tears of joy: frequency	Sometimes	8	1		9
	Once	6			6
	Never	4		2	6
	Many times	2			2
	I don't remember		1		1
		20	2	2	

who put it in there?" When the interview was coming to a close and this question emerged, it always caught the interviewee off guard. It looked like the topic was not as common for them, and the answers were often more succinct than when the topic of emotions was addressed. Similarly, when asked if they saw any connection between their experiences of TOJ and their definition of MOL, an expression of surprise returned: they had never thought about it before, but yes, they did see a connection; respondents, both Indian and Japanese, leaned toward yes: life has meaning (**Table 4**). The MOL was defined according to the following categories: helping, having a positive impact on others, loving, having good relationships, achieving important goals, doing one's best, having ambition, following the flow, happiness, a sense of wholeness, being healthy, worshiping God, being creative, and having experiences. Similar to the experiences of TOJ most commonly found in the literature, the terms that occur most frequently for defining MOL are "help/having good impact," "love/good relationship," "achievement/ambition/doing the best you can": having good connections with others, and achieving personal life goals. We cry for joy for reasons connected to what we believe to be the main meaning of our lives. When asked to elaborate further on what they meant by "meaning of life" respondents used expressions such as: doing something good, connecting with others, God, death, making a difference, having an influence, finding the reason behind, one's dignity, deciding for one's dreams, improving oneself, changing one's perspective, positivity, doing with what one has, something non-materialistic, personal ambitions.

As we have said, there is a connection between TOJ and the MOL for respondents. However, not all respondents answered this question; those who did mention it leaned toward yes (**Table 5**). So much so that, even in the analysis of the relationship between codes, there is a strong co-presence between those who said "Sometimes I have cried for joy" and those who said "Yes, life has a meaning" (**Table 6**).

DISCUSSION AND CONCLUSION

Through this research, participants had the opportunity to talk about their emotions. Conducting interviews allowed them to name unusual emotional manifestations, and link them to specific events in their lives. The use of narrative methods highlighted some typicalities of the dimorphous emotional expression of TOJ. This is an experience that has been lived by almost all of the interviewees, though not with particular frequency. The Indian participants reported having experienced TOJ a few times, while the Japanese participants reported more frequently that it had happened to them only once; this could be due to the cultural tendency, typical of Japanese people, to favor a greater control of emotional expressions. In this sense, those who reported never having cried for joy also tended to describe themselves as inflexible. The typical profile that emerged during the interviews is of a human being who cries for joy a few times, and who does so—consistently with the findings in the literature—when achieving an important result in their life. In addition, this is often when achieving an important result which they were not sure they would be able to achieve. The emotional experience of TOJ is completely unexpected for the person experiencing it and the triggering event is unexpected (e.g., the person did not expect that they would win a competition). The strength of the joyful reaction experienced upon achieving an important life goal is unexpected too. It was interesting to note that respondents spoke of an emotional tension—experienced prior to the TOJ—mainly due to not knowing whether they (themselves or a family member) would be able to achieve a given goal. Thus, it seems that the unexpected happiness of TOJ is more easily accessible to those who strongly desire to achieve a goal but do not feel completely confident in their abilities. The typical profile that emerged during the interviews is also a person who believes that life has a meaning; this person also believes that there is a strong connection between the MOL and the episodes in which they experienced TOJ. Both Indian and Japanese participants argued that—as is consistent with findings in the literature—the meaning of life corresponds with, on the one hand, having good relationships with others, helping them and having a good impact on them, and on the other hand in doing one's best and accomplishing important goals. The main reasons why people cry for joy seem to have a close connection to the themes that people report when describing the meaning of their lives.

Given the data collected from the research, we believe we have identified some elements to support the hypothesis that TOJ can be considered not only a dimorphous emotional expression of joy, but also as an emotion in its own right with specific characteristics; moreover, the literature goes in the direction of

indicating an increasing number of human emotions that are interconnected and have multiple nuances. The possible adaptive function of TOJ could be to direct people toward a higher level of wellbeing by pointing them to the types of experiences that make their lives meaningful. We conclude by pointing out that the present research contains all the typical limitations of qualitative research, including a very small sample of respondents and a greater freedom for both the interviewer and the respondent to "let oneself go" during the dialogue; so much so that some topics of the research were not discussed with all respondents. We hope that in future more space will be given to the study of TOJ and dimorphous emotional expressions, and that the connection between TOJ and people's definitions of the MOL will be further investigated using both qualitative and quantitative methods.

DATA AVAILABILITY STATEMENT

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

ETHICS STATEMENT

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

AUTHOR CONTRIBUTIONS

BP designed the research, conducted the interviews, contributed to the interviews' coding, and wrote the research section and the conclusions. RG conducted the literature research, transcribed interviews, contributed to the interviews' coding, and wrote the literature sections. ED identified the methodological approach, contributed to the data analysis and interpretations, and wrote the methodological section. All authors have read and approved the final manuscript.

ACKNOWLEDGMENTS

Rohit Bajaj (India): review of the interview transcripts of Indian interviewees. Sachiko Ogata (Japan): language mediation with Japanese interviewees. Kadhiravan Subramanian (India): Interview facilitation at Periyar University of Salem. Jack Coulton (England) and Caine Meyers (Canada): language review. We would like to thank Auriemma Vincenzo (Italy) for the invitation to participate in this special issue, and the two reviewers for their precious suggestions aimed at improving the paper's quality.

REFERENCES

Aragón, O. R. (2017). "Tears of joy" and "tears and joy?" personal accounts of dimorphous and mixed expressions of emotion. *Motiv. Emot.* 41, 370–392. doi: 10.1007/s11031-017-9606-x

Aragón, O. R., and Bargh, J. A. (2018). "So happy i could shout!" and "So happy i could cry!" Dimorphous expressions represent and communicate motivational aspects of positive emotions. *Cogn. Emot.* 32, 286–302. doi: 10.1080/02699931.2017.1301388

Aragón, O. R., and Clark, M. S. (2017). Tears of joy" & "smiles of joy" prompt distinct patterns of interpersonal emotion regulation. *Cogn. Emot.* 32, 1–27. doi: 10.1080/02699931.2017.1360253

Aragón, O. R., Clark, M. S., Dyer, R. L., and Bargh, J. A. (2015). Dimorphous expressions of positive emotion: displays of both care and aggression in response to cute stimuli. *Psychol. Sci.* 26, 259–273. doi: 10.1177/0956797614561044

Braun, V., and Clarke, V. (2006). Using thematic analysis in psychology. *Qual. Res. Psychol.* 3, 77–101. doi: 10.1191/1478088706qp063oa

Bruner, J. (1990). *Acts of Meaning*. Cambridge: Harvard University Press.

Bruner, J. (2002). *Making Stories. Law, Literature and Life*. New York, NY: Farrar, Strass e Grioux.

Bryant, F. (2003). Savoring Beliefs Inventory (SBI): a scale for measuring beliefs about savouring. *J. Mental Health.* 12, 175–196. doi: 10.1080/0963823031000103489

Bryant, F. B. (1989). A four-factor model of perceived control: avoiding, coping, obtaining, and savoring. *J. Pers.* 57, 773–797. doi: 10.1111/j.1467-6494.1989.tb00494.x

Bryant, F. B., Smart, C. M., and King, S. P. (2005). Using the past to enhance the present: boosting happiness through positive reminiscence. *J. Happiness Stud.* 6, 227–260. doi: 10.1007/s10902-005-3889-4

Bryant, F. B., and Veroff, J. (2007). *Savoring: A New Model of Positive Experience*. Mahwah, NJ: Lawrence Erlbaum Associates Publishers.

Cowen, A. S., and Keltner, D. (2017). Self-report captures 27 distinct categories of emotion bridged by continuous gradients. *Proc. Natl. Acad. Sci. U.S.A.* 114, E7900–E7909. doi: 10.1073/pnas.1702247114

Datu, J. A. D. (2015). The synergistic interplay between positive emotions and maximization enhances meaning in life: a study in a collectivist context. *Curr. Psychol.* 35, 459–466. doi: 10.1007/s12144-015-9314-1

Diener, E. (1984). Subjective well-being. *Psych. Bull.* 95, 542–575. doi: 10.1037/0033-2909.95.3.542

Eid, M., and Diener, E. (2001). Norms for experiencing emotions in different cultures: inter- and intranational differences. *J. Pers. Soc. Psychol.* 81, 869–885. doi: 10.1037/0022-3514.81.5.869

Ekman, P. (1972). "Universal and cultural differences in facial expressions of emotion," in *Nebraska Symposium of Motivation*, Vol. 19, ed. J. Cole (Lincoln, NE: University of Nebraska Press).

Ekman, P., and Friesen, W. V. (1969). The repertoire of nonverbal behavior: categories, origins, usage, and coding. *Semiotica* 1, 49–98. doi: 10.1515/semi.1969.1.1.49

Emmons, R. A. (1986). Personal strivings: an approach to personality and subjective well-being. *J. Pers. Soc. Psychol.* 51, 1058–1068. doi: 10.1037/0022-3514.51.5.1058

Emmons, R. A. (2003). "Personal goals, life meaning, and virtue: wellsprings of a positive life," in *Flourishing: Positive Psychology and the Life Well-Lived*, eds C. L. M. Keyes and J. Haidt (Washington, DC: American Psychological Association), 105–128. doi: 10.1037/10594-005

Fredrickson, B. L. (1998). What good are positive emotions? *Rev. Gen. Psychol.* 2, 300–319. doi: 10.1037/1089-2680.2.3.300

Friesen, W. V. (1972). *Cultural Differences in Facial Expressions in a Social Situation: an Experimental Test of the Concept of Display Rules*. Ph.D. thesis. San Francisco, CA: University of California.

Frijda, N. H. (1997). "On the functions of emotional expression," in *The (non)Expression of Emotions in Health and Disease*, eds A. J. J. M. Vingerhoets, F. J. Van Bussel, and A. J. W. Boelhouwer (Tilburg: Tilburg University Press), 1–14.

Gable, S. L., and Reis, H. T. (2010). Good news! Capitalizing on positive events in an interpersonal context. *Adv. Exp. Soc. Psychol.* 42, 195–257. doi: 10.1016/S0065-2601(10)42004-3

Gable, S. L., Reis, H. T., Impett, E. A., and Asher, E. R. (2004). What do you do when things go right? The intrapersonal and interpersonal benefits of

sharing positive events. *J. Pers. Soc. Psychol.* 87, 228–245. doi: 10.1037/0022-3514.87.2.228

Gross, J. J. (1998). The emerging field of emotion regulation: an integrative review. *Rev. Gen. Psychol.* 2, 271–299. doi: 10.1037/1089-2680.2.3.271

Gross, J. J. (2001). Emotion regulation in adulthood: timing is everything. *Curr. Dir. Psychol. Sci.* 10, 214–219. doi: 10.1111/1467-8721.00152

Gross, J. J. (ed.) (2007). *Handbook of Emotion Regulation*. New York, NY: The Guilford Press.

Gross, J. J., and John, O. P. (2003). Individual differences in two emotion regulation processes: implications for affect, relationships, and well-being. *J. Pers. Soc. Psychol.* 85, 348–362. doi: 10.1037/0022-3514.85.2.348

Heckathorn, D. D. (1997). Respondent-driven sampling: a new approach to the study of hidden populations. *Soc. Prob.* 44, 174–199. doi: 10.2307/3096941

Hendriks, M. C. P., Croon, M. A., and Vingerhoets, A. J. J. M. (2008). Social reactions to adult crying: the help-soliciting function of tears. *J. Soc. Psychol.* 148, 22–41. doi: 10.3200/SOCP.148.1.22-42

Hendriks, M. C. P., Rottenberg, J., and Vingerhoets, A. J. J. M. (2007). Can the distress-signal and arousal-reduction views of crying be reconciled? Evidence from the cardiovascular system. *Emotion* 7, 458–463. doi: 10.1037/1528-3542.7.2.458

Hoffman, E., Garg, N. R., and Gonzalez-Mujica, J. (2013). Tears of joy in India. *Ind. J. Pos. Psychol.* 4, 212–217.

