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A social information processing perspective on social connectedness

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ABSTRACT

Social connectedness (SC) is one of the most important predictors for physical and mental health. Consequently, SC is addressed in an increasing number of studies, providing evidence for the multidimensionality of the construct, and revealing several factors that contribute to individual differences in SC. However, a unified model that can address SC subcomponents is yet missing. Here we take a novel perspective and discuss whether individual differences in SC can be explained by a person's social information processing profile that represents individual tendencies of how social information is perceived and interpreted and leads to motivated social behavior. After summarizing the current knowledge on SC and core findings from the fields of social perception and mentalizing, social motivation and social action, we derive a working model that links individual stages of social information processing to structural, functional, and qualitative aspects of SC. This model allows for deriving testable hypotheses on the foundations of SC and we outline several suggestions how these aspects can be addressed by future research.

1. Introduction

"If you want to go fast, go alone, if you want to go far, go together." (African proverb)

1.1. Societal relevance of social connectedness

Humans need social connections to prosper. Acknowledging its global importance, fostering social connections has been defined as a priority by the U.S. Department of Health and Human Services, and is the focus of recently funded global initiatives (Holt-Lunstad, 2023). Along with this increase in societal awareness, there is a steep increase in scientific publications on the relationship between social connectedness (SC) and well-being or health in recent years. Many of these studies come from the field of etiology research and were conducted on large, representative samples (Linde and Egede, 2023; Schwartz and Litwin, 2019; Steiner et al., 2019). In a nutshell, they show that SC increases individuals' well-being and has a protective function for maintaining health. A lack of SC is associated with a decline in mental (Hare-Duke et al., 2019; Wickramaratne et al., 2022) and physical health (Eisenberger, 2013; Holt-Lunstad, 2018, 2021) and can even increase mortality (Holt-Lunstad et al., 2010; Holt-Lunstad and Smith, 2012). Given its societal importance, accounting for individual differences in SC has been identified as one of most relevant research goals today (Global Initiative on Loneliness and Connection, n.d.; Samuel Centre For Social Connectedness, n.d.). Moreover, the NIMH - one of the largest federal funding agencies in the US - has recently highlighted the need to deepen our understanding of basic social-behavioral mechanisms and processes underlying SC in both health and clinical contexts, paralleled by respective funding opportunities (Research on Social Connectedness and Isolation, n.d.).

Previous research has identified many different factors and

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mechanisms that are related to individual differences in SC. However, a unified model of SC that integrates these different predictors is lacking. The challenges for developing such a model are twofold. First, a model assuming a direct influence of many different variables would be extremely complex and therefore hard to test. Second, SC is a multidimensional concept, consisting of different subcomponents. Thus, apart from including all possible factors and mechanisms, an integrative model of SC would also need to account for these different subcomponents. To tackle these challenges, in this perspective piece, we promote an information processing perspective on SC and develop a testable working model that links individual differences in social information processing to individual differences in SC subcomponents. To do so, first we introduce definitions and measures of SC, second, we review some exemplary factors and mechanisms that have been related to individual differences in SC in previous research, and third, discuss how the different stages of social information processing (social perception and mentalizing, social motivation, social action processing) are modulated by these factors. In a final section, we introduce our information processing perspective on SC and discuss challenges and promising approaches for future research.

1.2. Definitions and measures of social connectedness

In layman's terms, SC has a number of different meanings. For example, it is used to describe closeness to others, the presence and quality of a couple's relationship, the number of friends and acquaintances, or the general satisfaction with the support of one's social network. Scientific definitions of SC are similarly diverse, resulting in a variety of different questionnaires and measures (see Table 1). While some authors understand SC as the opposite of loneliness (Cacioppo and Patrick, 2008; O'Rourke and Sidani, 2017), other definitions focus on relationship ties. For example, in developmental psychology, SC exists between a child and a person, a group, or an institution that provides a sense of belonging (Barber and Schluterman, 2008; Jose and Lim, 2014).

Table 1
Exemplary measures of social connectedness.

Measure	Description
Self-report questionnaires	
Social connectedness questionnaires (van Bel et al., 2009)	Two questionnaires to assess social connectedness at the individual level and at the overall level. Both questionnaires include qualitative and quantitative aspects of social connectedness.
Social Connectedness Scale (SCS), (R. M. Lee and Robbins, 1995) and revised Social Connectedness Scale (SCS-R), (R. M. Lee et al., 2001)	Based on the psychoanalytic "self psychology" model, assessing the extent to which a person feels connected to others in their surrounding social area.
UCLA loneliness scale (Russell et al., 1978)	Social connectedness can be inferred from low loneliness scores.
Multidimensional Scale of Social Support (MSPSS) (Zimet et al., 1988)	Social connectedness is linked to high scores on perceived social support.
Social network size (Siette et al., 2021)	Social connectedness is related to perceived social network size.
Observational data	
Social Connectedness Index, SCI (Bailey et al., 2018)	Social connectedness is inferred from the relative frequency of social contacts in online applications.
Social contacts in real life (Cattuto et al., 2010; Stehlé et al., 2011)	Social connectedness is derived from dynamics of person-to-person interactions.
Social network statistics (Knoke and Yang, 2020)	Social network analyses are used to identify key influencers and detect the spread of ideas or behaviors among individuals. Social connectedness can then be inferred from these metrics for different individuals of the network.

Note: This list is only meant to illustrate the diversity of measures and is not exhaustive. References highlight exemplary applications of such approaches.

In contrast to these concepts that define connectedness as an expression of interconnection and mutual dependency (Chodorow, 1978), psychoanalytic theory (e.g., "self psychology"; Kohut 1971, 1984) defines SC from the perspective of an independent individual. Here, SC is considered "an attribute of the self that reflects cognitions of enduring interpersonal closeness with the social world in toto" (R. M. Lee et al., 2001, p. 310). This definition differentiates SC from belongingness, as defined by group membership and peer affiliation (Baumeister and Leary, 1995) and from loneliness as defined by the emotions regarding the loss or lack of relationships (Marangoni and Ickes, 1989). Other definitions combine the developmental and psychoanalytical approach and define SC as "the sense of belonging and subjective psychological bond that people feel in relation to individuals and groups of others" (Haslam et al., 2015, p. 1). Moreover, these authors distinguish SC from social networks ("structure of relationships and interconnections") and other related concepts such as social support ("care in times of need derived from social relationships"), social capital ("network of relationships between people in a society/community, which supports their functioning") and social integration ("behavioral and cognitive elements of social relationships"). Contrasting this view, other authors use social network size as a direct indicator of SC (Bailey et al., 2018).

In our view, the multidimensionality of the concept is best captured by definitions assuming that SC consists of several components (e.g., qualitative and quantitative; van Bel et al., 2009, p. 67). A more recent model of Holt-Lunstad (2018) distinguishes between three aspects: A first *structural* component can be defined as "the existence and interconnections among differing social ties and roles" (Holt-Lunstad et al., 2017, p. 521). Structural indicators of SC are typically quantitative in nature and refer to the number or diversity of social relationships or roles. Examples are the existence of a romantic relationship or the density and diversity of social networks (e.g., family, friends, housemates, clubs). A second *functional* component goes beyond evaluating the mere presence or absence of others and refers to the "functions provided or perceived to be available by social relationships" (Holt-Lunstad et al., 2017, p. 521). It therefore describes the actual or perceived availability of aid, resources, and support provided by the social network and is typically assessed by self-report questionnaires on the accessibility of emotional, informational, tangible, or belonging support when needed. Beyond the general functions that a relationship serves, a third *quality* component reflects "perceptions of positive and negative aspects" of these social relationships (Holt-Lunstad et al., 2017, p. 521). This includes subjective ratings of satisfaction, adjustment, and cohesion in romantic relationships or perceptions of conflict, distress, or ambivalence. These three components independently predict mental and physical health and are typically only moderately correlated (Holt-Lunstad et al., 2010). Although they are not perfectly orthogonal to each other, they can have partly dissociable effects on SC. For example, a person can be structurally and functionally well connected based on the number of individual contacts and the general availability of social support but perceive it as relatively ineffective and thus rather negative on the quality dimension.

1.3. Potential predictors of social connectedness

Individual differences in SC have been addressed through the lens of different psychological theories and concepts. These theories propose different mechanisms that explain the development and maintenance of SC as well as factors contributing to its manifestation. Within the scope of this perspective piece, we can only address a selection of exemplary SC predictors. One important *factor* that has been related to individual differences in SC is an individual's early attachment with the primary caregiver. This account originates from attachment theory (Bowlby, 2008), proposing that early attachment influences the closeness and stability of social relationships throughout the lifespan. There is evidence that a secure attachment style is related to a larger and denser social network (Doherty and Feeney, 2004), while an insecure

attachment style is associated with low scores on the social connectedness scale, mediated by other variables such as perfectionism (Cheng et al., 2012). Questionnaire measures of adult attachment were also linked to longitudinal changes in perceived social closeness to multiple (up to ten) close persons (J. Lee and Gillath, 2016).

Other theories propose *mechanisms* that contribute to SC. For example, from the perspective of Self-Categorization theory (Turner et al., 1987, 1994) SC is linked to the mechanism of subjective identification with a relevant social group (Bentley et al., 2020; Cruwys et al., 2016). According to this account, individuals can flexibly categorize themselves as parts of different social groups or as individuals and thus adapt to changing social contexts. The underlying processes are interactive and dynamic because the individual selects the social category (e.g., based on current needs), and collective processes mediate the cognitive functioning of the individual. The ability to flexibly navigate between social groups and social identities shapes an individual's SC (Iyer and Jetten, 2023). Yet other *mechanistic* models assume that achieving social connections is tied to experiencing shared reality with others (Rossignac-Milon and Higgins, 2018). In those situations, where the personal perspective overlaps with the perspective of others, shared attention occurs (Shteynberg, 2015, 2018) which strengthens social connections via increasing similarity with others (also in terms of neural reactions; Baek and Parkinson, 2022) and facilitating the understanding and compliance to group norms. Forming a shared reality across different social contexts requires communication skills and the ability to infer the states of others to adapt one's own behavior accordingly (Echterhoff and Higgins, 2018).

In summary, the reviewed theories propose a number of different factors and mechanisms that are linked to individual differences in SC. To integrate this evidence, one could assume that each of these factors or mechanisms has a direct effect on SC, along with many other variables one could add. An alternative, equally plausible conception is that these different factors and mechanisms affect SC indirectly via their effect on basic information processing. This latter suggestion is inspired by previous interdisciplinary approaches that rely on models from cognitive psychology and/or neuroscience to understand social interactions (Molapour et al., 2021), adaptive social behavior (Crick and Dodge, 1994; Dodge, 1986; Dodge and Price, 1994; Price and Landsverk, 1998) and aggression (Dodge, 2011; Dodge and Schwartz, 1997; Huesmann, 1998) as well as social cognition in general (Adolphs, 2010; Beer and Ochsner, 2006; Holyoak andGordon, 1984; J. P. Mitchell, 2006; Semin and Cacioppo, 2008). In fact, it has been argued that social cognition can be conceptualized in a classical action-perception model framework with a subset of processes concerned with social perception and interpretation (e.g., reading facial expressions), social motivation (e.g., should this person be approached) and social actions (e.g., initiating facial expressions; (Frith, 2008). Social information processing models are characterized by reciprocity in the sense that one person's response is another person's input (see Fig. 1).

Inspired by these interdisciplinary approaches, the current article promotes an information processing perspective on SC. This perspective exceeds previous work in this domain, because it can integrate multiple factors and mechanisms that were assumed to contribute to individual SC differences in a parsimonious way. It also extends previous information processing models in the realm of social cognition, as it can motivate testable predictions for individual differences in SC subcomponents (structural, functional, qualitative; corresponding to our favored SC definition), instead of assessing SC as a unified and rather unspecified concept. To develop such a model, in the following we will introduce the different stages of social information processing and discuss how they are influenced by factors or mechanisms that have been linked to individual differences in SC (as for example attachment, self-categorization, and the construction of a shared reality).

2. Stages of social information processing

Human experience and behavior in social situations can be described by a set of cognitive operations that form a closed action-perception loop (Wickens and Carswell, 2021). Based on previous conceptualizations of a hierarchy of social information processing (Adolphs, 2010), we assume that at least three stages should be dissociated: First, a social situation is *perceived and interpreted* which involves sharing of the other's state based on empathy or mentalizing. Second, social *motivation* arises from an interplay of stable dispositions and situational characteristics. Third, *actions* are initiated to affect the social environment (see Fig. 1). These three information processing stages are intertwined within an individual and they are linked to other persons' action-perception loops in social situations. In other words, one person's action serves as another person's input (Semin and Cacioppo, 2008). Thus, the mere fact that a person connects with others influences this person's social information processing chain (Bodenhausen and Todd, 2010; Turner et al., 1987).

Neuroscientific evidence indicates that the different stages are linked to a multitude of different brain regions ranging from early sensory cortices via multimodal areas relevant for planning and energizing behavior to brain regions implicated in forming predictions about future events (see Fig. 2). Most of these brain regions are not considered specifically *social* and also subserve functions in the non-social domain but it has been argued that human brain evolution and development have

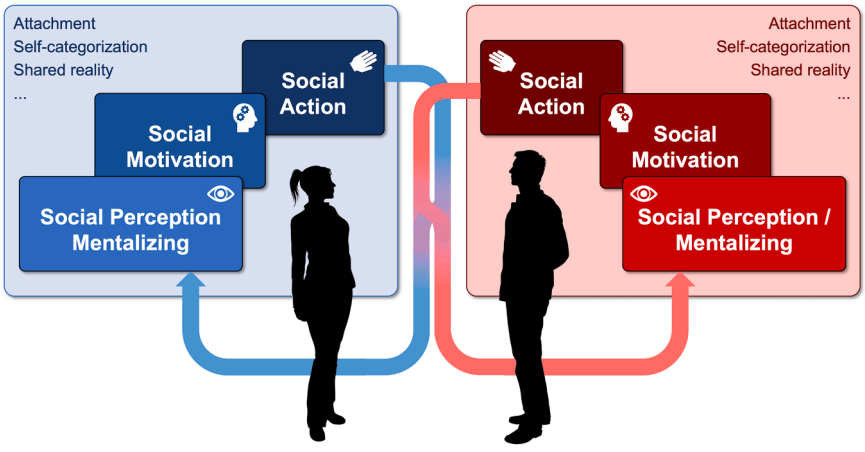

Fig. 1. Illustration of a processing model for social information in a dyadic interaction. The model is based on an action-perception cycle including separate but interrelated stages for social perception and mentalizing, social motivation and social action. These loops are intertwined in social encounters such that the action of one individual is the perceptual input of the other. All these processes are influenced by various factors including attachment styles and mechanisms such as self-categorization processes and the construction of a shared reality.

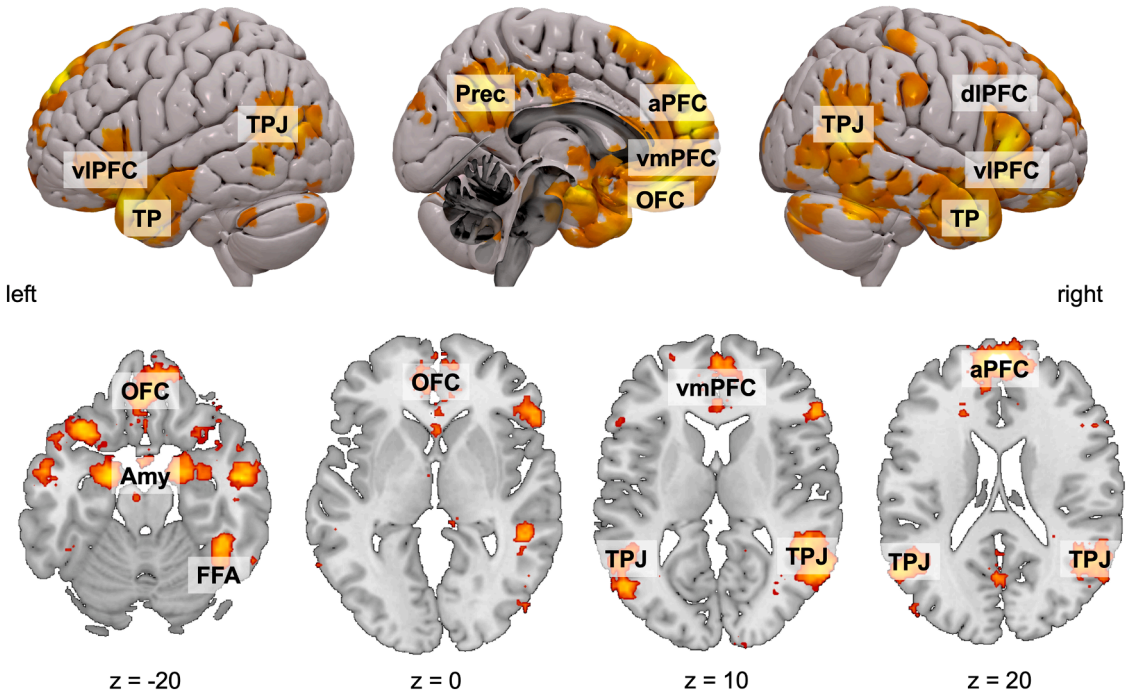

Fig. 2. Brain regions implicated in social information processing. Warm colors reflect significant activations extracted from an automated meta-analysis using Neurosynth (Yarkoni et al., 2011; keyword "social", data extracted from 1302 studies on October 18th, 2024). Amy = amygdala, aPFC = anterior prefrontal cortex, dlPFC = dorsolateral prefrontal cortex, FFA = fusiform face area, OFC = orbitofrontal cortex, Prec = precuneus, TP = temporal pole, TPJ = temporoparietal junction, vlPFC = ventrolateral prefrontal cortex, vmPFC = ventromedial prefrontal cortex.

been strongly driven by the increased complexity of our social environment requiring progressively higher levels of sophistication of social information processing (Frith, 2007; Parkinson and Wheatley, 2015). As discussed in more detail below, social perception and mentalizing, social motivation and social action processing partly rely on dissociable neural mechanisms but there also seems to be a substantial degree of overlap between these functions. On the one hand, this seems obvious given that the different stages of social information processing overlap and form a closed action-perception loop (see Fig. 1). On the other hand, it might also reflect shared neural computations between different aspects of social information processing.

Importantly, information processing on all three stages is influenced by factors and mechanisms that have been linked to individual differences in SC, as for example individual differences in attachment, self-categorization and perceived shared reality (Fig. 1). The three sections below take a selective SC-focused view on these three stages of social information processing. For extensive summaries on social perception (Freiwald et al., 2016; Morrison and Bellack, 1981), social motivation (Geen, 1991; Reykowski, 1982) and social action (Behrens et al., 2009), we refer the reader to other comprehensive reviews in the field.

2.1. Social perception and mentalizing

The first stage of social information processing involves the perception and interpretation of social situations. Thereby, it crucially rests on attentional processes that prioritize the selection and intake of social information and the ability to infer unobservable mental states of others, also referred to as mentalizing (J. P. Mitchell, 2009). Several studies argue for early ontogenetic roots of social perception and suggest that predispositions of these processes are already present at birth or are formed early during development. For example, newborns preferentially direct their attention to faces or face-like cues (Farroni et al., 2005) and even show signs of gaze following (Farroni et al., 2004). Likewise, they seem to be specifically prepared for processing human voices and show an early discrimination of emotions in the voice signal (Cheng et al., 2012). In addition, social touch has been shown to reliably reduce stress responses (Eckstein et al., 2020) and infants already differentiate between sources of interpersonal touch within their first year of life (Aguirre et al., 2019). These processes can be shaped by the quality of social interactions with the primary caregiver. For example, infant-mother *attachment* was shown to predict emotion recognition abilities in children (Steele et al., 2008), and adult attachment styles modulate the perception and interpretation of social situations (Vrtička et al., 2012).

There is converging evidence that faces - as the central social stimulus category - receive a processing advantage compared to other stimuli. For example, faces are quickly detected in the environment (Hershler and Hochstein, 2005), guide attentional selection (End and Gamer, 2017; Rösler et al., 2017) and are rapidly processed concerning their gaze direction (Böckler et al., 2014; Breil et al., 2022) and emotional expression (Eimer and Holmes, 2007). Even more complex trait inferences of other persons can be derived from minimal visual input (Willis and Todorov, 2006), indicating the presence of a finely tuned mechanism for person perception (Todorov et al., 2008). Based on the timing of face prioritization in neural (Pourtois et al., 2004) and behavioral responses (Crouzet et al., 2010), it has been suggested that a social amplification of perceptual processes already occurs in primary sensory cortices and occipitotemporal regions in extrastriate visual cortex (West et al., 2011; Whalen et al., 2006), potentially modulated by the amygdala (Gamer et al., 2013; Rutishauser et al., 2011; see Fig. 2). A more elaborate analysis of invariant aspects of faces was supposed to be mediated by face-responsive regions in the fusiform gyrus while changeable aspects such as eye gaze were assumed to be processed in the superior temporal sulcus (Haxby et al., 2000). Interestingly, the association of individuals to specific groups can bias face detection (Kawakami et al., 2017; Prunty et al., 2023) and the neural processing of faces in high-level visual cortex (Hughes et al., 2019). While the attentional prioritization of social cues is a very robust phenomenon, it also shows surprising interindividual variability (Constantino et al., 2017; De Haas et al., 2019) that generalizes to real-world scenarios (Peterson

et al., 2016) and predicts other social preferences (Berlijn et al., 2022) or skills (e.g., face recognition abilities; De Haas et al., 2019).