Hoffman, E., Tran, A., Compton, W. C., and Sasaki, H. (2016). Tears of joy among Japanese young adults: implications for counselling. *Asia Pac. J. Counsel. Psychother.* 7, 1–11. doi: 10.1080/21507686.2016.1214157

Ishii, Y., and Shinya, Y. (2021). Positive emotions have different impacts on mood and sympathetic changes in crying from negative emotions. *Motiv. Emot.* 45, 530–542. doi: 10.1007/s11031-021-09887-1

Joormann, J., and Stanton, C. H. (2016). Examining emotion regulation in depression: a review and future directions. *Behav. Res. Ther.* 86, 35–49. doi: 10.1016/j.brat.2016.07.007

King, L. A., Hicks, J. A., Krull, J. L., and Del Gaiso, A. K. (2006). Positive affect and the experience of meaning in life. *J. Pers. Soc. Psychol.* 90, 179–196. doi: 10.1037/0022-3514.90.1.179

Kottler, J. A., and Montgomery, M. J. (2001). "Theories of crying," in *Adult Crying: A Biopsychosocial Approach*, eds A. J. J. M. Vingerhoets and R. R. Cornelius (Hove: Brunner-Routledge), 1–17.

Kraemer, D. L., and Hastrup, J. L. (1986). Crying in natural settings. *Behav. Res. Ther.* 24, 371–373. doi: 10.1016/0005-7967(86)90199-3

Krompinger, J. W., Moser, J. S., and Simons, R. F. (2008). Modulations of the electrophysiological response to pleasant stimuli by cognitive reappraisal. *Emotion* 8, 132–137. doi: 10.1037/1528-3542.8.1.132

Kuckartz, U. (2013). *Qualitative Text Analysis: A Guide to Methods, Practice and Using Software*. London: Sage. doi: 10.4135/9781446288719

Kuckartz, U., and Rädiker, S. (2019). *Analyzing Qualitative Data with MAXQDA*. Berlin: Springer. doi: 10.1007/978-3-030-15671-8

Lambert, N. M., Stillman, T. F., Hicks, J. A., Kamble, S., Baumeister, R. F., and Fincham, F. D. (2013). To belong is to matter: sense of belonging enhances meaning in life. *Pers. Soc. Psychol. Bull.* 39, 1418–1427. doi: 10.1177/0146167213499186

Langston, C. A. (1994). Capitalizing on and coping with daily-life events: expressive responses to positive events. *J. Pers. Soc. Psychol.* 67, 1112–1125. doi: 10.1037/0022-3514.67.6.1112

Larsen, J. T., and McGraw, A. P. (2014). The case for mixed emotions. *Soc. Pers. Psychol. Compass* 8, 263–274. doi: 10.1111/spc3.12108

Larsen, J. T., McGraw, A. P., and Cacioppo, J. T. (2001). Can people feel happy and sad at the same time? *J. Pers. Soc. Psychol.* 81, 684–696. doi: 10.1037/0022-3514.81.4.684

Lazarus, R. S. (1991). *Emotion and Adaptation*. Oxford: Oxford University Press.

Machell, K. A., Kashdan, T. B., Short, J. L., and Nezlek, J. B. (2015). Relationships between meaning in life, social and achievement events, and positive and negative affect in daily life. *J. Pers.* 83, 287–298. doi: 10.1111/jopy.12103

Mancuso, J. C., and Sarbin, T. R. (1983). "The self-narrative in the enactment of roles," in *Studies in Social Identity*, eds T. R. Sarbin and K. E. Scheibe (New York, NY: Praeger), 233–253.

Matarazzo, O., and Zammuner, V. L. (2009). *La Regolazione Delle Emozioni*. Bologna: il Mulino.

Matsumoto, D. (1989). Cultural influences on the perception of emotion. *J. Cross Cult. Psychol.* 20, 92–105. doi: 10.1177/0022022189201006

Matsumoto, D. (1990). Cultural similarities and differences in display rules. *Motiv. Emot.* 14, 195–214. doi: 10.1007/BF00995569

Matsumoto, D. (1991). Cultural influences on facial expressions of emotion. *South. Comm. J.* 56, 128–137. doi: 10.1080/10417949109372824

Matsumoto, D. (1992). American-Japanese cultural differences in the recognition of universal facial expressions. *J. Cross Cult. Psychol.* 23, 72–84. doi: 10.1177/0022022192231005

Matsumoto, D., Kasri, F., and Kooken, K. (1999). American–Japanese cultural differences in judgements of expression intensity and subjective experience. *Cogn. Emot.* 13, 201–218. doi: 10.1080/026999399379339

McAdams, D. P., Hoffman, B. J., Mansfield, E. D., and Day, R. (1996). Themes of agency and communion in significant autobiographical scenes. *J. Pers.* 64, 339–377. doi: 10.1111/j.1467-6494.1996.tb00514.x

McDonald, M. J., Wong, P. T., and Gingras, D. T. (2012). "Meaning-in- life measures and development of a brief version of the personal meaning profile," in *The Human Quest for Meaning: Theories, Research, and Applications*, 2nd Edn, ed. P. T. P. Wong (New York, NY: Routledge), 357–382.

Miyake, K., and Yamazaki, K. (1995). "Self-conscious emotions: the psychology of shame, guilt, embarrassment, and pride," in *Self-Conscious Emotions: The Psychology of Shame, Guilt, Embarrassment, and Pride*, eds J. P. Tangney and K. W. Fischer (New York, NY: Guilford Press), 488–504.

Morgan, D. (2008). "Snowball sampling," in *The SAGE Encyclopedia of Qualitative Research Methods*, ed. L. Given (Thousand Oaks, CA: SAGE Publications Inc), 816–817.

Murray, K. D. (1995). "Narratology," in *Rethinking Psychology*, eds J. A. Smith, R. Harré, and L. Van Langenhove (London: Sage), 179–195.

Nakane, C. (1970). *Japanese Society. A Practical Guide to Understanding the Japanese Mindset and Culture*. North Clarendon, VT: Tuttle Publishing.

Noon, J. M., and Lewis, J. R. (1992). Therapeutic strategies and outcomes: perspectives from different cultures. *Br. J. Med. Psychol.* 65, 107–117. doi: 10.1111/j.2044-8341.1992.tb01691.x

Pauw, L. S., Sauter, D. A., van Kleef, A., and Fischer, A. H. (2019). Stop crying! The impact of situational demands on interpersonal emotion regulation. *Cogn. Emot.* 33, 1587–1598. doi: 10.1080/02699931.2019.1585330

Plutchik, R. (2001). The nature of emotions. *Am. Sci.* 89, 344–350. doi: 10.1511/2001.4.344

Reis, H. T., Smith, S. M., Carmichael, C. L., Caprariello, P. A., Tsai, F. F., Rodrigues, A., et al. (2010). Are you happy for me? How sharing positive events with others provides personal and interpersonal benefits. *J. Pers. Soc. Psychol.* 99, 311–329. doi: 10.1037/a0018344

Rottenberg, J., Wilhelm, F. H., Gross, J. J., and Gotlib, I. H. (2003). Vagal rebound during resolution of tearful crying among depressed and nondepressed individuals. *Psychophysiology* 40, 1–6. doi: 10.1111/1469-8986.00001

Ruini, C. (2017). *Positive Psychology in the Clinical Domains, Research and Practice*. Bologna: Springer International Publishing. doi: 10.1007/978-3-319-52112-1

Ryan, G. V., and Russell Bernard, H. (2003). Techniques to identify themes. *Field Meth.* 15, 85–109. doi: 10.1177/1525822X02239569

Safdar, S., Friedlmeier, W., Matsumoto, D., Yoo, S. H., Kwantes, C. T., Kakai, H., et al. (2009). Variations of emotional display rules within and across cultures: a comparison between Canada, USA, and Japan. *Can. J. Behav. Sci.* 41, 1–10. doi: 10.1037/a0014387

Sarbin, T. R. (1986a). "The narrative as root metaphor for psychology," in *Narrative Psychology. The Storied Nature of Human Conduct*, ed. T. R. Sarbin (New York, NY: Praeger), 3–21.

Sarbin, T. R. (1986b). *Narrative Psychology. The Storied Nature of Human Conduct*. New York, NY: Praeger.

Smith, B. (2013). Disability, sport and men's narratives of health: a qualitative study. *Health Psychol.* 32, 110–119. doi: 10.1037/a0029187

Smith, B., and Monforte, J. (2020). Stories, new materialism and pluralism: understanding, practising and pushing the boundaries of narrative analysis. *Meth. Psychol.* 2:100016. doi: 10.1016/j.metip.2020.100016

Tooby, J., and Cosmides, L. (2008). "The evolutionary psychology of the emotions and their relationship to internal regulatory variables," in *Handbook of*

Emotions, eds M. Lewis, J. M. Haviland-Jones, and L. F. Barrett (New York, NY: Guilford Press), 114–137.

Tracy, S. J. (2010). Qualitative quality: eight "big-tent" criteria for excellent qualitative research. *Qual. Inq.* 16, 837–851. doi: 10.1177/1077800410383121

Van Hemert, D. A., van de Vijver, F. J. R., and Vingerhoets, A. J. J. M. (2011). Culture and crying: prevalences and gender differences. *Cross Cult. Res. J. Comp. Soc. Sci.* 45, 399–431. doi: 10.1177/1069397111404519

Vingerhoets, A. J. J. M., and Becht, M. C. (1997). "International study on adult crying: some first results," in *Poster at the Annual Meeting of the American Psychosomatic Society*, Santa Fe, NM.

Vingerhoets, A. J. J. M., Bylsma, L., and Rottenberg, J. (2009). "Crying: a biopsychosocial phenomenon," in *Tears in the Graeco-Roman World*, ed. T. Fogen (Berlin: de Guyter), 439–475.

Vingerhoets, A. J. J. M., Cornelius, R. R., Van Heck, G. L., and Becht, M. C. (2000). Adult crying: a model and review of the literature. *Rev. Gen. Psychol.* 4, 354–377. doi: 10.1037/1089-2680.4.4.354

Watt Smith, T. (2015). *The Book of Human Emotions. An Encyclopedia of Feeling From Anger to Wanderlust*. London: Wellcome Collection.

Williams, D. G., and Morris, G. H. (1996). Crying, weeping or tearfulness in British and Israeli adults. *Br. J. Psychol.* 87, 479–505. doi: 10.1111/j.2044-8295.1996.tb02603.x

Zaki, J., and Williams, W. C. (2013). Interpersonal emotion regulation. *Emotion* 13, 803–810. doi: 10.1037/a0033839

Zickfeld, J., Seibt, B., Lazarevic, L., Zezelj, I., and Vingerhoets, A. J. J. M. (2020). A model of positive tears. *PsyArXiv* [Preprint]. doi: 10.31234/osf.io/sf7pe

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.

APPENDIX

Text of the Semi-Structured Interview

I am an Italian psychologist. I'm going around the world to collect interviews on some psychological topics that relate to life, relationships, and important choices. Can I give you an interview? It will be completely anonymous. I will record the interview, which will last about 45 min. At the end I will ask you to sign a privacy form in which I declare the total protection and secrecy of your personal information.

The purpose of this interview is twofold: on the one hand to collect some information for research that I am conducting at the international level, on the other hand to help the interviewee to reflect on important aspects of his/her life on which, if anything, he/she had never thought before.

The first part of the interview is dedicated to emotions, and to one emotion in particular: tears of joy. This is a particular emotion because, on the one hand, if you look at the person's face, he or she seems to be crying with sadness, but inside, instead, they feel joy. Have you ever experienced this type of emotion? (If the person didn't understand what the emotion was, some typical episodes in which people cry for joy were suggested, such as at the birth of a child, or during a wedding, or winning a competition. If the person still did not understand, two pictures of people crying for joy were shown: Fedez and Chiara Ferragni at the birth of Leone, and Javier Zanetti with the Inter jersey raising his hands to the sky). How many times have you experienced this emotion? Could you describe some episodes in which it has happened? What did you feel at that moment? The fact that you cried with joy in those very situations, what does that say about you?

Going in the opposite direction, I'd like to talk about a different kind of emotion: boredom. Do you find yourself bored? How many times a week or month does it happen to you? If it happens to you every day, what percentage of the time does boredom happen to you during a day? In what situations does it happen to you? Why do you find yourself in those situations? What does it say about you that you are bored in those situations? Do you have any strategies you put in place to try to manage boredom? Which ones work best?

As I mentioned at the beginning, I'm a psychologist, and also a psychotherapist; that's why I'm so interested in emotions. Are you familiar with psychotherapy? Do you know what it is and how it works? What is the image that people in general have of psychotherapy? What problems do you think people bring to psychotherapy?

In psychotherapy, especially in the kind of psychotherapy I use—Brief Therapy—there is a lot of focus on the effective and ineffective strategies that people put in place. So I'd like to know about two moments in your life: a first instance where you were really proud of the way you handled the situation; and a second instance, on the other hand, where you were not very proud of the way you handled the situation. Would you like to tell me about these two episodes? What strategies did you implement in the first case? And in the second?

Now there are the last two themes, somewhat unrelated to the previous ones, on which I would like to know your point of view. The first theme is about the meaning of life. What is the meaning of your life? Have you ever asked yourself that before? In your opinion, does the meaning of life exist in itself or do we invent/choose it? Is there any connection between the episodes in which you cried for joy and the meaning of your life? Finally, the last theme. Do you remember a story, fairy tale, nursery rhyme, or song from your childhood that your parents, or caregivers, used to put you to sleep? Would you like to tell/sing it to me?

frontiers | Frontiers in Behavioral Neuroscience

ORIGINAL RESEARCH
published: 13 May 2022
doi: 10.3389/fnbeh.2022.807599

Social Interaction With an Anonymous Opponent Requires Increased Involvement of the Theory of Mind Neural System: An fMRI Study

Maya Zheltyakova[1], Alexander Korotkov[1], Ruslan Masharipov[1], Artem Myznikov[1], Michael Didur[1], Denis Cherednichenko[1], Lisa Wagels[2], Ute Habel[2], Maxim Kireev[1,3] and Mikhail Votinov[1,2]**

[1] N.P. Bechtereva Institute of the Human Brain, Russian Academy of Science, Saint Petersburg, Russia, [2] Department of Psychiatry, Psychotherapy and Psychosomatics, Medical Faculty, RWTH Aachen University, Aachen, Germany, [3] Institute for Cognitive Studies, Saint Petersburg State University, Saint Petersburg, Russia

OPEN ACCESS

Edited by:
Gennaro Iorio,
University of Salerno, Italy

Reviewed by:
Valeria Manera,
Université Côte d'Azur, France
Chiara Begliomini,
University of Padua, Italy
Rossella Canese,
National Institute of Health (ISS), Italy

***Correspondence:**
Mikhail Votinov
mvotinov@ukaachen.de
Alexander Korotkov
korotkov@ihb.spb.ru

Specialty section:
This article was submitted to Individual and Social Behaviors, a section of the journal Frontiers in Behavioral Neuroscience

Received: 02 November 2021
Accepted: 07 March 2022
Published: 13 May 2022

Citation:
Zheltyakova M, Korotkov A, Masharipov R, Myznikov A, Didur M, Cherednichenko D, Wagels L, Habel U, Kireev M and Votinov M (2022) Social Interaction With an Anonymous Opponent Requires Increased Involvement of the Theory of Mind Neural System: An fMRI Study. Front. Behav. Neurosci. 16:807599. doi: 10.3389/fnbeh.2022.807599

An anonymous interaction might facilitate provoking behavior and modify the engagement of theory of mind (TOM) brain mechanisms. However, the effect of anonymity when processing unfair behavior of an opponent remains largely unknown. The current functional magnetic resonance imaging (fMRI) study applied the Taylor aggression paradigm, introducing an anonymous opponent to this task. Thirty-nine healthy right-handed subjects were included in the statistical analysis (13 males/26 females, mean age 24.5 ± 3.6 years). A player winning the reaction-time game could subtract money from the opponent during the task. Participants behaved similarly to both introduced and anonymous opponents. However, when an anonymous opponent (when compared to the introduced opponent) subtracted money, the right inferior frontal gyrus (IFG) demonstrated an increased BOLD signal and increased functional connectivity with the left IFG. Further, increased functional connectivity between the right IFG, the right temporal parietal junction and precuneus was observed during the perception of high provocation (subtracting a large amount of money) from the anonymous compared to the introduced opponent. We speculate that the neural changes may underlie different inferences about the opponents' mental states. The idea that this reorganization of the TOM network reflects the attempt to understand the opponent by "completing" socially relevant details requires further investigation.

Keywords: anonymity, theory of mind, competitive game, functional connectivity, fMRI

INTRODUCTION

Currently, an increasing number of social interactions occur online. Apart from the positive aspects, an online environment provides conditions for aggressive behavior (Demsar et al., 2021), which might be because most virtual communication is anonymous (Pornari and Wood, 2010; Runions and Bak, 2015). The term "aggression" can refer to "any behavior directed toward another individual that is carried out with the intent to cause harm" (Anderson and Bushman, 2002). Anonymity is a factor that influences social behavior, such that it can be characterized by higher levels of aggression (Zimmerman and Ybarra, 2016), a greater tendency to punish unfairness

(Yu et al., 2015), and an increased self-interest in economic games (Burnham, 2003; Charness and Gneezy, 2008) compared to conditions when opponents know each other's true identity. An important facet of aggressive behavior in an anonymous online environment is understanding another person's mental states, especially in the case of receiving provocation. The ability to attribute thoughts, beliefs, and intentions to oneself and others is paraphrased as the theory of mind (TOM) (Premack and Woodruff, 1978), which is underpinned by a set of brain regions, the TOM network (Schurz et al., 2020a). According to meta-analytic studies, the network mainly includes the bilateral temporoparietal junction (TPJ), the medial prefrontal cortex (mPFC), the precuneus, and the superior temporal sulcus (Mar, 2011; Bzdok et al., 2012; Dufour et al., 2013; Molenberghs et al., 2016). Additional parts of the TOM network comprise the temporal pole, the middle temporal gyrus, the right visual cortex (MT/V5), the amygdala, and the inferior frontal gyrus (IFG) (Mar, 2011; Bzdok et al., 2012). The neural basis of TOM abilities has been extensively studied in both normal and pathological states [e.g., autism spectrum disorders (Andreou and Skrimpa, 2020), borderline personality disorder (Bora, 2021), psychopathy (van Dongen, 2020), schizophrenia (Vucurovic et al., 2020)]. However, data regarding the re-organization of the TOM network in response to social provocation in anonymous competition contexts are lacking to our knowledge.

Thus, we aimed to study local activity and connectivity of the TOM network during the interaction with an anonymous repeatedly provoking opponent. We base our hypotheses on the assumption that increased local activity in one given area will reflect increased involvement in processes underlying such an interaction. Increased functional connectivity is assumed to support the mental and behavioral processes during the interaction via a stronger communication between the involved structures. The opposite patterns are assumed to indicate reduced involvement in the processes underlying the interaction in the TAP. To address this question, we applied a functional magnetic resonance imaging (fMRI)-compatible version of the Taylor aggression paradigm (TAP) (Repple et al., 2017; Wagels et al., 2019). In this paradigm, participants select a monetary punishment in response to prior social provocation by the opponent. TOM areas are associated with aggressive decision-making during the TAP (Beyer et al., 2014b), but modifying the type of experimental task and considering individual differences between subjects may provide a better understanding of the role of the TOM network. For example, in a previous version of TAP where participants had an alternative to avoid aggression, the activity in the IFG and the TPJ was decreased during aggressive responses compared to avoiding aggression (Buades-Rotger et al., 2017). In addition, participants with high emotional reactivity to threat, measured as fear potentiation (FP) of the startle response, had lower activity in the mPFC, TPJ, precuneus, and IFG during punishment selection for a highly provoking opponent (Beyer et al., 2014a). Different activity might be related to differences in the interpretation of the opponent's action. Such an interpretation might differ depending on how much a participant knows about the opponent. In order to manipulate this knowledge about the opponent, we modified the TAP task as follows (see 'Stimuli and procedure' in the Materials and Methods section for more details): (1) The participants were told they would interact with two different opponents. While they were introduced to one opponent during the instruction (the known opponent), they did not meet the other opponent prior to or after the experiment (the anonymous opponent). (2) We separated the decision-making phase (selecting the punishment) from the motor performance of this action.

The first evidence characterizing brain mechanisms underlying the interaction with an opponent whose identity is unknown or uncertain (anonymous opponent), compared to an interaction with a person with a known identity (known opponent), is provided by electrophysiological studies investigating event-related potentials (ERPs) using an ultimatum game and dictator game (Wu et al., 2011; Yu et al., 2015). These games required the participants to evaluate fair and unfair monetary distributions decided by the opponent. Fairness evaluation is important to establish cooperative behavior, however, in unfair scenarios individuals often get angry and punish others. The study by Yu et al. (2015) has shown increased attentional resources allocated to receiving fair offers from an anonymous (versus known) person, reflected by the increased amplitude of P300. With regard to unfair scenarios, Wu et al. (2011) reported a less positive P300 compared to fair offers only in the anonymous condition. The authors conclude that contextual factors such as anonymity modulate fairness concerns. This may ultimately influence aggressive behavior as shown in previous studies assessing the effect of deindividuation on aggression (Lightdale and Prentice, 1994). However, such investigations are limited with regard to the localization of involved brain regions.

Potential regions for observing the effect of anonymity are those attributed to the TOM network. In the TAP, participants see how much money the opponent has subtracted, after which they have to choose the amount of money, they will subtract from the opponent. They know that the decision will only be implemented in case of the player winning the round. Thus, participants need to understand the intention and reason behind the opponent's actions to select a corresponding reaction. However, in the anonymous scenario, participants do not have information regarding the opponent, and relevant details about the emotional state of the other (such as the opponent's face) are absent. Missing information may exacerbate the interpretation of the other's intention. Hence, it is expected that TOM network nodes will work differently during the anonymous interaction.

A primary hypothesis may be that TOM areas will be less involved when engaging with anonymous versus known people because less information about the opponent is present. Based on our assumptions, we expect a decrease in local activity in TOM-related structures or/and connectivity between them during interacting with an anonymous, compared to a known opponent. In line with this idea, performing an image-phrase compatibility task for images with blurred faces was characterized by decreased local activity in areas of visual social information processing (Proverbio et al., 2018). Furthermore, comparing the categorization of non-social scenes to the categorization of social scenes revealed reduced activity of the TOM areas: the bilateral

temporal pole and superior temporal sulcus, mPFC, precuneus, and right IFG (Wagner et al., 2011).

An alternative hypothesis could be that hyper-involvement of the TOM areas may be required because the additional effort is applied to attribute thoughts, beliefs, and intentions to the anonymous opponent to understand his/her actions. Based on our assumption, we expect that increased local activity in TOM-related structures or/and connectivity between them should be found when comparing interaction with an anonymous opponent to interaction with a known one. Yu et al. (2015) have suggested a re-distribution of attentional resources in order to confirm the anonymous opponent's identity. Similarly, conditions that involve a greater load on TOM-related social-cognitive processes on the neural level are characterized by increased activity of areas within the TOM system. Notably, compared to the task of predicting the intentions of another player (low-level TOM involvement), the task of predicting the thoughts of another player concerning one's own intentions (high-level TOM involvement) during a strategic game has been associated with increased activity in the left anterior insula and right IFG (Bhatt and Camerer, 2005). In addition, the dorsolateral prefrontal cortex has been reported to encode the depth of reasoning about others' thoughts (Yoshida et al., 2010), while the degree of how often people use high-level reasoning in strategic games correlated with activity in the medial prefrontal cortex (Coricelli and Nagel, 2009).

Finally, it might be the case that both increased and decreased activity or/and functional connectivity in distinct areas of the TOM network will be observed in association with anonymous interaction. Previous meta-analyses of effective connectivity studies on social cognition indicated that both negative coupling (i.e., segregation) and positive coupling (i.e., integration) between different networks do not imply a contradiction (Shine and Poldrack, 2018; Schurz et al., 2020a). Instead, this may reflect two rivaling constraints on cognitive function.

Based on the relevance of the TOM system during the evaluation of social contexts, such as provocation-aggression contexts, and the influence of social information provided about the other party, the objective of the current study was to study activity and connectivity of the TOM network while performing the TAP task against an anonymous or known opponent. We hypothesized that the local BOLD-signal and functional connectivity in the TOM areas reorganize and that this reorganization is twofold. On the one hand, a lack of information to process will be associated with decreased local activity and functional connectivity in some areas of the TOM system. On the other hand, as mentalizing during the interaction with an anonymous may be more demanding in terms of required resources, increased levels of local activity and distant interactions of other TOM system areas will be observed.

MATERIALS AND METHODS

Participants

Forty-two healthy right-handed volunteers (26 females and 13 males, age 24.5 $\pm$ 3.6 years) without a history of psychiatric or neurological diseases or current medication intake were recruited via an advertisement placed on social network and took part in the experiment for a monetary reward (1,500 rubles). We assessed the handedness of the participants using the Edinburgh Handedness Inventory (Oldfield, 1971). All participants provided written informed consent prior to commencing the study. We performed all procedures in accordance with the Declaration of Helsinki, and they were approved by the Ethics Committee of the N.P. Bechtereva Institute of the Human Brain, St. Petersburg, Russia. After the experiment, the participants filled out a questionnaire concerning their game strategy and opinions about the opponent.