There is a gradual transition between perceiving and interpreting social situations and some authors even argue that certain attributions (e.g., concerning animacy or intentionality) occur directly on the perceptual stage without requiring any higher-level processes (Scholl and Gao, 2013). Emotional states of the perceiver are also capable of quickly biasing perceptions (Baumann and DeSteno, 2010) and judgements of the current (social) situation (Clore and Huntsinger, 2007). However, others have pointed out that additional cognitive operations are necessary to make inferences about internal states of interaction partners (Adolphs, 2003), i.e., *share the social reality of others*. This process, also coined mentalizing or Theory of Mind (Frith and Frith, 2005), may also encompass affective understanding and sharing that is described as empathy (Baron-Cohen, 2005; Hein et al., 2021; Pollerhoff et al., 2022; Weisz and Cikara, 2021) and plays an important role in motivating social behavior (see below). Neuroimaging meta-analyses suggest that cognitive and affective aspects of social inferences are related to partly dissociable but also overlapping patterns of neural activity across large parts of the parietal, temporal and frontal cortex (Schurz et al., 2021). The ability to mentalize is shaped during the first years of life and seems to depend on early attachment relationships to caregivers (C. Freeman, 2016). Moreover, self-referential information biases social inferences (see egocentric mentalizing; Todd and Tamir, 2024), enabling the influence of *self-categorization* processes on interpretations of social situations.

To sum up, social perception allows for selecting and processing relevant aspects of our social environment. This information can be rapidly used to drive social motivation and behavior based on simple heuristics (e.g., world knowledge, stereotypes) but it is also essential for inferring mental states of others to allow for more deliberate and well-considered actions. Social perception and mentalizing are shaped by attachment and self-categorization processes and were found to be stable within individuals. Since both are necessary to identify and analyze the structure of our social environment to assist the selection of appropriate behavior, it seems plausible to assume that social perception and mentalizing modulate different aspects of SC and thereby contribute to establishing and maintaining social relationships.

2.2. Social motivation

On its most basic grounds, SC is related to the motivation to approach other individuals. Social approach motivation can result from trait-like stable personality dimensions or dispositions (e.g., Maslow, 1943, 1970; McClelland, 1985, 1988; Murray, 1938), for example the need to belong (Baumeister and Leary, 1995) or the need to *identify positively with a social group* (Abrams, 2001). Individual differences in the need to belong (Leary et al., 2013), and to identify with a social group (Rom and Mikulincer, 2003) were found to be related to individual differences in *attachment styles*. In addition to these enduring needs, social motivation is also influenced by transient, situational variables (Kruglanski et al., 2002; Lewin, 1951). For example, in a hostile social environment, an individual's social approach motivation might be low, despite a strong individual need to belong. Moreover, approach and avoidance motivation depends on the social category the individual currently identifies with (Kawakami et al., 2017). The flexible change of social categories results in context-dependent changes of social motivation. From early on (Murray, 1938), most researchers have acknowledged that motivation is generated and shaped by the interaction between transient, situationally specific states and enduring individual dispositions, because this interaction determines the needs of the individual (Gollwitzer and Oettingen, 2001).

From a reinforcement learning perspective, such individual needs or goals are encoded in an individual's reward function, which guides the individual towards desirable outcomes. Reward functions assign positive value to actions that fulfill these needs (e.g., calling a friend when feeling lonely) and are thought to be initialized by priors, that is pre-existing knowledge or assumptions about a social environment an individual might enter for the first time. For example, individuals with adverse family history may use this experience and consequently show different levels of trust towards novel interaction partners (Reiter et al., 2023). While the reward function defines goals and provides feedback about past actions, this feedback is also used to update expectations about future reward. A violation of these expectations in the current situation (e.g., friend reacts negatively) generates a prediction error that is known to motivate, and, if repeated, to change behavior (e.g., call a different friend next time) based on reinforcement learning processes (Behrens et al., 2009; Diaconescu et al., 2017; Mussel et al., 2022; Reiter, Diaconescu, et al., 2021; Weiß et al., 2019). These learning processes form the basis for changes in social motivation and thus adaptive social behavior in different social contexts. For example, unexpected positive social experiences with a group or a social environment that was perceived as hostile were found to elicit positive prediction errors that resulted in increased empathy with the formerly avoided group (Hein et al., 2016) and observing unexpected empathic reactions of others can enhance or decrease empathy (Zhou et al., 2024). Given that empathy is characterized by the sharing of others' emotions or states, it is crucial for creating a *shared reality* that has been discussed as an important mechanism for enabling SC (Baek and Parkinson, 2022).

The neural mechanisms underlying social motivation and social learning processes are extensively reviewed elsewhere (Hackel and Amodio, 2018; Olsson et al., 2020; Ruff and Fehr, 2014; Tusche and Bas, 2021). In a nutshell, reinforcement learning and the paralleling changes in motivation have been associated with the dopaminergic system, involving different midbrain and cortical regions (Schultz, 2007). There is mounting evidence that social motivation and the underlying value computations rely on neural circuits that also support motivation and learning processes in the non-social domain, including the dorsolateral, medial and ventromedial prefrontal cortex, the orbitofrontal cortex, the ventral striatum, the amygdala and the hippocampus. In addition to these domain-unspecific circuitries, social motivation and learning processes recruit brain regions that have been associated with mentalizing such as the temporal pole and the temporo-parietal junction (TPJ) (Olsson et al., 2020; see Fig. 2).

There is a long debate whether motivational processes can and should be distinguished from emotions. On the one hand, traditional motivation models generally avoided the concept of emotion, due to its subjectivity (Hebb, 1955; Stellar, 1954). Other theories explicitly distinguish between emotion and motivation. For example, some theorists argue that the characteristics of motivational processes that drive "emotional" actions may qualitatively differ from those underlying other forms of goal-directed actions. Specifically, "emotional" actions are posited to be stimulus-driven, more impulsive or automatic, and potentially less reliant on cost-benefit analyses (Frijda, 2010; Roseman, 2011).

On the other hand, it has been suggested that emotions (Beall and Tracy, 2017; Bradley and Lang, 2007) and emotional appraisal (Frijda et al., 2014; Scheffer and Heckhausen, 2018) motivate behavior along with goals or motives (Moors and Fischer, 2019), because they signal a desired (or undesired) state and thus specify which changes in the environment should be generated by an action (Bramson et al., 2023; Eder, 2023). Based on these considerations, prominent models started to integrate motivational and emotional processes (Buck, 1985; Forgas, 1994). In more detail, emotions have been proposed as navigational aids to motivation (Grynberg and Konrath, 2020; Rauchbauer et al., 2023). For example, the unfulfilled need to belong can motivate social approach, resulting in behaviors that maximize the social contact with others (e.g., going out; becoming a member of a sports team), or further social avoidance (as for example shown by individuals scoring high on social anxiety). The selection between the two motives, here whether to approach or to avoid others, depends on the expected outcome of one's behavior (i.e., being rejected or socially integrated into the group one

approaches) but also the emotional appraisal of the outcome (Clore and Huntsinger, 2007; Forgas, 1994; Gregorová et al., 2024). In the current example, social approach is the dominant motive if social contact is anticipated to lead to positive emotions (e.g., happiness, satisfaction), and social avoidance is the dominant motive if social contact is worried to lead to negative emotions (e.g., fear of rejection).

In the context of SC, the interplay between social emotions and motivation is particularly relevant. Social emotions have been defined as affective states that arise when individuals interact with others and that depend on the social context (Lamm and Singer, 2010). Within this framework, social emotions include empathic experiences, i.e., experiences in which the others' emotions or states are shared, in line with the definition of empathy as an emotional response (Cuff et al., 2016). However, note that there are other definitions of empathy, including its conceptualization as an ability (Keysers and Gazzola, 2014; Levenson and Ruef, 1992). Despite these different notions, there is a broad agreement that sharing the others' states or emotions can elicit empathic concern, i.e., a positive emotion that then results in social approach behavior, e.g., helping (Batson, 2014; Batson et al., 1981; Saulin et al., 2024; Zhou et al., 2024). That said, sharing the others' state or emotion can also induce distress, i.e., a negative instead of a positive emotion, which then leads to withdrawal (social avoidance) instead of social approach (Bloom, 2018; Hein et al., 2021; Pollerhoff et al., 2022; Weisz and Cikara, 2021). In our view, these examples show that emotions and social motivation are too closely intertwined to be discussed as separate entities.

To sum up, we propose that an individual's SC is influenced by the interplay between emotions and social motivation processes, because they determine the individual valence of a given social cue and the balance between social approach and avoidance motivation. Social motivation and integrated emotional processes are dynamically shaped by social learning, are influenced by social categorization processes and attachment styles and they reflect the dispositional and situational need to connect with others or to avoid them.

2.3. Social action

According to a definition of the sociologist Max Weber, action is considered 'social' insofar as it is related to the behavior of other individuals as well as oriented towards others' behavior during its course (Weber, 1978). Within the action-perception cycle (see Fig. 1), there are generally two views on action in a social context: First, the social environment can serve as a stimulus affecting our actions. Second, actions may be motivated by intentions, goals, and desired outcomes, that is, they are initiated in order to affect the social environment. Thus, social action rests on social perception, mentalizing and social motivation, and the action itself generates input to action-perception loops of interaction partners.