Stimuli and Procedure

The participants were informed that they were going to play a reaction time game against two opponents. They became acquainted, spent some time with one of their opponents while receiving the instructions about the experiment, and learned that another opponent would remain anonymous before and after the experiment. The fMRI scanning consisted of four sessions presented in random order: In two of them, the volunteer played with a known opponent and in another two with an anonymous opponent. There were 160 trials across all four sessions: 80 in sessions with a known opponent and 80 in sessions with an anonymous opponent. Each trial (game round) consisted of four phases: "Decision," "Scale," "Game," and "Feedback" (see **Figure 1**).

In the first phase (the "Decision" phase), the inscription "Decide how much money you will take from your opponent" and a picture—either with an anonymous avatar or a photo of a real opponent (whom they had recently met)—appeared on the screen. An avatar represented a silhouette, and no information (sex, age, appearance) could be inferred from it. According to the instructions, during this phase, the volunteers had to decide the amount of money they would subtract from the opponent in case of winning the round.

In the second phase (the "Scale" phase), a gradual filling scale indicating the sum of 0, 20, 80, and 100 roubles appeared on the screen. The volunteers had to press the button with their right index finger when the scale corresponded to the amount they chose earlier in the "Decision" phase.

In the third phase (the "Game" phase), an image of a soccer ball appeared randomly in one of the four corners of the playing field (screen). The task was to press the button with the right index finger as fast as possible upon seeing the ball. At the same time, the participants were asked not to press the button ahead of time (before the ball appeared).

In the fourth phase (the "Feedback" phase), either an avatar of an anonymous opponent or a photo of a real opponent appeared on the screen with the inscription indicating losing ("Your opponent took 0/20/80/100 roubles from you"!) or winning the game ("You won 50 roubles"!).

According to the instructions, the number chosen by the participant at the beginning of the round predisposed the amount of money lost by the opponent in case the volunteer won. The amount taken from the volunteers in case they lost depended, in turn, on their opponent's choice. It was emphasized that the

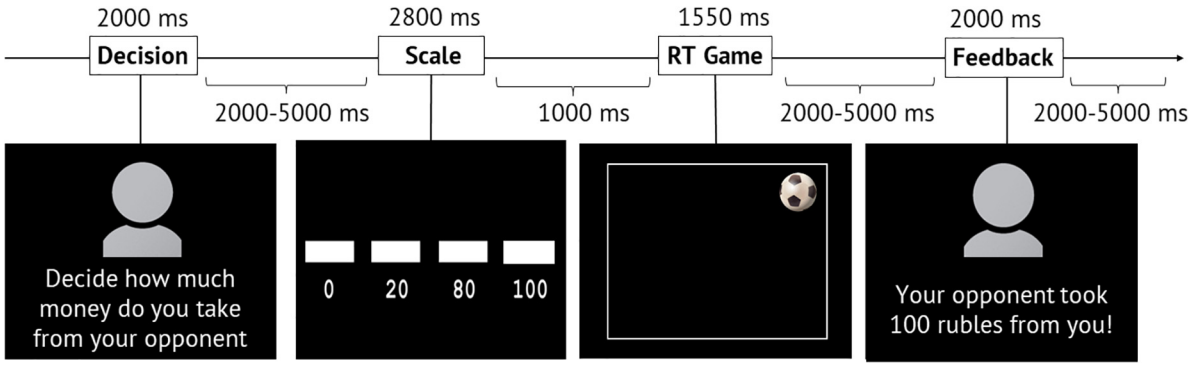


FIGURE 1 | Structure and temporal characteristics of the modified TAP paradigm. During the "Scale" phase, a scale indicating the amount of money was gradually filled, and the volunteer had to press the button when the box appeared above the selected amount. RT, reaction time.

participants would not earn the money they took away from the opponent. The sum gained in case of victory was fixed to 50 roubles for all players. Thus, subtracting money from a known person or anonymous player could be defined as a reactive, aggressive action (Baron et al., 1994).

In reality, we programmed the "Feedback" phase: The participants won 60 trials across all four sessions, lost 0 and 100 roubles across 48 trials, and lost 20 and 80 roubles across 52 trials. These trials were presented in random order while being matched for the trails played against a known or anonymous opponent respectively. The programmed number of trials could only be changed if the volunteers did not press the button when catching the ball. In this case, 0 or 20 roubles were always taken from the volunteer during the "Feedback" phase. Observing the amount of money lost in the game was considered a social provocation, which could be high (80 or 100 roubles) or low (0 or 20 roubles).

The "Decision" phase lasted for 2 s. The duration of the "Scale" phase was 2.8 s (the first sum of the scale appeared for 1 s, three subsequent ones for 600 ms). On average, the "Game" phase lasted for 1.55 s (1.2–1.8 s), out of which for 700–1200 ms, no ball appeared on the screen, and for 600 ms, the ball was shown. Next, "Feedback" appeared on the screen for 2 s. The interval between the "Decision" and "Scale" phases varied from 2 to 5 s (average: 3.5 s). The interval between the "Scale" and "Game" phases was 1 s. The interval between the "Game" and "Feedback" phases varied from 2 to 5 s (average: 3.5 s). The interval between trials also varied from 2 to 5 s and averaged 3.5 s (see **Figure 1**).

fMRI Image Acquisition Procedure and Image Processing

fMRI data were recorded using a 3 Tesla Philips Achieva scanner. Structural images were acquired prior to the task using a T1weighted pulse sequence (T1W3DFFE; repetition time [TR] = 25 ms; echo time [TE] = 2.2 ms; 30° flip angle), measuring 130 axial slices (field of view [FOV] = 240 × 240 mm) of 1 mm thickness and a 1 × 1 mm pixel size. Functional images were obtained using an echo-planar imaging (EPI) sequence (TR = 2 s, TE = 35 ms; 90° flip angle; FOV = 200 × 186 mm). In total, 32 continuous 3.5 mm thick axial slices (voxel size = 3 × 3 × 3.5 mm) covering the entire cerebrum and most of the cerebellum were oriented with respect to structural images.

An MR-compatible cervical collar was used to prevent head movements. Data preprocessing and subsequent statistical analyses were performed via SPM12 software[1] run in MATLAB R2017a (Mathworks Inc., Natick, MA, United States, США). The preprocessing of raw fMRI data for each participant included the following stages: realignment, slice-time correction, co-registration, segmentation, normalization, and smoothing (8 mm FWHM). During the realignment stage, 6 parameters of head movement relative to the first image were generated (translations and rotations in three coordinate axes).

Statistical Analysis

First, statistical analysis was performed for each participant separately, and individual general linear models (GLMs) were generated. The same GLM models, with 11 regressors representing the temporal characteristics of the experimental phases, were created for anonymous and known opponents. Events were classified similar to the GLMs created by Wagels et al. (2019), who also applied an fMRI compatible version of the TAP task. Namely, events were modeled with the onset at the beginning of the experimental phase and duration equal to zero. The "Feedback" phase (provocation) corresponded to three GLM regressors: low provocation (the loss of 0 or 20 roubles), high provocation (the loss of 80 or 100 roubles), and no provocation (winning). "Decision" and "Scale" phases were sorted according to provocation in the preceding trial: low, high, and no provocation. The "Game" phase corresponded to a separate regressor. GLMs also included first trials and mistakes in one separate regressor of no interest and six regressors for six head movement parameters obtained during preprocessing (realignment) (Johnstone et al., 2006). Regressors were then convolved with the standard hemodynamic response function (HRF).

Second, beta values of regression coefficients for the regressors in GLMs were estimated at the individual level of analysis. Linear contrasts of beta coefficients of each game phase and the baseline

[1]http://www.fil.ion.ucl.ac.uk/spm

were calculated and used as a variable for the second-level analysis. At the second-level random-effect analysis, models were generated for each game phase of interest ("Decision," "Scale," and "Feedback") separately and included two factors with two levels: "provocation" (high and low) and "opponent" (known and anonymous). F-contrasts for the main effect of the opponent, the main effect of the provocation, and the interaction between two factors were calculated.

Last, the obtained F-contrasts were used to make a voxelwise statistical inference on a group level. An uncorrected $p < 0.001$ threshold was applied at the voxel level, and a familywise error (FWE) corrected $p < 0.05$ threshold was applied at the cluster level. A gray matter mask, created from segmented structural images, was used to only select voxels within the gray matter in all subjects. Xjview Toolbox[2] was used to identify the anatomical location of voxels, with significant changes in local neuronal activity. The REX toolbox was applied to illustrate differences in values of beta coefficients in obtained clusters of changes in BOLD signal[3].

Psychophysiological Interaction Analysis

To estimate the effect of anonymity on changes in functional connectivity, the generalized form of psychophysiological interactions analysis (gPPI-analysis) was performed using the toolbox for SPM12[4] (McLaren et al., 2012). This method allows for distinguishing context-dependent changes in the strength of functional interactions from mere coactivations and correlations of spontaneous signal fluctuations observed during the resting state. ROI was selected based on two criteria. First, the ROI should be a node of the TOM network. Second, the ROI should be characterized by differential neuronal activity during the interaction with the known and anonymous opponent obtained in the current study. One cluster comprising the right IFG satisfied the named criteria as characterized by differential activity in our study and assigned to the TOM network in previous meta-analyses (Mar, 2011; Bzdok et al., 2012). In addition, the local BOLD signal in the right IFG was increased for the observation of provocation from the anonymous opponent compared to the known opponent: "Anonymous opponent > Known opponent" contrast calculated for the "Feedback" phase (see "*The effect of provocation on local brain activity changes during the observation of social provocation [the 'Feedback' phase]"* paragraph in the Results section). Thus, we selected the right IFG cluster, with the center at MNI coordinates $x = 57$, $y = 11$, $z = 14$, as the ROI in the gPPI analysis.

In the gPPI analysis, individual GLMs described above (see section "Statistical Analysis") included additional regressors: a physiological regressor and PPI regressors. The physiological regressor *Xphysio(t)* represents the BOLD signal time series in the ROI. To create the PPI regressor *XPPI(t)*, BOLD signal time series from the ROI were deconvolved ($\otimes\hat{}$-1) with HRF*(t)* to reveal underlying neuronal activity *Zphysio(t)*: *Zphysio(t) = Xphysio(t)* $\otimes\hat{}$*-1 HRF(t)* (Gitelman et al., 2003). The obtained signal was multiplied by the temporal characteristics of experimental events *Zpsy(t)*. The outcome of this multiplication represented the psychophysiological interaction on the level of neuronal activity. To model this interaction on a level of the BOLD signal, it was convolved with the HRF: *XPPI(t) = (Zphysio(t)* · *Zpsy(t))* $\otimes$ *HRF(t)*. PPI regressors were created separately for anonymous and known opponents and for regressors of interest, including the "Feedback" phase with low and high provocation. The analysis was performed for the "Feedback" phase because significant changes in local BOLD signals were registered for this phase of receiving provocation from the anonymous opponent.

Similar to the analysis of BOLD signal changes, the group-level model included two factors with two levels: "provocation" (high and low) and "opponent" (known and anonymous). F-contrasts for the main effect of the opponent, the main effect of the provocation, and the interaction between two factors were calculated.

An uncorrected $p < 0.001$ threshold was applied at the voxel level, and a FWE-corrected $p < 0.05$ threshold was applied at the cluster level. A gray matter mask, created from segmented structural images, was used to only select voxels within the gray matter in all subjects. xjView Toolbox[5] (see footnote 2) was employed to identify the anatomical location of voxels, with significant changes in local neuronal activity. To interpret and illustrate results in terms of which clusters obtained in the whole-brain analysis are localized within the TOM neural system, thresholded maps of seven TOM-related regions (the right TPJ (rTPJ) and left TPJ; the precuneus; the dorsal, middle, and ventral components of the medial prefrontal cortex; and the right STS) were used (Dufour et al., 2013), and downloaded from https://saxelab.mit.edu/use-our-theory-mind-group-maps/. Results obtained in the current study were overlayed with the regions obtained by Dufour et al. (2013). Only those clusters that overlapped with TOM regions were interpreted to be localized within the TOM system.

REX toolbox (see footnote 3) was applied to illustrate differences in values of regression coefficients in obtained clusters of changes in functional interactions.

RESULTS

Behavioral Results

In the statistical analysis, we included 39 out of 42 subjects (13 males/26 females, mean age 24.5 ± 3.6 years). We excluded three participants because their behavioral responses indicated that they did not believe or understand the instructions: One did not believe in having played against another human (according to the post-experimental questionnaire), one repeated the same order of answers throughout the experiment (no actual cognitive involvement), and one lost 74% of reaction time games due to pressing the button too fast (cheating).