Social or joint actions can take very different forms, but it can be helpful to distinguish three different classes of such co-regulation of behavior (Semin and Cacioppo, 2008). The first category has been termed entrainment and refers to the alignment of behavioral rhythms of two or more persons. Spontaneous entrainment has been documented for postural body or gestural movements (Schmidt and O'Brien, 1997) as well as speech pauses in dyadic interactions (Cappella and Planalp, 1981) and seems to play an important role in supporting social cohesion and early development (Wass et al., 2020). The second category termed mirroring or mimicry refers to the imitation of facial expressions, behavioral movements, or verbal patterns of another person. Similar to entrainment, mimicry can occur outside conscious awareness and without intention. Affiliative goals, eye contact and individual differences in prosocial orientation increase the amount of mimicry (Duffy and Chartrand, 2015) and current evidence suggests that mimicry increases liking and rapport in social interactions (Chartrand and Lakin, 2013) and facilitates prosocial behavior (Müller et al., 2012). The last, and probably most diverse category of social action has been labeled coordination (Semin and Cacioppo, 2008) and includes all social behaviors that involve an alignment of individuals in terms of complementary action instead of mere behavioral imitation. This includes communication by verbal (Treiman et al., 2003) and non-linguistic means (e.g., via non-verbal body gestures or eye gaze; Breil and Böckler, 2021), cooperative and competitive behavior (e.g., in sports or game settings; Furley, 2019; Hewig et al., 2011), as well as behavioral phenomena such as gaze cueing and joint attention (Großekathöfer et al., 2020; McKay et al., 2021). Current evidence suggests that *attachment styles* can exert diverse effects on behavior in social situations, influencing both prosocial (Gross et al., 2017) and disruptive behaviors (Waters et al., 1993), as well as behaviors in novel social encounters (Feeney et al., 2008).

The reciprocal coupling of individuals' behaviors on a moment-to-moment basis has also been termed we-mode (Gallotti and Frith, 2013). Thus, people develop a *shared reality and intentionality* in social interactions and start to act as groups rather than as individuals. This enables the influence of *self-categorization* processes, as individual group membership can determine in which constellations and with which people a sense of we-mode emerges. Research has shown that even arbitrary assignments of individuals to specific groups can promote cooperation (Wit and Wilke, 1992) and induce favorable behavior towards their own group as compared to others (Tajfel et al., 1971).

In addition to on-line social behavior that involves mutual alignment of individuals and reciprocity, social actions can also occur in off-line situations with unidirectional transmission of information from one person to another (Gallotti et al., 2017). This is the case when the performance of one individual is improved or impaired simply because another person is present (even outside the person's field of view; Belletier et al., 2019; Wühr and Huestegge, 2010; Zajonc, 1965) or when behavior is altered to match that of others after having observed other individuals (i.e., social contagion; Reiter et al., 2019; Reiter, Moutoussis, et al., 2021; Suzuki et al., 2016).

On the neural level, social action has often been linked to the mirror neuron system since these neurons seem to allow for an embodiment of perceived actions of other individuals (Rizzolatti and Craighero, 2004). Thus, mirror neurons - that were first discovered in premotor areas of macaques (di Pellegrino et al., 1992) - respond similarly to observed and self-generated actions. In humans, comparable mechanisms were reported, and mirror neurons are believed to be located in various cortical regions such as the premotor and motor cortex, the ventrolateral prefrontal cortex and parts of the temporoparietal junction (see Fig. 2). Mirror neurons have been hypothesized to serve as the neural basis for representing and inferring goals of observed actions (Kohler et al., 2002), which is needed to appropriately respond to the behavior of conspecifics (Bonini et al., 2022). During social action, for example during communication, it was furthermore observed that the brains of communication partners synchronize (Kingsbury and Hong, 2020). This synchronization includes sensory brain regions (due to the joint perception of a given situation) but also higher-order brain areas in the prefrontal cortex relevant for the processing of meaning. Specifically, enhanced synchronization was found to improve comprehension in such communication scenarios (Stephens et al., 2010), and thus generates a *shared reality*.

Taken together, social actions are diverse, strongly bound to particular situations and contexts and they are modulated by attachment style, self-categorization processes and the individual's identification with specific groups. On the one hand, they can share characteristics with habits that are quasi-automatically activated whenever a certain (social) situation is present (e.g., facial mimicry or gaze following). On the other hand, social actions may also be closely linked to motivational goals and can be deliberately selected based on anticipation of their effects in the social environment (e.g., Horstmann and Herwig, 2013). These aspects highlight the dual nature of social action, which is driven by and impacting on the social surroundings. Thereby, social actions critically contribute to SC, because they allow for creating

communication signals that help to interact with the social environment and encompass specific behaviors (e.g., cooperation vs. aggression) that themselves determine the quality of the individual's future interactions.

3. Information processing perspective of social connectedness

Similar to other complex social phenomena, SC presumably requires adaptive processing of social information on three processing stages: on the perceptual level input is perceived and interpreted based on simple heuristics and more elaborate mentalizing processes; on the motivational level, social approach or avoidance motivation is generated; and on the action level humans interact and synchronize with others. Moreover, we have shown that all these stages of social information processing are modulated by factors and mechanisms that have been associated with individual differences in SC such as attachment styles, self-categorization processes and the construction of a shared reality. These moderating influences are important, but there are certainly many more variables that affect SC and could be added here. Developing a coherent model of SC that contains all potential variables influencing SC and their interactions appears cumbersome and could become excessively complex if more and more variables are added. To make matters even more complicated, SC is a multidimensional phenomenon, consisting of a structural, functional, and qualitative aspect. Thus, apart from including all possible factors and mechanisms, a unifying SC model would also need to account for these different subcomponents.

To solve these issues and integrate the individual findings discussed above, we propose an information processing model of SC. This model relies on the assumption that individual dispositions (e.g., personality traits), early influences (e.g., attachment to the caregiver) and higher-order social processes (e.g., self-categorization) that are known to affect SC have one important commonality - they all affect how social information is processed (Fig. 1). Thus, individual differences in social information processing capture the effects of these multiple "SC predictors", and in turn predict individual differences in SC components. Based on these considerations, we propose a new working model of SC that provides a unified framework for investigating individual differences in the three SC subcomponents (structural, functional, and qualitative SC) and that can be empirically tested using methods from psychology and/or social (cognitive) neuroscience.

Given access to social interaction partners, our model assumes that establishing and maintaining a social network (i.e., *structural* component of SC) requires the adequate perception and interpretation of social cues, the motivation to approach others, and the selection of adequate social actions that signal social approach or cooperation. Thus, individual differences in the *structural* component of SC should be related to individual differences at all three processing stages. The evaluation of the valence of social relationships (i.e., *quality* component of SC) is presumably based on the processing of social cues (social perception and mentalizing), as well as social motivation processes that determine the individual valence of a given social cue. For example, a smiling face is usually assigned a positive valence and consequently leads to social approach motivation. An angry face, in contrast, is rather assigned a negative valence and leads to social avoidance motivation. Thus, individual variability in the *quality* component of SC should be related to individual differences in social perception/mentalizing and social motivation processes. Finally, individual differences in the perceived availability of social support (i.e., *functional* component of SC) should mainly be linked to social perception and mentalizing processes that allow for identifying those individuals in the social network that may offer support when needed (see Fig. 3).

Prior knowledge, belief systems or socially established discourses enter the model via their influence on learning processes that in turn shape social motivation (see Section 2.2), but also social perception (J. B. Freeman and Johnson, 2016). External factors such as financial resources are likely to modulate SC via their influence on the social action processing stage. For example, sufficient financial resources will enable the individual to perform joint actions with many different individuals (e.g., visiting bars or concerts), while a lack of financial resources will limit the range of possible social actions.

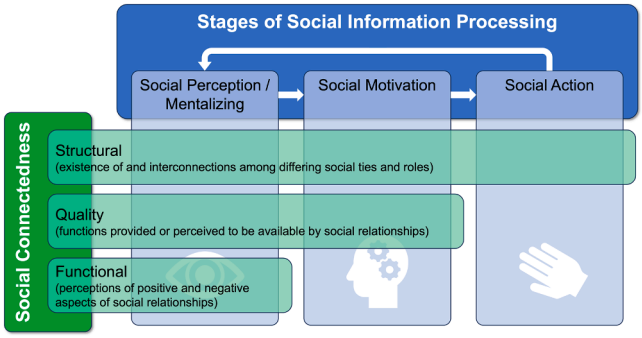

Fig. 3. The information processing model of social connectedness assumes differential contributions of social perception and mentalizing, social motivation and social action on structural, quality and functional components of social connectedness. Such a pattern of partly combined influences of multiple stages of social information processing can also explain moderate correlations between subcomponents of social connectedness.

Based on the proposed relationships, we would for example predict that high levels of social perception and mentalizing skills (e.g., above average performance in emotion recognition and theory of mind tasks) are positively related to structural, functional and quality aspects of SC. Respective individuals would therefore be proposed to have large and diverse (i.e., consisting of multiple subgroups) social networks as well as experience high functionality and quality of social relationships. On the other hand, individuals that learn quickly from social interactions, form adequate expectations about their social environment and as a consequence develop appropriate approach and avoidance tendencies towards social encounters are also expected to develop large and diverse social networks (i.e., structural SC) that offer aid, resources, and support (i.e., qualitative SC). However, these aspects of social motivation are not necessarily related to the perceptions of positive and negative aspects of these social relationships (i.e., functional component of SC) that rather require appropriate social perception and mentalizing skills. Finally, while aspects of social action such as mimicry or socially coordinated behavior might allow for establishing social networks (i.e., structural component of SC), they are presumably not sufficient to receive and appreciate social support (functional SC) or allow for affectively valuing social relationships (qualitative SC). Importantly, influences of social information processing on SC presumably rely on the appropriateness of social cognition and behavior instead of the mere quantity or quality of these processes. Thus, certain biases in interpreting social cues (e.g., egocentric or altercentric biases) can have equally detrimental effects on SC as general difficulties in the processing of social signals.

The proposed working model focuses on SC from the perspective of the individual. Moreover, given that the vast majority of daily social interactions happen in small groups or dyads (Peperkoorn et al., 2020), it mainly incorporates social information processes linked to the intertwined action-perception loops of few interaction partners (see Fig. 1). However, it is important to note that this working model is not limited to considering small groups only and can easily accommodate interactions in larger groups by assuming that social information processing depends on group identification as highlighted by Self-Categorization theory (Turner et al., 1987, 1994) which in turn modulates different facets of SC (Bentley et al., 2020; Cruwys et al., 2016).

4. Future directions

Testing the proposed model that links mechanisms of social information processing to SC (Fig. 3) may appear straightforward: Researchers would simply need to investigate individual differences in

social perception and mentalizing, social motivation and social action processing to establish a person's "social information processing profile". These profiles could then be used to predict individual differences in structural, functional, and quality domains of real-world SC. Taking a closer look, however, it becomes evident that such a research approach requires several adaptations of current research strategies:

1) Present research on social information processing often remains domain-specific in using experimental protocols that exclusively focus on isolated aspects of the information processing chain. Moreover, depending on the precise research focus, a variety of different subjective (e.g., interpretation of and feelings in social situations), behavioral (e.g., body movement or eye-tracking), autonomic (e.g., electrodermal or cardiovascular activity), electroencephalographic or neuroimaging data are used. Such a fragmented approach is unlikely to capture the complexity of SC, because the different stages of social information processing build on each other and are likely to interact. Furthermore, the diverse measures address different aspects of the respective processes. Therefore, future research needs to cut across all processing stages and examine how social perception, mentalizing, motivation and action are related to and modulate each other. To do so, novel experimental paradigms and study designs are necessary that assess all stages of social information processing in a comparable manner (e.g., based on comparable classes of stimuli or situations) on the subjective, behavioral, autonomic, and neural level. Such research needs to seriously consider psychometric aspects of the used tasks or methods to ensure that they are measuring the respective facet of social information processing reliably (i.e., with low measurement error) and validly (i.e., the task results reflect actual differences in the respective process). While some tasks were already proposed for assessing individual differences in social perception (e.g., Broda et al., 2024) or affective sharing and mentalizing (e.g., Kanske et al., 2015), more work is needed to develop appropriate methods and establish their psychometric properties.
2) Most research on social information processing is based on laboratory experiments that are necessary to identify cause-and-effect relationships under controlled conditions. Unfortunately, however, several aspects of real-world social encounters are often neglected in such experimental designs which might limit the generalizability of laboratory findings (e.g., Schilbach et al., 2013; Zaki and Ochsner, 2009). This issue has been recognized and discussed in the literature (Berkowitz and Donnerstein, 1982; Osborne-Crowley, 2020) and it has been recommended to either explicitly test which laboratory findings do generalize to real-world conditions (G. Mitchell, 2012) or to use a reversed approach of first examining behavior in the very situation where it naturally occurs before trying to dissect different aspects in more restricted laboratory environments (so-called cognitive ethology approach; Kingstone, 2009; Kingstone et al., 2008). To validate the currently proposed relationship between social information processing and SC, we propose to realize similar research strategies that include enhancing ecological validity of laboratory research, explicitly testing the generalizability to real-world conditions, and observing social behavior in unrestricted natural conditions to derive hypotheses for subsequent laboratory research.
3) Currently, different methods are used to assess SC depending on the respective conceptualization of this construct (see Table 1). Here, we argue that the multidimensional concept of SC consisting of structural, functional, and quality components (Holt-Lunstad, 2018) is best suited to understand its relationship to individual differences in social information processing. Current methods to assess these different components are mainly based on single diagnostic items (e.g., concerning marital status or number of people in household), psychometrically evaluated questionnaires or - more rarely - observational data (see Table 1; Holt-Lunstad et al., 2010). To gain more direct access to the different facets of this construct, we propose to develop reliable and valid measures of structural, functional, and quality components of SC in real-world conditions using experience sampling methods. In addition to general questions on the structure of social relationships, such an approach would allow for gathering online ratings on the momentary availability of social support and the evaluation of positive and negative aspects of specific social relationships. These measures could then be used to generate individual profiles of real-life connectedness that could be the basis for targeted interventions. Ideally, SC should be assessed from the perspective of the individual (i.e., ego-perspective) as well as from the perspective of the social environment, including multiple, interdependent interactions between several people and the perception of individual SC by others (i.e., network perspective, see Fig. 4).
4) Investigating individual differences in social perception, social motivation, and social action processing on the one hand, and individual differences in (real-life) SC on the other hand generates complex data sets. Future research should embrace new data analysis techniques including machine learning methods such as representation learning approaches (Bengio et al., 2013) for jointly modeling subjective, behavioral, autonomic, and neural measures of social perception and mentalizing, social motivation and social action processing and for testing their power to predict real-life SC. Moreover, to elucidate potential causal relationships between differences in social information processing on the one hand and different facets of SC in the other (see Fig. 3), prospective-developmental studies are advantageous that measure individual differences in social perception and mentalizing, social motivation and social action in younger ages and use this social information processing profile to predict structural, functional and qualitative aspects of SC at later time points.
5) Reduced SC can be a transdiagnostic risk factor for the development of mental illness and it can contribute to a more severe course of the disorder (Wickramaratne et al., 2022). Furthermore, there is abundant evidence that social deficits in mental disorders are linked to malfunctions in social perception (Cavieres and López-Silva, 2022), social motivation (Campellone et al., 2018) and social action (Griffiths et al., 2014). However, the sources of these deficits and whether social problems are the cause or consequence of mental health issues are relatively unclear. We suggest that the currently proposed perspective on SC is a fruitful approach to delineate on which level of social information processing problems occur for specific mental disorders and how this might be related to specific alterations of SC subcomponents. For example, individuals with autism spectrum disorders (ASD) experience difficulties in social communication that may be driven by deficits in social perception (Wang et al., 2015) and problems to process social emotions (Wallace et al., 2008), leading to a reduced social approach motivation (Garon et al., 2009) and therefore presumably low SC on all levels. Patients with social anxiety disorders (SAD), on the other hand, who are characterized by an intense and persistent fear of social situations and negative evaluation by others (Stein and Stein, 2008) also tend to avoid social situations due to the high stress levels they elicit. Although this pattern seems comparable to ASD at first sight, it rather seems to rely on problems in social motivation (Rapee and Spence, 2004) as opposed to social perception. Such patients might therefore have smaller social networks and biases in evaluating their quality, but they can presumably correctly perceive and receive aid, resources, and support from their relationships. These examples highlight the importance of more precisely linking clinical symptoms and disorders to specific cognitive functions to enhance our understanding of how distinct social deficits arise and can be effectively treated. For example, a dedicated social perception training might be more important for ASD patients than for individuals with SAD. Taking a closer look at the interrelation of social

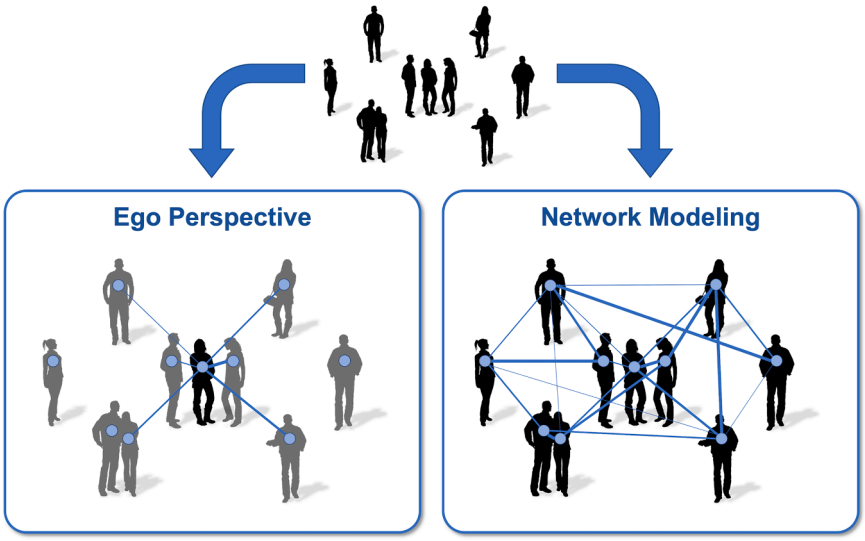

Fig. 4. Processes of social exchange and social connectedness were typically examined from a so-called "ego perspective". Thus, one individual was identified and characterized according to their connections with other people (see left side). This approach likely misses important indirect effects that involve individuals without direct connections to the individual under examination. Therefore, it might be necessary to model larger networks of people including their bidirectional connections (see right side).

information processing and facets of SC using the proposed methodological advancements might help to specify the source of social deficits in clinical populations and thereby facilitate a better understanding of heterogeneity in treatment responses and a development of targeted intervention programs for specific patients or patient groups.

5. Conclusions

Social connectedness is a strong predictor of health, well-being and longevity and has therefore been identified as a relevant target for psychosocial interventions (Holt-Lunstad, 2018, 2021; Xu et al., 2023). SC is modulated by numerous factors such as attachment styles and mechanisms such as self-categorization processes or the construction of a shared reality, but a model that integrates these different perspectives is yet missing. Here we suggest that such influences can be mediated by fundamental aspects of social information processing which then constitute the basis for the development and maintenance of social connections. Accordingly, we propose a working model of how social information processing might influence different components of SC that has the potential to provide insights into the psychological and neural foundations of this important construct. Testing this model requires a research strategy that specifically addresses interactions between individual stages of social information processing, relies on comparable research designs and methods and explicitly considers conditions that are characteristic of social situations in real life. This approach might yield important insights into the processes underlying SC within both health and clinical contexts and could ultimately stimulate the development of individualized intervention programs for increasing SC via dedicated training of social information processing skills.

Declaration of Competing Interest

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

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Data Availability

No data was used for the research described in the article.

References

Abrams, D., 2001. Social Identity, Psychology of. In: Smelser, N.J., Baltes, P.B. (Eds.), International Encyclopedia of the Social & Behavioral Sciences. Pergamon, pp. 14306–14309. https://doi.org/10.1016/B0-08-043076-7/01728-9.

Adolphs, R., 2003. Cognitive neuroscience of human social behavior. Nat. Rev. Neurosci. 4 (3), 165–178.

Adolphs, R., 2010. Conceptual challenges and directions for social neuroscience. Neuron 65 (6), 752–767. https://doi.org/10.1016/j.neuron.2010.03.006.

Aguirre, M., Couderc, A., Epinat-Duclos, J., Mascaro, O., 2019. Infants discriminate the source of social touch at stroking speeds eliciting maximal firing rates in CT-fibers. Dev. Cogn. Neurosci. 36, 100639. https://doi.org/10.1016/j.dcn.2019.100639.

Baek, E.C., Parkinson, C., 2022. Shared understanding and social connection: Integrating approaches from social psychology, social network analysis, and neuroscience. Soc. Personal. Psychol. Compass 16 (11), e12710. https://doi.org/10.1111/spc3.12710.

Bailey, M., Cao, R., Kuchler, T., Stroebel, J., Wong, A., 2018. Social connectedness: Measurement, determinants, and effects. J. Econ. Perspect. 32 (3), 259–280. https://doi.org/10.1257/jep.32.3.259.

Barber, B.K., Schluterman, J.M., 2008. Connectedness in the lives of children and adolescents: a call for greater conceptual clarity. J. Adolesc. Health 43 (3), 209–216. https://doi.org/10.1016/j.jadohealth.2008.01.012.

Baron-Cohen, S., 2005. The empathizing system: A revision of the 1994 model of the Mindreading System. In: Ellis, B.J., Bjorklund, D.F. (Eds.), Origins of the social mind: Evolutionary psychology and child development. Guilford Press, New York, USA, pp. 468–492.

Batson, C.D., 2014. The Altruism Question: Toward a Social-psychological Answer. Psychology Press. https://doi.org/10.4324/9781315808048.