When performing the TAP task, participants on average selected low punishment (subtracting 0 or 20 roubles) in 62% of the trials and high punishment (subtracting 80 or 100 roubles) in 38% of the trials. However, we did not detect any significant difference between the anonymous and known

[2]http://www.alivelearn.net/xjview

[3]http://www.nitrc.org/projects/rex/

[4]http://www.nitrc.org/projects/gppi

opponents in terms of the proportion of trials with low and high selected punishments.

Imaging Results

The Effect of Anonymity on Local Brain Activity Changes During Decision-Making (the "Decision" Phase)

We observed a main effect of the factor "opponent" on the BOLD signal changes during the phase of decision-making. This period comprised the time when the participant *thought about* the amount of money to subtract from the respective opponent after seeing his/her provocation. Compared to an anonymous person, the *thought about* reacting toward an introduced opponent was associated with increased BOLD signals in the fusiform gyrus bilaterally (see **Figure 2** and **Table 1**). No voxels demonstrated a significant increase in the BOLD signal if participants *thought about* the amount to subtract from an anonymous opponent. We did not observe any significant changes for the main effect of the factor "provocation" (high or low) and the interaction of factors "opponent" and "provocation" for the "decision" phase.

The Effect of Provocation on Local Brain Activity Changes During the Selection of Punishment (the "Scale" Phase)

We observed a main effect of "provocation" during the Scale phase. *Subtracting* a high amount of money (80 or 100 roubles) compared to the low amount of money (0 or 20 roubles), irrespective of whether the opponent was introduced or not, was associated with an increased BOLD signal in the left putamen (see **Table 2**). No voxels demonstrated a significant increase in the BOLD signal during selection to *subtract* a low (versus high) amount of money. We did not observe any significant changes for the main effect of the factor "opponent" or the interaction of factors for the "Scale" phase.

The Effect of Anonymity on Local Brain Activity Changes During the Observation of Social Provocation (the "Feedback" Phase)

We noted the main effect of the factor "opponent" on the BOLD signal changes during the phase when participants received the provocation (the "Feedback" phase). Compared to a known opponent, observing feedback from an anonymous opponent was associated with increased BOLD signals localized in the right IFG (see **Figure 3** and **Table 3**). Compared to observing feedback from an anonymous person, receiving the provocation from a known opponent was associated with increased BOLD signals localized in the right fusiform gyrus (see **Figure 3** and **Table 3**), resembling the finding for the "Decision" phase. We did not observe any effect of interaction between the two factors ("opponent" and "provocation") for the "Feedback" phase.

The Effect of Provocation on Local Brain Activity Changes During the Observation of Social Provocation (the "Feedback" Phase)

When observing provocative feedback from opponents, high provocation (80 or 100 roubles), compared to low

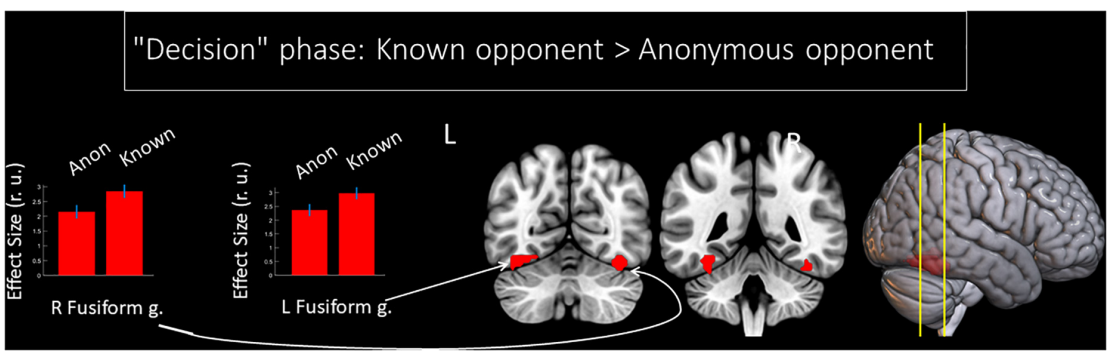


FIGURE 2 | Results of the group-level BOLD signal analysis. Clusters of increased BOLD signals associated with decision-making after being provoked for the F-contrast "Known opponent vs. Anonymous opponent" (uncorrected $p < 0.001$ at the voxel level, FWE-corrected at the cluster level $p < 0.05$, $k = 15$). Plots show effect sizes with 95% confidence intervals. L/R, left/right hemisphere; g., gyrus; Anon, anonymous opponent; Known, introduced opponent.

TABLE 1 | Results of the group-level analysis of the BOLD signal associated with decision-making after being provoked (uncorrected $p < 0.001$ on the voxel level, FWE-corrected at the cluster level $p < 0.05$, and $k = 15$).

	Cluster		Peak			Peak MNI coordinates		
Brain area	**p(FWE-corr.)**	**k**	**p(unc.)**	**F**	**Z**	**x**	**y**	**z**
"Decision" phase: Known opponent > Anonymous opponent								
L Fusiform g.	<0.001	160	<0.001	36.21	5.47	−36	−46	−19
R Fusiform g.	0.001	143	<0.001	34.71	5.37	39	−64	−16
No significant changes were obtained for the "Decision" phase: Anonymous opponent > Known opponent								

k, cluster size in voxels; FWE, familywise error correction; L/R, left/right hemisphere; g., gyrus.

TABLE 2 | Results of the group-level analysis of the BOLD signal associated with selection of punishment (uncorrected $p < 0.001$ at the voxel level, FWE-corrected at the cluster level $p < 0.05$, and $k = 15$).

	Cluster		Peak			Peak MNI coordinates		
Brain area	**p(FWE-corr.)**	**k**	**p(unc.)**	**F**	**Z**	**x**	**y**	**z**
"Scale" phase: High provocation > Low provocation								
L Putamen	0.018	106	<0.001	26.49	4.73	–18	11	8
No significant changes were obtained for the "Scale" phase: Low provocation > High provocation								

k, cluster size in voxels; FWE, familywise error correction; L/R, left/right hemisphere.

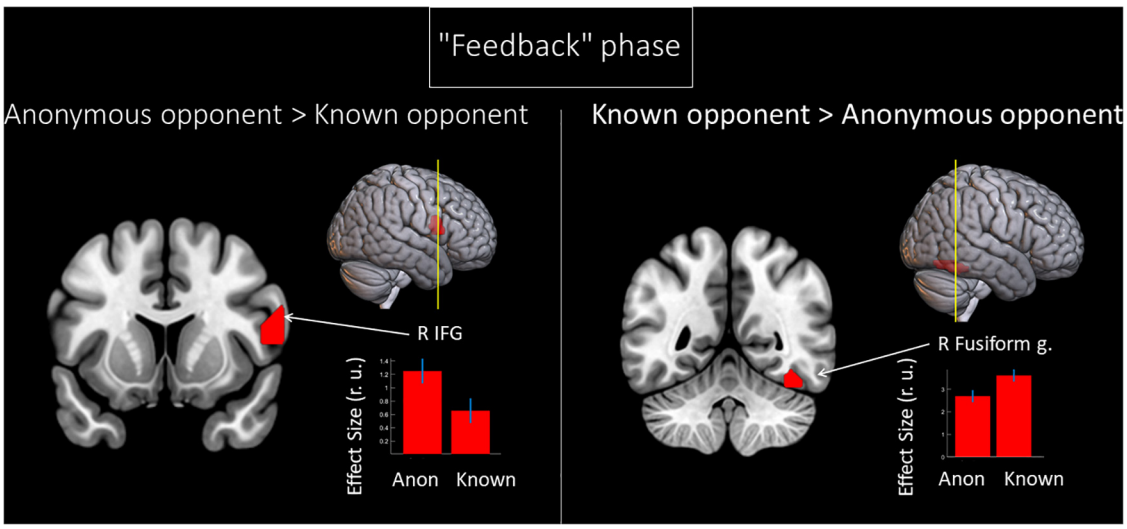


FIGURE 3 | Results of the group-level BOLD signal analysis. Clusters of increased BOLD signals associated with the observation of provocation for the F-contrast "Anonymous opponent vs. Known opponent" (uncorrected $p < 0.001$ at the voxel level, FWE-corrected at the cluster level $p < 0.05$, and $k = 15$). Plots show effect sizes with 95% confidence intervals. L/R, left/right hemisphere; g., gyrus; IFG, inferior frontal gyrus; Anon, anonymous opponent; Known, introduced opponent.

TABLE 3 | Results of the group-level analysis of the BOLD signal associated with the observation of provocation (uncorrected $p < 0.001$ at the voxel level, FWE corrected at the cluster level $p < 0.05$, and $k = 15$).

	Cluster		Peak			Peak MNI Coordinates		
Brain area	**p(FWE-corr.)**	**k**	**p(unc.)**	**F**	**Z**	**x**	**y**	**z**
"Feedback" phase: Anonymous opponent > Known opponent								
R Inferior frontal g.	0.009	111	<0.001	29.65	4.99	57	11	14
"Feedback" phase: Known opponent > Anonymous opponent								
R Fusiform g.	0.005	126	<0.001	58.47	6.76	39	–52	–19

k, cluster size in voxels; FWE, familywise error correction; L/R, left/right hemisphere; g., gyrus.

provocation (0 or 20) roubles, was associated with an increased local BOLD signal in the angular gyrus and supplementary motor area (see **Table 4**). Compared to high provocation, low provocation was associated with increased BOLD signals localized in the right middle frontal gyrus and left IFG, the left angular gyrus, and the right precuneus (see **Table 4**). Among these structures, the right angular gyrus, left angular gyrus, and right precuneus are localized within the rTPJ, left TPJ, and precuneus clusters of the TOM system, respectively, according to masks generated by Dufour et al. (2013). We did not observe any effect of interaction between the two factors ("opponent" and "provocation") for the "Feedback" phase.

Functional Connectivity Changes of the Right Inferior Frontal Gyrus: The Effect of Anonymity on the Observation of Social Provocation During the "Feedback" Phase

Compared to a known opponent, observing feedback from an anonymous opponent was associated with increased functional connectivity between the right and left IFGs (see **Figure 4** and **Table 5**). However, we did not witness any significant

TABLE 4 | Results of the group-level analysis of the BOLD signal associated with the observation of provocation (uncorrected $p < 0.001$ at the voxel level, FWE-corrected at the cluster level $p < 0.05$, and $k = 15$).

	Cluster		Peak			Peak MNI coordinates		
Brain area	**p(FWE-corr.)**	**k**	**p(unc.)**	**F**	**Z**	**x**	**y**	**z**
"Feedback" phase: High provocation > Low provocation								
R Angular g.	<0.001	502	<0.001	48.33	6.23	48	–52	29
R SMA	0.001	173	<0.001	40.66	5.77	6	11	62
"Feedback" phase: Low provocation > High provocation								
R Middle frontal g.	<0.001	749	<0.001	48.12	6.21	39	20	44
L Angular g.	0.001	166	<0.001	29.15	4.95	–54	–58	38
L Inferior frontal g.	0.001	176	<0.001	24.95	4.60	–39	20	32
R Precuneus	0.002	151	<0.001	24.84	4.59	6	–55	41

k, cluster size in voxels; FWE, familywise error correction; L/R, left/right hemisphere; g., gyrus; SMA, supplementary motor area.

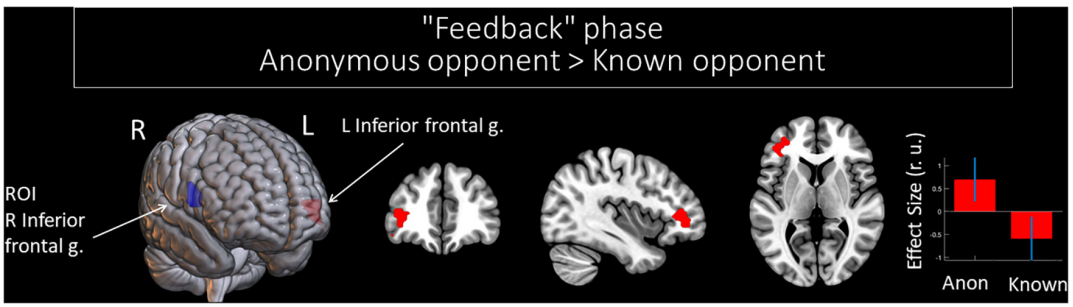


FIGURE 4 | Results of the group-level gPPI analysis with the ROI in the right IFG. Clusters of significant changes in functional connectivity, with the right IFG associated with the anonymity of the opponent (uncorrected $p < 0.001$ at the voxel level, FWE-corrected at the cluster level $p < 0.05$, and $k = 15$), are shown in red. The ROI in the right IFG is presented in blue. The plot shows effect sizes with 95% confidence intervals. L/R, left/right hemisphere; g., gyrus; ROI, the region of interest; Anon, anonymous opponent; Known, introduced opponent.

TABLE 5 | Results of the group-level gPPI analysis with the ROI in the right IFG, associated with the observation of provocation from anonymous and known opponents (uncorrected $p < 0.001$ at the voxel level, FWE-corrected at the cluster level $p < 0.05$, and $k = 15$).

	Cluster		Peak			Peak MNI coordinates		
Brain area	**p(FWE-corr.)**	**K**	**p(unc.)**	**F**	**Z**	**x**	**y**	**z**
"Feedback" phase: Anonymous opponent > Known opponent								
L Inferior frontal g.	0.011	91	<0.001	22.20	4.34	–39	41	5
No significant changes were obtained for the "Feedback" phase: Known opponent > Anonymous opponent								

k, cluster size in voxels; FWE, familywise error correction; ROI, region of interest; L/R, left/right hemisphere; g., gyrus.

changes in the functional connectivity of the right IFG for the observed provocation from the known opponent compared to the anonymous opponent.

Functional Connectivity Changes of the Right Inferior Frontal Gyrus: The Effect of the Level of Provocation on the Observation of Social Provocation During the "Feedback" Phase

When observing provocative feedback from opponents, low provocation (0 or 20 roubles), compared to high provocation (80 or 100 roubles), irrespective of whether the opponent was introduced or not, was associated with increased functional connectivity of the right IFG with the right superior temporal gyrus and left cerebellum (see **Table 6**). However, no significant changes in the functional connectivity of the right IFG were associated with observing high provocative feedback compared to low provocative feedback (0 or 20 roubles) from opponents.

Functional Connectivity Changes of the Right Inferior Frontal Gyrus: Interactions Between Anonymity and the Level of Observed Provocation Regarding the Observation of Social Provocation During the "Feedback" Phase

We noted significant changes in functional connectivity for the ROI in the right IFG and the interactions between the factors of "opponent" and "provocation." The right IFG changes functional

TABLE 6 | Results of the group-level gPPI analysis with the ROI in the right IFG, associated with the observation of different levels of provocation (uncorrected $p < 0.001$ at the voxel level, FWE-corrected at the cluster level $p < 0.05$, and $k = 15$).

	Cluster		Peak			Peak MNI coordinates		
Brain area	**p(FWE-corr)**	**K**	**p(unc)**	**F**	**Z**	**x**	**y**	**z**
"Feedback" phase: Low provocation > High provocation								
R Superior temporal g.	0.054	59	<0.001	22.87	4.41	51	–10	–4
L Cerebellum	0.002	133	<0.001	20.36	4.16	–6	–49	–4
No significant changes were obtained for the "Feedback" phase: High provocation > Low provocation								

k, cluster size in voxels; FWE, familywise error correction; ROI, region of interest; L/R, left/right hemisphere; g., gyrus.

TABLE 7 | Results of the group-level gPPI analysis with the ROI in the right IFG for the interaction between the level of observed provocation and the anonymity of the opponent during the "Feedback" phase (uncorrected $p < 0.001$ at the voxel level, FWE-corrected at the cluster level $p < 0.05$, and $k = 15$).

	Cluster		Peak			Peak MNI coordinates		
Brain area	**p(FWE-corr.)**	**k**	**p(unc.)**	**F**	**Z**	**x**	**y**	**z**
R cerebellum	<0.001	457	<0.001	57.83	6.72	9	–37	–22
L cerebellum	0.019	80	<0.001	48.98	6.26	–30	–58	–34
R angular g.	0.001	150	<0.001	48.16	6.22	42	–61	29
R middle frontal g.	0.054	59	<0.001	45.84	6.08	30	32	44
L precentral g.	<0.001	195	<0.001	38.10	5.60	–36	–16	50
R insula	<0.001	363	<0.001	37.96	5.59	36	8	2
R SMA	0.010	95	<0.001	36.68	5.51	12	8	47
L fusiform g.	0.041	64	<0.001	26.57	4.74	–30	–49	–16
L superior temporal g.	<0.001	232	<0.001	26.46	4.73	-51	2	–13
R precuneus	<0.001	190	<0.001	25.84	4.68	12	–58	53
R precentral g.	0.020	79	<0.001	24.47	4.55	39	–4	50
L SMA	0.002	127	<0.001	20.80	4.21	0	–10	56

During the perception of the provocation from the anonymous opponent, functional interactions between the IFG and the listed areas were increased in the condition of high (versus low provocation). This interaction was inversed compared to observing provocation from the known opponent. We did not observe any significant results for other directions of comparison.
k, cluster size in voxels; FWE, familywise error correction; ROI, region of interest; L/R, left/right hemisphere; g., gyrus; SMA, supplementary motor area.

connectivity with the bilateral cerebellum, precentral gyrus, and supplementary motor area; left fusiform gyrus and superior temporal gyrus; right middle frontal gyrus, insula, precuneus, and angular gyrus (see **Table 7**). Among these structures, the right angular gyrus and right precuneus are localized within the rTPJ and precuneus clusters of the TOM system, respectively, according to masks generated by Dufour et al. (2013) (see **Figure 5**). During the perception of the provocation from the anonymous opponent, functional interactions between the IFG and the named areas were increased in the condition of high (versus low provocation). Along with that, this interaction was inversed compared to observing provocation from the known opponent. We did not observe any significant results for other directions of comparison.

DISCUSSION

The current fMRI study demonstrates differences in both activity and functional connectivity within the TOM network associated with observing anonymous versus known opponent provocations during a modified TAP task. This paradigm allows studying only competitive scenarios while social interactions presume cooperation as well (Decety et al., 2004; Kanske et al., 2015a; Tsoi et al., 2016; Liu et al., 2017; Bitsch et al., 2018). Although participants can decide not to compete, in the TAP there is no possibility to cooperate which may result in very different interactions. Therefore, the obtained data should be attributed only to competitive interactions. While we did not witness any behavioral differences in terms of punishment selected by our subjects for different opponents, the data support the hypothesis about the increased involvement of TOM network nodes during the evaluation of anonymous opponent's actions in contrast to known opponent's actions. Compared to observing provocation from a known opponent, being provoked by an anonymous opponent was underpinned by an increased BOLD signal in the right IFG and increased functional connectivity between the right and left IFGs. In addition, we noted increased functional connectivity between the right IFG, rTPJ, and precuneus, when observing high provocation (subtraction of a high amount of money) from an anonymous opponent versus a known opponent.

The obtained results indicate that functional connectivity in the TOM network changes depending on the knowledge

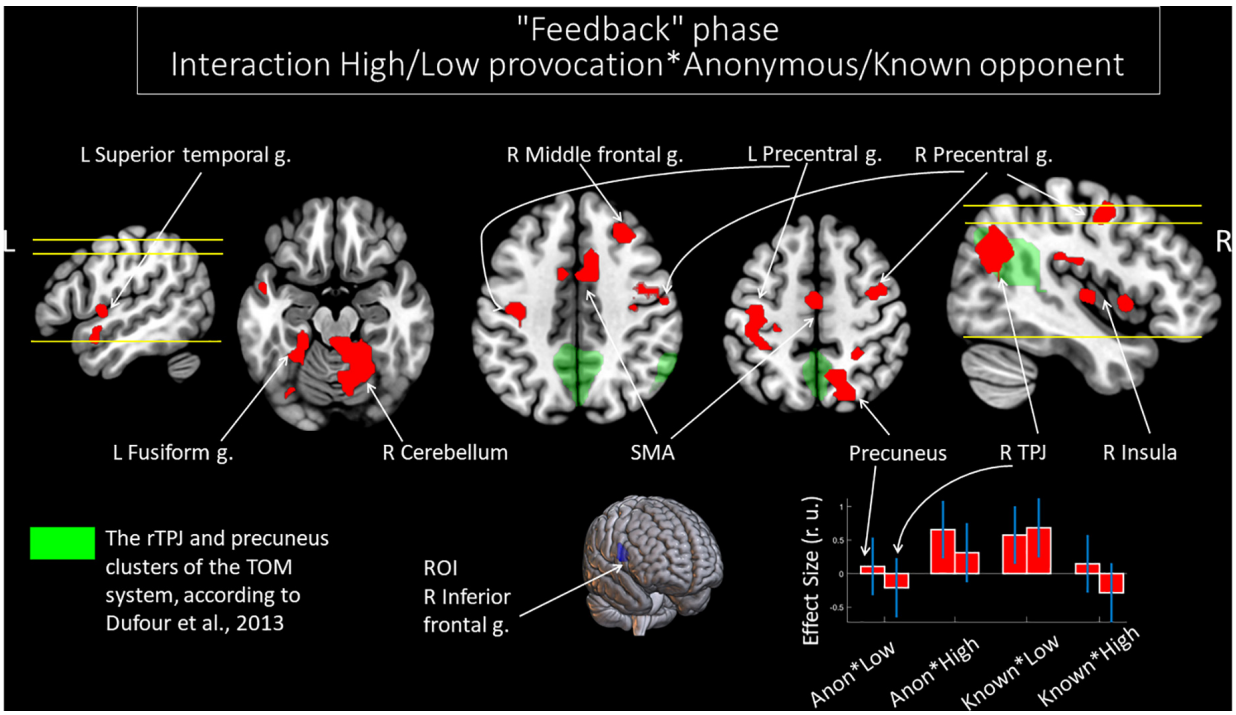


FIGURE 5 | Results of the group-level gPPI analysis with the ROI in the right IFG. Clusters of significant changes in functional connectivity with the right IFG, associated with the interactions between the level of observed provocation and the anonymity of the opponent (uncorrected $p < 0.001$ at the voxel level, FWE-corrected at the cluster level $p < 0.05$, and $k = 15$), are shown in red. The TOM system clusters are presented in green according to the results of Dufour et al. (2013). The plot on the lower right side indicates effect sizes with 95% confidence intervals. L/R, left/right hemisphere; g., gyrus; TPJ, temporoparietal junction; SMA, supplementary motor area; ROI, region of interest; Anon, anonymous opponent; Known, introduced opponent; High, high provocation; Low, low provocation.

an opponent. In more detail, higher functional connectivity seems to support interactions with anonymous in contrast to known opponents. We speculate that these changes underlie the compensatory process of "completing" socially relevant details, as if by "thinking out" this missing information. Furthermore, only specific parts of the TOM network demonstrated increased involvement in the interaction with the anonymous vs. known opponent. This may generate the hypothesis for a twofold character of re-organization of the TOM network: although the bilateral IFG, rTPJ, and precuneus are the nodes in the TOM network (Mar, 2011; Bzdok et al., 2012; Dufour et al., 2013; Molenberghs et al., 2016), the results do not include the exhaustive list of other network nodes. Our results are in line with the fact that the TOM network is heterogeneous. Indeed its nodes have been shown to demonstrate differential involvement in performance, including the activity and interaction between different underlying resting-state networks (Default Mode and Control networks), depending on the experimental task used (Molenberghs et al., 2016; Schurz et al., 2020a). Thus, obtained results in the current study support the assumption that social interactions with an anonymous opponent in a competitive context are associated with re-organization of the TOM network functioning. The observed re-organization consists of hyperactivation and increased functional connectivity in specific parts of the TOM network. A hypothesis to be systematically tested in future studies may be that the re-organization is needed to compensate for the lack of socially relevant information.

Increased Activity in the Right Inferior Frontal Gyrus and Increased Functional Connectivity Between the Right and Left Inferior Frontal Gyrus in the Anonymous Condition Underlie the Compensatory Visual Face Processing Mechanism

In addition to being part of the TOM network, the bilateral IFG is a key node in the mirror neuron system (Rizzolatti and Craighero, 2004; Cattaneo and Rizzolatti, 2009). This attribution is supported by meta-analysis (Molenberghs et al., 2012). It is generally assumed that the mirror neuron system is responsible for understanding the goals and intentions of others' motor acts by matching them to one's own motor repertoire (Rizzolatti et al., 2001; Rizzolatti and Fabbri-Destro, 2008).

In the same vein, areas of the mirror neuron system are involved in observing facial expressions. The face conveys information about an individual's emotional state, and allows the observer to access the individual's emotional status (Ferrari and Coudé, 2018). For example, the gray matter volume in the right IFG is associated with the ability to recognize emotions via other people's facial expressions (Uono et al., 2017). In addition, the stimulation of this area increases performance in facial emotion

and identity perception tasks (Penton et al., 2017). Moreover, increased activity in the right IFG was observed when, by viewing photographs of faces, participants assessed the likelihood that a society or the participant himself/herself would interact with the presented person (Yamakawa et al., 2009). Meta-analyses also confirm higher activation associated with emotional face vs. neutral face contrast in the right IFG (Liu et al., 2021), left IFG (Schirmer, 2018), and IFG in both hemispheres (Sabatinelli et al., 2011; Müller et al., 2018).