Batson, C.D., Duncan, B.D., Ackerman, P., Buckley, T., Birch, K., 1981. Is empathic emotion a source of altruistic motivation? J. Personal. Soc. Psychol. 40 (2), 290–302. https://doi.org/10.1037/0022-3514.40.2.290.

Baumann, J., DeSteno, D., 2010. Emotion guided threat detection: Expecting guns where there are none. J. Personal. Soc. Psychol. 99 (4), 595–610. https://doi.org/10.1037/a0020665.

Baumeister, R.F., Leary, M.R., 1995. The need to belong: Desire for interpersonal attachments as a fundamental human motivation. Psychol. Bull. 117 (3), 497–529. https://doi.org/10.1037/0033-2909.117.3.497.

Beall, A.T., Tracy, J.L., 2017. Emotivational psychology: How distinct emotions facilitate fundamental motives (Article). Soc. Personal. Psychol. Compass 11 (2), 2. https://doi.org/10.1111/spc3.12303.

Beer, J.S., Ochsner, K.N., 2006. Social cognition: a multi level analysis. Brain Res. 1079 (1), 98–105. https://doi.org/10.1016/j.brainres.2006.01.002.

Behrens, T.E.J., Hunt, L.T., Rushworth, M.F.S., 2009. The computation of social behavior. Science 324 (5931), 1160–1164. https://doi.org/10.1126/science.1169694.

van Bel, D.T., Smolders, K.C.H.J., IJsselsteijn, W.A., De Kort, Y.A.W., 2009. Social Connectedness: Concept and Measurement. Intelligent Environments 2009. IOS Press., pp. 67–74. https://doi.org/10.3233/978-1-60750-034-6-67

Belletier, C., Normand, A., Huguet, P., 2019. Social-facilitation-and-impairment effects: from motivation to cognition and the social brain (Article). Curr. Dir. Psychol. Sci. 28 (3), 3. https://doi.org/10.1177/0963721419829699.
Bengio, Y., Courville, A., Vincent, P., 2013. Representation learning: a review and new perspectives (IEEE Transactions on Pattern Analysis and Machine Intelligence). IEEE Trans. Pattern Anal. Mach. Intell. 35 (8), 1798–1828. https://doi.org/10.1109/TPAMI.2013.50.
Bentley, S.V., Greenaway, K.H., Haslam, S.A., Cruwys, T., Steffens, N.K., Haslam, C., Cull, B., 2020. Social identity mapping online. J. Personal. Soc. Psychol. 118 (2), 213–241. https://doi.org/10.1037/pspa0000174.
Berkowitz, L., Donnerstein, E., 1982. External validity is more than skin deep: some answers to criticisms of laboratory experiments. Am. Psychol. 37 (3), 245–257. https://doi.org/10.1037/0003-066X.37.3.245.
Berlijn, A.M., Hildebrandt, L.K., Gamer, M., 2022. Idiosyncratic viewing patterns of social scenes reflect individual preferences. J. Vis. 22 (13), 10. https://doi.org/10.1167/jov.22.13.10.
Bloom, P., 2018. *Against empathy: The case for rational compassion* (First ecco paperback edition). Ecco.
Böckler, A., Van Der Wel, R.P.R.D., Welsh, T.N., 2014. Catching eyes: effects of social and nonsocial cues on attention capture. Article 3. Psychol. Sci. 25 (3). https://doi.org/10.1177/0956797613516147.
Bodenhausen, G.V., Todd, A.R., 2010. Social cognition. WIREs Cogn. Sci. 1 (2), 160–171. https://doi.org/10.1002/wcs.28.
Bonini, L., Rotunno, C., Arcuri, E., Gallese, V., 2022. Mirror neurons 30 years later: implications and applications. Trends Cogn. Sci. 26 (9), 767–781. https://doi.org/10.1016/j.tics.2022.06.003.
Bowlby, J., 2008. Attachment. Basic books.
Bradley, M.M., Lang, P.J., 2007. Emotion and motivation. In: Cacioppo, J.T., Tassinary, L.G., Berntson, G. (Eds.), Handbook of Psychophysiology. Cambridge University Press, pp. 581–607. https://doi.org/10.1017/CBO9780511546396.025.
Bramson, B., Toni, I., Roelofs, K., 2023. Emotion regulation from an action-control perspective. Neurosci. Biobehav. Rev. 153, 105397. https://doi.org/10.1016/j.neubiorev.2023.105397.
Breil, C., Böckler, A., 2021. Look away to listen: The interplay of emotional context and eye contact in video conversations. Vis. Cogn. 29 (5), 277–287. https://doi.org/10.1080/13506285.2021.1908470.
Breil, C., Raettig, T., Pittig, R., Van Der Wel, R.P.R.D., Welsh, T., Böckler, A., 2022. Don't look at me like that: Integration of gaze direction and facial expression. Article 10. J. Exp. Psychol.: Hum. Percept. Perform. 48 (10). https://doi.org/10.1037/xhp0001046.
Broda, M.D., Borovska, P., de Haas, B., 2024. Individual differences in face salience and rapid face saccades. J. Vis. 24 (6), 16. https://doi.org/10.1167/jov.24.6.16.
Buck, R., 1985. Prime theory: An integrated view of motivation and emotion. Psychol. Rev. 92 (3), 389–413. https://doi.org/10.1037/0033-295X.92.3.389.
Cacioppo, J.T., Patrick, W., 2008. Loneliness: Human Nature and the Need for Social Connection. , 317. W W Norton & Co, p. xiv.
Campellone, T.R., Truong, B., Gard, D., Schlosser, D.A., 2018. Social motivation in people with recent-onset schizophrenia spectrum disorders. J. Psychiatr. Res. 99, 96–103. https://doi.org/10.1016/j.jpsychires.2018.01.006.
Cappella, J.N., Planalp, S., 1981. Talk and silence sequences in informal conversations III: Interspeaker influence. Hum. Commun. Res. 7 (2), 117–132. https://doi.org/10.1111/j.1468-2958.1981.tb00564.x.
Cattuto, C., Broeck, W.V., den, Barrat, A., Colizza, V., Pinton, J.-F., Vespignani, A., 2010. Dynamics of person-to-person interactions from distributed RFID sensor networks. PLOS ONE 5 (7), e11596. https://doi.org/10.1371/journal.pone.0011596.
Cavieres, Á., López-Silva, P., 2022. Social perception deficit as a factor of vulnerability to psychosis: a brief proposal for a definition. Front. Psychol. 13, 805795. https://doi.org/10.3389/fpsyg.2022.805795.
Chartrand, T.L., Lakin, J.L., 2013. The antecedents and consequences of human behavioral mimicry. Annu. Rev. Psychol. 64 (1), 285–308. https://doi.org/10.1146/annurev-psych-113011-143754.
Cheng, Y., Lee, S.-Y., Chen, H.-Y., Wang, P.-Y., Decety, J., 2012. Voice and emotion processing in the human neonatal brain. J. Cogn. Neurosci. 24 (6), 1411–1419. https://doi.org/10.1162/jocn_a_00214.
Chodorow, N., 1978. The reproduction of mothering: Psychoanalysis and the sociology of gender, (1st ed.). University of California Press. https://doi.org/10.2307/jj.2373318.
Clore, G.L., Huntsinger, J.R., 2007. How emotions inform judgment and regulate thought. Trends Cogn. Sci. 11 (9), 393–399.
Constantino, J.N., Kennon-McGill, S., Weichselbaum, C., Marrus, N., Haider, A., Glowinski, A.L., Gillespie, S., Klaiman, C., Klin, A., Jones, W., 2017. Infant viewing of social scenes is under genetic control and is atypical in autism. Nature 547 (7663), 340–344. https://doi.org/10.1038/nature22999.
Crick, N.R., Dodge, K.A., 1994. A review and reformulation of social information-processing mechanisms in children's social adjustment. Psychol. Bull. 115 (1), 74–101. https://doi.org/10.1037/0033-2909.115.1.74.
Crouzet, S.M., Kirchner, H., Thorpe, S.J., 2010. Fast saccades toward faces: face detection in just 100 ms. J. Vis. 10 (4), 16. https://doi.org/10.1167/10.4.16.
Cruwys, T., Steffens, N.K., Haslam, S.A., Haslam, C., Jetten, J., Dingle, G.A., 2016. Social identity mapping: a procedure for visual representation and assessment of subjective multiple group memberships. Br. J. Soc. Psychol. 55 (4), 613–642. https://doi.org/10.1111/bjso.12155.
Cuff, B.M.P., Brown, S.J., Taylor, L., Howat, D.J., 2016. Empathy: a review of the concept. Emot. Rev. 8 (2), 144–153. https://doi.org/10.1177/1754073914558466.
De Haas, B., Iakovidis, A.L., Schwarzkopf, D.S., Gegenfurtner, K.R., 2019. Individual differences in visual salience vary along semantic dimensions. Proc. Natl. Acad. Sci. 116 (24), 11687–11692. https://doi.org/10.1073/pnas.1820553116.
di Pellegrino, G., Fadiga, L., Fogassi, L., Gallese, V., Rizzolatti, G., 1992. Understanding motor events: a neurophysiological study. Exp. Brain Res. 91 (1), 176–180. https://doi.org/10.1007/BF00230027.
Diaconescu, A.O., Mathys, C., Weber, L.A.E., Kasper, L., Mauer, J., Stephan, K.E., 2017. Hierarchical prediction errors in midbrain and septum during social learning. Soc. Cogn. Affect. Neurosci. 12 (4), 618–634. https://doi.org/10.1093/scan/nsw171.
Dodge, K.A., 1986. A social information processing model of social competence in children. In: Perlmutter, M. (Ed.), *Cognitive perspectives on children's social and behavioral development*. Psychology Press, pp. 77–125. https://doi.org/10.4324/9781315802343.
Dodge, K.A., 2011. Social information processing patterns as mediators of the interaction between genetic factors and life experiences in the development of aggressive behavior. In: Shaver, P.R., Mikulincer, M. (Eds.), Human aggression and violence: Causes, manifestations, and consequences. American Psychological Association, pp. 165–185. https://doi.org/10.1037/12346-009.
Dodge, K.A., Price, J.M., 1994. On the relation between social information processing and socially competent behavior in early school-aged children. Child Dev. 65 (5), 1385–1397. https://doi.org/10.2307/1131505.
Dodge, K.A., Schwartz, D., 1997. Social information processing mechanisms in aggressive behavior. In: Stoff, D.M., Breiling, J., Maser, J.D. (Eds.), Handbook of Antisocial Behavior. John Wiley & Sons Inc, pp. 171–180.
Doherty, N.A., Feeney, J.A., 2004. The composition of attachment networks throughout the adult years. Pers. Relatsh. 11 (4), 469–488. https://doi.org/10.1111/j.1475-6811.2004.00093.x.
Duffy, K.A., Chartrand, T.L., 2015. Mimicry: causes and consequences. Curr. Opin. Behav. Sci. 3, 112–116. https://doi.org/10.1016/j.cobeha.2015.03.002.
Echterhoff, G., Higgins, E.T., 2018. Shared reality: construct and mechanisms. Curr. Opin. Psychol. 23, iv–vii. https://doi.org/10.1016/j.copsyc.2018.09.003.
Eckstein, M., Mamaev, I., Ditzen, B., Sailer, U., 2020. Calming effects of touch in human, animal, and robotic interaction—scientific state-of-the-art and technical advances. Front. Psychiatry 11, 555058. https://doi.org/10.3389/fpsyt.2020.555058.
Eder, A.B., 2023. A perceptual control theory of emotional action. Cogn. Emot. 37 (7), 1167–1184. https://doi.org/10.1080/02699931.2023.2265234.
Eimer, M., Holmes, A., 2007. Event-related brain potential correlates of emotional face processing. Neuropsychologia 45 (1), 15–31. https://doi.org/10.1016/j.neuropsychologia.2006.04.022.
Eisenberger, N.I., 2013. Social ties and health: a social neuroscience perspective. Curr. Opin. Neurobiol. 23 (3), 407–413. https://doi.org/10.1016/j.conb.2013.01.006.
End, A., Gamer, M., 2017. Preferential processing of social features and their interplay with physical saliency in complex naturalistic scenes. Front. Psychol. 8. https://doi.org/10.3389/fpsyg.2017.00418.
Farroni, T., Massaccesi, S., Pividori, D., Johnson, M.H., 2004. Gaze following in newborns. Infancy 5 (1), 39–60. https://doi.org/10.1207/s15327078in0501_2.
Farroni, T., Johnson, M.H., Menon, E., Zulian, L., Faraguna, D., Csibra, G., 2005. Newborns' preference for face-relevant stimuli: Effects of contrast polarity. Proc. Natl. Acad. Sci. 102 (47), 17245–17250. https://doi.org/10.1073/pnas.0502205102.
Feeney, B.C., Cassidy, J., Ramos-Marcuse, F., 2008. The generalization of attachment representations to new social situations: Predicting behavior during initial interactions with strangers. J. Personal. Soc. Psychol. 95 (6), 1481–1498. https://doi.org/10.1037/a0012635.
Forgas, J.P., 1994. The role of emotion in social judgments: an introductory review and an Affect Infusion Model (AIM). Eur. J. Soc. Psychol. 24 (1), 1–24. https://doi.org/10.1002/ejsp.2420240102.
Freeman, C., 2016. What is mentalizing? an overview. Br. J. Psychother. 32 (2), 189–201. https://doi.org/10.1111/bjp.12220.
Freeman, J.B., Johnson, K.L., 2016. More than meets the eye: split-second social perception. Trends Cogn. Sci. 20 (5), 362–374. https://doi.org/10.1016/j.tics.2016.03.003.
Freiwald, W., Duchaine, B., Yovel, G., 2016. Face processing systems: from neurons to real-world social perception. Annu. Rev. Neurosci. 39 (1), 325–346. https://doi.org/10.1146/annurev-neuro-070815-013934.
Frijda, N.H., 2010. Impulsive action and motivation. Biol. Psychol. 84 (3), 570–579. https://doi.org/10.1016/j.biopsycho.2010.01.005.
Frijda, N.H., Ridderinkhof, K.R., Rietveld, E., 2014. Impulsive action: emotional impulses and their control. Front. Psychol. 5. https://doi.org/10.3389/fpsyg.2014.00518.
Frith, C.D., 2007. The social brain? Philos. Trans. R. Soc. B: Biol. Sci. 362 (1480), 671–678. https://doi.org/10.1098/rstb.2006.2003.
Frith, C.D., 2008. Social cognition. Philos. Trans. R. Soc. B: Biol. Sci. 363 (1499), 2033–2039. https://doi.org/10.1098/rstb.2008.0005.
Frith, C.D., Frith, U., 2005. Theory of mind. Curr. Biol. 15 (17), R644–R645. https://doi.org/10.1016/j.cub.2005.08.041.
Furley, P., 2019. What modern sports competitions can tell us about human nature. Perspect. Psychol. Sci. 14 (2), 138–155. https://doi.org/10.1177/1745691618794912.
Gallotti, M., Frith, C.D., 2013. Social cognition in the we-mode. Trends Cogn. Sci. 17 (4), 160–165. https://doi.org/10.1016/j.tics.2013.02.002.
Gallotti, M., Fairhurst, M.T., Frith, C.D., 2017. Alignment in social interactions. Conscious. Cogn. 48, 253–261. https://doi.org/10.1016/j.concog.2016.12.002.
Gamer, M., Schmitz, A.K., Tittgemeyer, M., Schilbach, L., 2013. The human amygdala drives reflexive orienting towards facial features. Curr. Biol. 23 (20), R917–R918. https://doi.org/10.1016/j.cub.2013.09.008.