This functional role of the bilateral IFG may be of particular importance for processing provocation. For example, when receiving feedback in the present study, the participants saw both the provocative inscription and the picture of their opponent, who was giving the feedback: either an avatar (a silhouette with no information about the true appearance) of an anonymous opponent or a photo of a real opponent appeared on the screen (see **Figure 1**). Thus, information about the face of the anonymous opponent was absent. While this is speculative at this stage, the interaction with the anonymous opponent could have required the compensatory, resource-demanding process induced by the lack of socially relevant face information. This is reflected by areas associated with face processing: some of them demonstrate increased involvement (right IFG activity and functional connectivity with the left IFG), while others underperform. The latter is valid for the right fusiform gyrus associated with the decreased level of the BOLD signal for the anonymous opponent compared to the known opponent, while receiving punishment after losing the game, irrespective of the selected punishment level.

Potential Mechanisms Underpinned by the Increased Functional Connectivity of the Right Inferior Frontal Gyrus With the rTPJ and Precuneus in the Anonymous Condition

With regard to functional connectivity, the rTPJ and precuneus showed increased connectivity with the right IFG during the observation of high provocation in the anonymous condition compared to the known condition.

One possible mechanism that could explain this outcome are the interactions between different components of the TOM ability. A recent meta-analytic study characterized a number of TOM subcomponents and allocated social neurocognitive processes into three groups: (1) predominantly cognitive processes; (2) more affective processes; (3) combined processes, which engage cognitive and affective functions in parallel (Schurz et al., 2020b). The affective TOM component refers to the capacity to represent valence, emotions, and feelings, whereas the cognitive TOM component concerns valence-free, unemotional inference of others' mental states (Brothers and Ring, 1992). Meta-analyses performed for cognitive and affective TOM tasks separately demonstrated that tasks requiring affective TOM showed increased involvement of the bilateral IFG, whereas the bilateral TPJ and precuneus were attributed to the cognitive aspect of TOM (Schurz et al., 2014; Molenberghs et al., 2016). In line with that, clustering meta-analyses have found activation changes in temporoparietal areas related to the cognitive component and signal alterations across the right frontal cortex, peaking in the IFG, related to the affective component (Schurz et al., 2020b).

Contrary to these findings, increased BOLD signals in the rTPJ and precuneus were also associated with the affective TOM condition (Bodden et al., 2013), while involvement of the right IFG underpinned cognitive perspective taking (Hynes et al., 2006) in direct comparisons of the affective (versus cognitive) TOM. In addition, affective and cognitive TOM conditions had common activations in the bilateral TPJ (Sebastian et al., 2012; Corradi-Dell'Acqua et al., 2014). In the work of Kanske et al. (2015a,b), similar results were obtained: two neighboring but distinct peaks related, one to affect sharing, and another to understanding others' mental states, were detected in the temporoparietal cortex. This indicated that dorsal and ventral subregions of the TPJ are involved in different aspects of social-cognitive mechanisms.

Despite this distinction, previous studies highlight the integration between named areas. For example, the right IFG was one of the regions with the highest level of overlap across PPI analyses for all social brain regions (including the bilateral TPJ and precuneus) during a social evaluation task, in which participants were asked to consider others' thoughts about themselves (McCormick et al., 2018). It was also argued that affective and cognitive routes of understanding others may coactivate and cooperate in complex social situations (Kanske, 2018; Schurz et al., 2020b). Specifically, Schurz et al. (2020b) have found that clusters in the bilateral IFG, attributed to tasks, requiring affective TOM, and clusters in the bilateral TPJ, and precuneus, attributed to tasks, requiring cognitive TOM, overlap with neural activations associated with the third cluster of tasks (intermediate). The third cluster comprises tasks which engage cognitive and affective functions in parallel. From this angle, the observed connectivity between these regions may reflect the increased requirements of both TOM components and their interactions. The involvement of different TOM components may be needed to figure out the reasons or motives as well as potential emotional states related to the high provocation from the anonymous (vs. known) opponent when the clear socially relevant information was lacking.

Taken together, these studies suggest that the additional involvement of the rTPJ and precuneus, through increased functional connectivity, characterizes the requirement of different aspects of TOM ability or higher-order analysis of social information as a compensatory mechanism during processing anonymous provocation. Since no systematic behavioral differences in the interactions with a known or anonymous opponent were observed, we assume that the anonymous status itself is associated with the connectivity changes. One possible explanation would be that the increased connectivity reflects the attempt to understand the opponent by "completing" socially relevant details.

Limitations and Suggestions for Further Research

The main limitation of the current study is connected to the experimental design used. The effect of anonymity was calculated in the context of competitive social interaction using the TAP task. Although this task is widely used in psychophysiological studies of aggression, it is discussed controversially, how aggression should be defined using the TAP (Elson et al., 2014; McCarthy and Elson, 2018). Namely, participants' motives for subtracting money from the opponent cannot be unambiguously measured and linked to prior provocations from the opponent. Furthermore, larger amounts of subtracted money do not obligatory reflect only higher levels of aggression. Even though aggression is not the main concern of the current study, the limitation is related to the classification of experimental events. Also, a reaction to provocation may significantly differ depending on individual differences between participants (Hyatt et al., 2019). Collecting and considering psychometric data may further characterize the obtained results and demonstrate otherwise undiscovered effects of anonymity in different groups of subjects. Notably, anonymous interactions occur in different social settings not limited to competitive games as applied in this experiment. Therefore, future research is required to clarify, if the observed effects are fundamental and can be applied to other conditions of social interaction.

CONCLUSION

For the current study, we modified the TAP by introducing to this paradigm an anonymous opponent to examine the reorganization of the TOM brain system in settings of deficits with socially relevant information. A competitive interaction with an anonymous (compared to known) person was associated with functional reorganization in the TOM network: both functional activity and functional connectivity of and between several network nodes were increased. Due to no systematic behavioral differences in the interaction with a known or anonymous opponent, these activity and connectivity changes refer to the degree of knowledge about the opponent. We speculate that the neural changes may underlie different inferences about the opponents' mental states. The idea that this reorganization of the TOM network reflects the attempt to understand the opponent by "completing" socially relevant details requires further investigation. The obtained data extend the current view on how the brain processes socially relevant information.

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 Ethics Committee of the N.P. Bechtereva Institute of the Human Brain, St. Petersburg, Russia. The patients/participants provided their written informed consent to participate in this study.

AUTHOR CONTRIBUTIONS

MV, RM, AK, and MK conceived and designed the analysis. AM, RM, and MZ collected the fMRI data. RM, AM, MK, and MV performed the analysis of fMRI data. MZ, AM, MV, DC, UH, LW, MD, MK, and AK wrote the manuscript. All the authors reviewed the manuscript and approved the submitted version.

FUNDING

This study was supported by the Russian Science Foundation, Grant No. 19-18-00436. MD and DC worked within the state assignment of IHB RAS.

REFERENCES

Anderson, C. A., and Bushman, B. J. (2002). Human aggression. *Annu. Rev. Psychol.* 53, 27–51. doi: 10.1146/ANNUREV.PSYCH.53.100901.135231

Andreou, M., and Skrimpa, V. (2020). Theory of mind deficits and neurophysiological operations in autism spectrum disorders: a review. *Brain Sci.* 10, 1–12. doi: 10.3390/BRAINSCI10060393

Baron, R. A., Richardson, D. S., and Deborah, S. (1994). *Human Aggression*. New York, NY: Wiley, 419.

Beyer, F., Münte, T. F., Erdmann, C., and Krämer, U. M. (2014a). Emotional reactivity to threat modulates activity in mentalizing network during aggression. *Soc. Cogn. Affect. Neurosci.* 9:1552. doi: 10.1093/SCAN/NST146

Beyer, F., Münte, T. F., and Krämer, U. M. (2014b). Increased neural reactivity to socio-emotional stimuli links social exclusion and aggression. *Biol. Psychol.* 96, 102–110. doi: 10.1016/J.BIOPSYCHO.2013.12.008

Bhatt, M., and Camerer, C. F. (2005). Self-referential thinking and equilibrium as states of mind in games: fMRI evidence. *Games Econ. Behav.* 52, 424–459. doi: 10.1016/J.GEB.2005.03.007

Bitsch, F., Berger, P., Nagels, A., Falkenberg, I., and Straube, B. (2018). The role of the right temporo–parietal junction in social decision-making. *Hum. Brain Mapp.* 39, 3072–3085. doi: 10.1002/hbm.24061

Bodden, M. E., Kübler, D., Knake, S., Menzler, K., Heverhagen, J. T., Sommer, J., et al. (2013). Comparing the neural correlates of affective and cognitive theory ofmind using fMRI: involvement of the basal ganglia in affective theory ofmind. *Adv. Cogn. Psychol.* 9:32. doi: 10.2478/V10053-008-0129-6

Bora, E. (2021). A meta-analysis of theory of mind and "mentalization" in borderline personality disorder: a true neuro-social-cognitive or meta-social-cognitive impairment? *Psychol. Med.* 51, 2541–2551. doi: 10.1017/S0033291721003718

Brothers, L., and Ring, B. (1992). A neuroethological framework for the representation of minds. *J. Cogn. Neurosci.* 4, 107–118. doi: 10.1162/JOCN.1992.4.2.107

Buades-Rotger, M., Beyer, F., and Krämer, U. M. (2017). Avoidant responses to interpersonal provocation are associated with increased amygdala and decreased mentalizing network activity. *Eneuro* 4, 337–353. doi: 10.1523/ENEURO.0337-16.2017

Burnham, T. C. (2003). Engineering altruism: a theoretical and experimental investigation of anonymity and gift giving. *J. Econ. Behav. Organ.* 50, 133–144. doi: 10.1016/S0167-2681(02)00044-6

Bzdok, D., Schilbach, L., Vogeley, K., Schneider, K., Laird, A. R., Langner, R., et al. (2012). Parsing the neural correlates of moral cognition: ALE meta-analysis on morality, theory of mind, and empathy. *Brain Struct. Funct.* 217, 783–796. doi: 10.1007/s00429-012-0380-y

Cattaneo, L., and Rizzolatti, G. (2009). The mirror neuron system. *Arch. Neurol.* 66, 557–560. doi: 10.1001/ARCHNEUROL.2009.41

Charness, G., and Gneezy, U. (2008). What's in a name? Anonymity and social distance in dictator and ultimatum games. *J. Econ. Behav. Organ.* 68, 29–35. doi: 10.1016/J.JEBO.2008.03.001

Coricelli, G., and Nagel, R. (2009). Neural correlates of depth of strategic reasoning in medial prefrontal cortex. *Proc. Natl. Acad. Sci. U.S A.* 106, 9163–9168. doi: 10.1073/PNAS.0807721106

Corradi-Dell'Acqua, C., Hofstetter, C., and Vuilleumier, P. (2014). Cognitive and affective theory of mind share the same local patterns of activity in posterior temporal but not medial prefrontal cortex. *Soc. Cogn. Affect. Neurosci.* 9, 1175–1184. doi: 10.1093/scan/nst097

Decety, J., Jackson, P. L., Sommerville, J. A., Chaminade, T., and Meltzoff, A. N. (2004). The neural bases of cooperation and competition: an fMRI investigation. *Neuroimage* 23, 744–751. doi: 10.1016/J.NEUROIMAGE.2004.05.025

Demsar, V., Brace-Govan, J., Jack, G., and Sands, S. (2021). The social phenomenon of trolling: understanding the discourse and social practices of online provocation. *J. Mark. Manag.* 37, 1058–1090. doi: 10.1080/0267257X.2021.1900335

Dufour, N., Redcay, E., Young, L., Mavros, P. L., Moran, J. M., Triantafyllou, C., et al. (2013). Similar brain activation during false belief tasks in a large sample of adults with and without autism. *PLoS One* 8:e75468. doi: 10.1371/journal.pone.0075468

Elson, M., Rohangis Mohseni, M., Breuer, J., Scharkow, M., and Quandt, T. (2014). Press CRTT to measure aggressive behavior: the unstandardized use of the competitive reaction time task in aggression research. *Psychol. Assess.* 26, 419–432. doi: 10.1037/A0035569

Ferrari, P. F., and Coudé, G. (2018). "Mirror neurons, embodied emotions, and empathy," in *Neuronal Correl. Empathy From Rodent to Human*, eds K. Z. Meyza and E. Knapska (Amsterdam: Elsevier), 67–77. doi: 10.1016/B978-0-12-805397-3.00006-1