Garon, N., Bryson, S.E., Zwaigenbaum, L., Smith, I.M., Brian, J., Roberts, W., Szatmari, P., 2009. Temperament and its relationship to autistic symptoms in a high-risk infant sib cohort. Article 1. J. Abnorm. Child Psychol. 37 (1). https://doi.org/10.1007/s10802-008-9258-0.

Geen, R.G., 1991. Social motivation. Article 1. Annu. Rev. Psychol. 42 (1). https://doi.org/10.1146/annurev.ps.42.020191.002113.

Global Initiative on Loneliness and Connection. (n.d.). GILC. Retrieved September 13, 2023, from ⟨https://www.gilc.global⟩.

Gollwitzer, P.M., Oettingen, G., 2001. *Motivation: History of the concept*. In: Smelser, N.J., Baltes, P.B. (Eds.), International Encyclopedia of the Social and Behavioral Sciences. Elsevier, Amsterdam, pp. 10109–10112.

Gregorová, K., Eldar, E., Deserno, L., Reiter, A.M.F., 2024. A cognitive-computational account of mood swings in adolescence. Trends Cogn. Sci. 28 (4), 290–303. https://doi.org/10.1016/j.tics.2024.02.006.

Griffiths, K.R., Morris, R.W., Balleine, B.W., 2014. Translational studies of goal-directed action as a framework for classifying deficits across psychiatric disorders. Front. Syst. Neurosci. 8. https://doi.org/10.3389/fnsys.2014.00101.

Gross, J.T., Stern, J.A., Brett, B.E., Cassidy, J., 2017. The multifaceted nature of prosocial behavior in children: Links with attachment theory and research. Soc. Dev. 26 (4), 661–678. https://doi.org/10.1111/sode.12242.

Großekathöfer, J.D., Suchotzki, K., Gamer, M., 2020. Gaze cueing in naturalistic scenes under top-down modulation – effects on gaze behaviour and memory performance. Vis. Cogn. 28 (2), 135–147. https://doi.org/10.1080/13506285.2020.1742826.

Grynberg, D., Konrath, S., 2020. The closer you feel, the more you care: positive associations between closeness, pain intensity rating, empathic concern and personal distress to someone in pain. Acta Psychol. 210, 103175. https://doi.org/10.1016/j.actpsy.2020.103175.

Hackel, L.M., Amodio, D.M., 2018. Computational neuroscience approaches to social cognition. Curr. Opin. Psychol. 24, 92–97. https://doi.org/10.1016/j.copsyc.2018.09.001.

Hare-Duke, L., Dening, T., de Oliveira, D., Milner, K., Slade, M., 2019. Conceptual framework for social connectedness in mental disorders: systematic review and narrative synthesis. J. Affect. Disord. 245, 188–199. https://doi.org/10.1016/j.jad.2018.10.359.

Haslam, C., Cruwys, T., Haslam, S.A., Jetten, J., 2015. Social connectedness and health. In: Pachana, N.A. (Ed.), Encyclopedia of Geropsychology. Springer, pp. 1–10. https://doi.org/10.1007/978-981-287-080-3_46-1.

Haxby, J., Hoffman, E., Gobbini, M., 2000. The distributed human neural system for face perception. Trends Cogn. Sci. 4 (6), 223–233.

Hebb, D.O., 1955. Drives and the C. N. S. (conceptual nervous system). Psychol. Rev. 62 (4), 243–254. https://doi.org/10.1037/h0041823.

Hein, G., Engelmann, J.B., Vollberg, M.C., Tobler, P.N., 2016. How learning shapes the empathic brain. Proc. Natl. Acad. Sci. 113 (1), 80–85. https://doi.org/10.1073/pnas.1514539112.

Hein, G., Qi, Y., Han, S., 2021. The biological foundations and modulation of empathy. Social psychology: Handbook of basic principles, 3rd ed. The Guilford Press, pp. 127–139.

Hershler, O., Hochstein, S., 2005. At first sight: a high-level pop out effect for faces. Vis. Res. 45 (13), 1707–1724. https://doi.org/10.1016/j.visres.2004.12.021.

Hewig, J., Kretschmer, N., Trippe, R.H., Hecht, H., Coles, M.G.H., Holroyd, C.B., Miltner, W.H.R., 2011. Why humans deviate from rational choice: irrational decisions. Article 4. Psychophysiology 48 (4). https://doi.org/10.1111/j.1469-8986.2010.01081.x.

Holt-Lunstad, J., 2018. Why social relationships are important for physical health: a systems approach to understanding and modifying risk and protection. Annu. Rev. Psychol. 69 (1), 437–458. https://doi.org/10.1146/annurev-psych-122216-011902.

Holt-Lunstad, J., 2021. The major health implications of social connection. Curr. Dir. Psychol. Sci. 30 (3), 251–259. https://doi.org/10.1177/0963721421999630.

Holt-Lunstad, J., 2023. National health guidelines for social connection: what is the evidence in support and what might the guidelines say? Policy Insights Behav. Brain Sci. 10 (1), 41–50. https://doi.org/10.1177/23727322221150204.

Holt-Lunstad, J., Smith, T.B., 2012. Social relationships and mortality. Article 1. Soc. Personal. Psychol. Compass 6 (1). https://doi.org/10.1111/j.1751-9004.2011.00406.x.

Holt-Lunstad, J., Smith, T.B., Layton, J.B., 2010. Social relationships and mortality risk: a meta-analytic review. Article 7. PLoS Med. 7 (7). https://doi.org/10.1371/journal.pmed.1000316.