Gitelman, D. R., Penny, W. D., Ashburner, J., and Friston, K. J. (2003). *Modeling Regional And Psychophysiologic Interactions In fMRI: The Importance Of Hemodynamic Deconvolution*. Amsterdam: Elsevier, doi: 10.1016/S1053-8119(03)00058-2

Hyatt, C. S., Zeichner, A., and Miller, J. D. (2019). Laboratory aggression and personality traits: a meta- analytic review. *Psychol. Violence* 9, 675–689. doi: 10.1037/VIO0000236

Hynes, C. A., Baird, A. A., and Grafton, S. T. (2006). Differential role of the orbital frontal lobe in emotional versus cognitive perspective-taking. *Neuropsychologia* 44, 374–383. doi: 10.1016/J.NEUROPSYCHOLOGIA.2005.06.011

Johnstone, T., Ores Walsh, K. S., Greischar, L. L., Alexander, A. L., Fox, A. S., Davidson, R. J., et al. (2006). Motion correction and the use of motion covariates in multiple-subject fMRI analysis. *Hum. Brain Mapp.* 27, 779–788. doi: 10.1002/hbm.20219

Kanske, P. (2018). The social mind: disentangling affective and cognitive routes to understanding others. *Interdiscip. Sci. Rev.* 43, 115–124. doi: 10.1080/03080188.2018.1453243

Kanske, P., Böckler, A., and Singer, T. (2015a). Models, mechanisms and moderators dissociating empathy and theory of mind. *Curr. Top. Behav. Neurosci.* 30, 193–206. doi: 10.1007/7854_2015_412

Kanske, P., Böckler, A., Trautwein, F. M., and Singer, T. (2015b). Dissecting the social brain: introducing the EmpaToM to reveal distinct neural networks and brain-behavior relations for empathy and theory of mind. *Neuroimage* 122, 6–19. doi: 10.1016/J.NEUROIMAGE.2015.07.082

Lightdale, J. R., and Prentice, D. A. (1994). Rethinking sex differences in aggression: aggressive behavior in the absence of social roles. *Personal. Soc. Psychol. Bull.* 20, 34–44. doi: 10.1177/0146167294201003

Liu, M., Liu, C. H., Zheng, S., Zhao, K., and Fu, X. (2021). Reexamining the neural network involved in perception of facial expression: a meta-analysis. *Neurosci. Biobehav. Rev.* 131, 179–191. doi: 10.1016/J.NEUBIOREV.2021.09.024

Liu, T., Saito, G., Lin, C., and Saito, H. (2017). Inter-brain network underlying turn-based cooperation and competition: a hyperscanning study using near-infrared spectroscopy. *Sci. Rep.* 71, 1–12. doi: 10.1038/s41598-017-09226-w

Mar, R. A. (2011). The neural bases of social cognition and story comprehension. *Annu. Rev. Psychol.* 62, 103–134. doi: 10.1146/annurev-psych-120709-145406

McCarthy, R. J., and Elson, M. (2018). A conceptual review of lab-based aggression paradigms. *Collab. Psychol.* 4, 1–12. doi: 10.1525/COLLABRA.104/112953

McCormick, E. M., van Hoorn, J., Cohen, J. R., and Telzer, E. H. (2018). Functional connectivity in the social brain across childhood and adolescence. *Soc. Cogn. Affect. Neurosci.* 13, 819–830. doi: 10.1093/SCAN/NSY064

McLaren, D. G., Ries, M. L., Xu, G., and Johnson, S. C. (2012). A generalized form of context-dependent psychophysiological interactions (gPPI): a comparison to standard approaches. *Neuroimage* 61, 1277–1286. doi: 10.1016/j.neuroimage.2012.03.068

Molenberghs, P., Cunnington, R., and Mattingley, J. B. (2012). Brain regions with mirror properties: a meta-analysis of 125 human fMRI studies. *Neurosci. Biobehav. Rev.* 36, 341–349. doi: 10.1016/J.NEUBIOREV.2011.07.004

Molenberghs, P., Johnson, H., Henry, J. D., and Mattingley, J. B. (2016). Understanding the minds of others: a neuroimaging meta-analysis. *Neurosci. Biobehav. Rev.* 65, 276–291. doi: 10.1016/j.neubiorev.2016.03.020

Müller, V. I., Höhner, Y., and Eickhoff, S. B. (2018). Influence of task instructions and stimuli on the neural network of face processing: an ALE meta-analysis. *Cortex.* 103:240. doi: 10.1016/J.CORTEX.2018.03.011

Oldfield, R. C. (1971). The assessment and analysis of handedness: the edinburgh inventory. *Neuropsychologia* 9, 97–113. doi: 10.1016/0028-3932(71)90067-4

Penton, T., Dixon, L., Evans, L. J., and Banissy, M. J. (2017). Emotion perception improvement following high frequency transcranial random noise stimulation of the inferior frontal cortex. *Sci. Rep.* 71, 1–7. doi: 10.1038/s41598-017-11578-2

Pornari, C. D., and Wood, J. (2010). Peer and cyber aggression in secondary school students: the role of moral disengagement, hostile attribution bias, and outcome expectancies. *Aggress. Behav.* 36, 81–94. doi: 10.1002/AB.20336

Premack, D., and Woodruff, G. (1978). Does the chimpanzee have a theory of mind? *Behav. Brain Sci.* 1, 515–526. doi: 10.1017/S0140525X00076512

Proverbio, A. M., Ornaghi, L., and Gabaro, V. (2018). How face blurring affects body language processing of static gestures in women and men. *Soc. Cogn. Affect. Neurosci.* 13:590. doi: 10.1093/SCAN/NSY033

Repple, J., Pawliczek, C. M., Voss, B., Siegel, S., Schneider, F., Kohn, N., et al. (2017). From provocation to aggression: the neural network. *BMC Neurosci.* 181:73. doi: 10.1186/S12868-017-0390-Z

Rizzolatti, G., and Craighero, L. (2004). The mirror-neuron system. *Annu. Rev. Neurosci.* 27, 169–192. doi: 10.1146/ANNUREV.NEURO.27.070203.144230

Rizzolatti, G., and Fabbri-Destro, M. (2008). The mirror system and its role in social cognition. *Curr. Opin. Neurobiol.* 18, 179–184. doi: 10.1016/J.CONB.2008.08.001

Rizzolatti, G., Fogassi, L., and Gallese, V. (2001). Neurophysiological mechanisms underlying the understanding and imitation of action. *Nat. Rev. Neurosci.* 2, 661–670. doi: 10.1038/35090060

Runions, K. C., and Bak, M. (2015). Online moral disengagement, cyberbullying, and cyber-aggression. *Cyberpsychology Behav. Soc. Netw.* 18, 400–405. doi: 10.1089/cyber.2014.0670

Sabatinelli, D., Fortune, E. E., Li, Q., Siddiqui, A., Krafft, C., Oliver, W. T., et al. (2011). Emotional perception: meta-analyses of face and natural scene processing. *Neuroimage* 54, 2524–2533. doi: 10.1016/J.NEUROIMAGE.2010.10.011

Schirmer, A. (2018). Is the voice an auditory face? An ALE meta-analysis comparing vocal and facial emotion processing. *Soc. Cogn. Affect. Neurosci.* 13, 1–13. doi: 10.1093/SCAN/NSX142

Schurz, M., Maliske, L., and Kanske, P. (2020a). Cross-network interactions in social cognition: a review of findings on task related brain activation and connectivity. *Cortex* 130, 142–157. doi: 10.1016/J.CORTEX.2020.05.006

Schurz, M., Radua, J., Tholen, M. G., Maliske, L., Margulies, D. S., Mars, R. B., et al. (2020b). Toward a hierarchical model of social cognition: a neuroimaging

meta-analysis and integrative review of empathy and theory of mind. *Psychol. Bull.* 147:293. doi: 10.1037/BUL0000303

Schurz, M., Radua, J., Aichhorn, M., Richlan, F., and Perner, J. (2014). Fractionating theory of mind: a meta-analysis of functional brain imaging studies. *Neurosci. Biobehav. Rev.* 42, 9–34. doi: 10.1016/J.NEUBIOREV.2014.01.009

Sebastian, C. L., Fontaine, N. M. G., Bird, G., Blakemore, S.-J., Brito, S. A., De McCrory, E. J. P., et al. (2012). Neural processing associated with cognitive and affective Theory of Mind in adolescents and adults. *Soc. Cogn. Affect. Neurosci.* 7:53. doi: 10.1093/SCAN/NSR023

Shine, J. M., and Poldrack, R. A. (2018). Principles of dynamic network reconfiguration across diverse brain states. *Neuroimage* 180, 396–405. doi: 10.1016/J.NEUROIMAGE.2017.08.010

Tsoi, L., Dungan, J., Waytz, A., and Young, L. (2016). Distinct neural patterns of social cognition for cooperation versus competition. *Neuroimage* 137, 86–96. doi: 10.1016/J.NEUROIMAGE.2016.04.069

Uono, S., Sato, W., Kochiyama, T., Sawada, R., Kubota, Y., Yoshimura, S., et al. (2017). Neural substrates of the ability to recognize facial expressions: a voxel-based morphometry study. *Soc. Cogn. Affect. Neurosci.* 12, 487–495. doi: 10.1093/SCAN/NSW142

van Dongen, J. D. M. (2020). The empathic brain of psychopaths: from social science to neuroscience in empathy. *Front. Psychol* 11:695. doi: 10.3389/FPSYG.2020.00695

Vucurovic, K., Caillies, S., and Kaladjian, A. (2020). Neural correlates of theory of mind and empathy in schizophrenia: an activation likelihood estimation meta-analysis. *J. Psychiatr. Res.* 120, 163–174. doi: 10.1016/J.JPSYCHIRES.2019.10.018

Wagels, L., Votinov, M., Kellermann, T., Konzok, J., Jung, S., Montag, C., et al. (2019). Exogenous testosterone and the monoamine-oxidase A polymorphism influence anger, aggression and neural responses to provocation in males. *Neuropharmacology* 156:107491. doi: 10.1016/J.NEUROPHARM.2019.01.006

Wagner, D. D., Kesslley, W. M., and Heatherton, T. F. (2011). Individual differences in the spontaneous recruitment of brain regions supporting mental state understanding when viewing natural social scenes. *Cereb. Cortex* 21, 2788–2796. doi: 10.1093/CERCOR/BHR074

Wu, Y., Leliveld, M. C., and Zhou, X. (2011). Social distance modulates recipient's fairness consideration in the dictator game: an ERP study. *Biol. Psychol.* 88, 253–262. doi: 10.1016/J.BIOPSYCHO.2011.08.009

Yamakawa, Y., Kanai, R., Matsumura, M., and Naito, E. (2009). Social distance evaluation in human parietal cortex. *PLoS One* 4:e4360. doi: 10.1371/JOURNAL.PONE.0004360

Yoshida, W., Seymour, B., Friston, K. J., and Dolan, R. J. (2010). Neural mechanisms of belief inference during cooperative games. *J. Neurosci.* 30, 10744–10751. doi: 10.1523/JNEUROSCI.5895-09.2010

Yu, R., Hu, P., and Zhang, P. (2015). Social distance and anonymity modulate fairness consideration: an ERP study. *Sci. Rep.* 51, 1–12. doi: 10.1038/srep13452

Zimmerman, A. G., and Ybarra, G. J. (2016). Online aggression: the influences of anonymity and social modeling. *Psychol. Pop. Media Cult.* 5, 181–193. doi: 10.1037/PPM0000038

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: All claims expressed in this article are solely those of the authors and do not necessarily represent those of their affiliated organizations, or those of the publisher, the editors and the reviewers. Any product that may be evaluated in this article, or claim that may be made by its manufacturer, is not guaranteed or endorsed by the publisher.

Advantages of publishing in Frontiers

OPEN ACCESS
Articles are free to read for greatest visibility and readership

FAST PUBLICATION
Around 90 days from submission to decision

HIGH QUALITY PEER-REVIEW
Rigorous, collaborative, and constructive peer-review

TRANSPARENT PEER-REVIEW
Editors and reviewers acknowledged by name on published articles

Frontiers
Avenue du Tribunal-Fédéral 34
1005 Lausanne | Switzerland

Visit us: www.frontiersin.org
Contact us: frontiersin.org/about/contact

REPRODUCIBILITY OF RESEARCH
Support open data and methods to enhance research reproducibility

DIGITAL PUBLISHING
Articles designed for optimal readership across devices

FOLLOW US
@frontiersin

IMPACT METRICS
Advanced article metrics track visibility across digital media

EXTENSIVE PROMOTION
Marketing and promotion of impactful research

LOOP RESEARCH NETWORK
Our network increases your article's readership