Holt-Lunstad, J., Robles, T.F., Sbarra, D.A., 2017. Advancing social connection as a public health priority in the United States. Am. Psychol. 72 (6), 517–530. https://doi.org/10.1037/amp0000103.

Holyoak, K.J., Gordon, P.C., 1984. Information processing and social cognition. In: Handbook of social cognition, 1. Lawrence Erlbaum Associates Publishers, pp. 39–70.

Horstmann, G., Herwig, A., 2013. Eye movements during highly inefficient visual search: what determines search efficiency differences in blank trials? J. Vis. 13 (9), Article 9.

Huesmann, L.R., 1998. The role of social information processing and cognitive schema in the acquisition and maintenance of habitual aggressive behavior. In: Geen, R.G., Donnerstein, E. (Eds.), Human Aggression. Academic Press, pp. 73–109. https://doi.org/10.1016/B978-012278805-5/50005-5.

Hughes, B.L., Camp, N.P., Gomez, J., Natu, V.S., Grill-Spector, K., Eberhardt, J.L., 2019. Neural adaptation to faces reveals racial outgroup homogeneity effects in early perception. Proc. Natl. Acad. Sci. 116 (29), 14532–14537. https://doi.org/10.1073/pnas.1822084116.

Iyer, A., Jetten, J., 2023. Disadvantaged-group members' experiences of life transitions: the positive impact of social connectedness and group memberships. Curr. Dir. Psychol. Sci. 32 (2), 91–97. https://doi.org/10.1177/09637214221122690.

Jose, P.E., Lim, B.T.L., 2014. Social connectedness predicts lower loneliness and depressive symptoms over time in adolescents. Open J. Depress 3 (4), Article 4. https://doi.org/10.4236/ojd.2014.34019.

Kanske, P., Böckler, A., Trautwein, F.-M., Singer, T., 2015. 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. https://doi.org/10.1016/j.neuroimage.2015.07.082.

Kawakami, K., Amodio, D.M., Hugenberg, K., 2017. Intergroup perception and cognition: An integrative framework for understanding the causes and consequences of social categorization. In: Olson, J.M. (Ed.), Advances in Experimental Social Psychology, 55. Academic Press, pp. 1–80. https://doi.org/10.1016/bs.aesp.2016.10.001.

Keysers, C., Gazzola, V., 2014. Dissociating the ability and propensity for empathy. Trends Cogn. Sci. 18 (4), 163–166. https://doi.org/10.1016/j.tics.2013.12.011.

Kingsbury, L., Hong, W., 2020. A multi-brain framework for social interaction. Trends Neurosci. 43 (9), 651–666. https://doi.org/10.1016/j.tins.2020.06.008.

Kingstone, A., 2009. Taking a real look at social attention. Curr. Opin. Neurobiol. 19 (1), 52–56. https://doi.org/10.1016/j.conb.2009.05.004.

Kingstone, A., Smilek, D., Eastwood, J.D., 2008. Cognitive ethology: a new approach for studying human cognition. Br. J. Psychol. 99 (3), 317–340. https://doi.org/10.1348/000712607X251243.

Knoke, D., Yang, S., 2020. Social network analysis, Third edition. SAGE.

Kohler, E., Keysers, C., Umiltà, M.A., Fogassi, L., Gallese, V., Rizzolatti, G., 2002. Hearing sounds, understanding actions: action representation in mirror neurons. Science 297 (5582), 846–848. https://doi.org/10.1126/science.1070311.

Kohut, H., 1971. The Analysis of the Self: A Systematic Approach to the Psychoanalytic Treatment of Narcissistic Personality Disorders. International Universities Press.

Kohut, H., 1984. How Does Analysis Cure? University of Chicago Press.

Kruglanski, A., Shah, J., Fishbach, A., Friedman, R., Chun, W.Y., Sleeth-Keppler, D., 2002. A Theory of Goal Systems. Adv. Exp. Soc. Psychol. 34, 331–378. https://doi.org/10.1016/S0065-2601(02)80008-9.

Lamm, C., Singer, T., 2010. The role of anterior insular cortex in social emotions. Brain Struct. Funct. 214 (5), 579–591. https://doi.org/10.1007/s00429-010-0251-3.

Leary, M.R., Kelly, K.M., Cottrell, C.A., Schreindorfer, L.S., 2013. Construct validity of the need to belong scale: mapping the nomological network. J. Personal. Assess. 95 (6), 610–624. https://doi.org/10.1080/00223891.2013.819511.

Lee, J., Gillath, O., 2016. Perceived closeness to multiple social connections and attachment style: a longitudinal examination. Soc. Psychol. Personal. Sci. 7 (7), 680–689. https://doi.org/10.1177/1948550616644963.

Lee, R.M., Robbins, S.B., 1995. Measuring belongingness: The social connectedness and the social assurance scales. J. Couns. Psychol. 42 (2), Article 2. https://doi.org/10.1037/0022-0167.42.2.232.

Lee, R.M., Draper, M., Lee, S., 2001. Social connectedness, dysfunctional interpersonal behaviors, and psychological distress: testing a mediator model. J. Couns. Psychol. 48 (3), 310–318. https://doi.org/10.1037/0022-0167.48.3.310.

Levenson, R.W., Ruef, A.M., 1992. Empathy: a physiological substrate. J. Personal. Soc. Psychol. 63 (2), 234–246. https://doi.org/10.1037/0022-3514.63.2.234.

Lewin, K., 1951. Field Theory in Social Science. Harper, New York.

Linde, S., Egede, L.E., 2023. Community social capital and population health outcomes. JAMA Netw. Open 6 (8), e2331087. https://doi.org/10.1001/jamanetworkopen.2023.31087.

Marangoni, C., Ickes, W., 1989. Loneliness: a theoretical review with implications for measurement. J. Soc. Pers. Relatsh. 6 (1), 93–128. https://doi.org/10.1177/026540758900600107.

Maslow, A.H., 1943. A theory of human motivation. Psychol. Rev. 50 (4), 370–396. https://doi.org/10.1037/h0054346.

Maslow, A.H., 1970. New introduction: religions, values, and peak-experiences. J. Transpers. Psychol. 2, 83–90.

McClelland, D.C., 1985. How motives, skills, and values determine what people do. Am. Psychol. 40 (7), 812–825. https://doi.org/10.1037/0003-066X.40.7.812.

McClelland, D.C., 1988. How motives interact with values and skills to determine what people do (Ed.). Human Motivation. Cambridge University Press, pp. 514–546. https://doi.org/10.1017/CBO9781139878289.015 (Ed.).

McKay, K.T., Grainger, S.A., Coundouris, S.P., Skorich, D.P., Phillips, L.H., Henry, J.D., 2021. Visual attentional orienting by eye gaze: a meta-analytic review of the gaze-cueing effect. Psychol. Bull. 147 (12), 1269–1289. https://doi.org/10.1037/bul0000353.

Mitchell, G., 2012. Revisiting truth or triviality: the external validity of research in the psychological laboratory. Perspect. Psychol. Sci. 7 (2), 109–117. https://doi.org/10.1177/1745691611432343.

Mitchell, J.P., 2006. Mentalizing and Marr: an information processing approach to the study of social cognition. Brain Res. 1079 (1), 66–75. https://doi.org/10.1016/j.brainres.2005.12.113.

Mitchell, J.P., 2009. Inferences about mental states. Philos. Trans. R. Soc. B: Biol. Sci. 364 (1521), 1309–1316. https://doi.org/10.1098/rstb.2008.0318.

Molapour, T., Hagan, C.C., Silston, B., Wu, H., Ramstead, M., Friston, K., Mobbs, D., 2021. Seven computations of the social brain. Soc. Cogn. Affect. Neurosci. 16 (8), 745–760. https://doi.org/10.1093/scan/nsab024.

Moors, A., Fischer, M., 2019. Demystifying the role of emotion in behaviour: toward a goal-directed account. Cogn. Emot. 33 (1), 94–100. https://doi.org/10.1080/02699931.2018.1510381.

Morrison, R.L., Bellack, A.S., 1981. The role of social perception in social skill. Behav. Ther. 12 (1), Article 1. https://doi.org/10.1016/S0005-7894(81)80107-4.

Müller, B.C.N., Maaskant, A.J., Van Baaren, R.B., Dijksterhuis, A., 2012. Prosocial consequences of imitation. Psychol. Rep. 110 (3), 891–898. https://doi.org/10.2466/07.09.21.PR0.110.3.891-898.

Murray, H.A., 1938. Explorations in Personality. Oxford Univ. Press.

Mussel, P., Weiß, M., Rodrigues, J., Heekeren, H., Hewig, J., 2022. Neural correlates of successful costly punishment in the Ultimatum game on a trial-by-trial basis. Soc. Cogn. Affect. Neurosci. 17 (6), 590–597. https://doi.org/10.1093/scan/nsab126.
O'Rourke, H.M., Sidani, S., 2017. Definition, determinants, and outcomes of social connectedness for older adults: a scoping review. J. Gerontol. Nurs. 43 (7), 43–52. https://doi.org/10.3928/00989134-20170223-03.
Olsson, A., Knapska, E., Lindström, B., 2020. The neural and computational systems of social learning. Nat. Rev. Neurosci. 21 (4), Article 4. https://doi.org/10.1038/s41583-020-0276-4.
Osborne-Crowley, K., 2020. Social cognition in the real world: Reconnecting the study of social cognition with social reality. Rev. Gen. Psychol. 24 (2), 144–158. https://doi.org/10.1177/1089268020906483.
Parkinson, C., Wheatley, T., 2015. The repurposed social brain. Trends Cogn. Sci. 19 (3), 133–141. https://doi.org/10.1016/j.tics.2015.01.003.
Peperkoorn, L.S., Becker, D.V., Balliet, D., Columbus, S., Molho, C., Lange, P.A.M.V., 2020. The prevalence of dyads in social life. PLOS ONE 15 (12), e0244188. https://doi.org/10.1371/journal.pone.0244188.
Peterson, M.F., Lin, J., Zaun, I., Kanwisher, N., 2016. Individual differences in face-looking behavior generalize from the lab to the world. J. Vis. 16 (7), 12. https://doi.org/10.1167/16.7.12.
Pollerhoff, L., Stietz, J., Depow, G.J., Inzlicht, M., Kanske, P., Li, S.-C., Reiter, A.M.F., 2022. Investigating adult age differences in real-life empathy, prosociality, and well-being using experience sampling. Sci. Rep. 12 (1), Article 1. https://doi.org/10.1038/s41598-022-06620-x.
Pourtois, G., Grandjean, D., Sander, D., Vuilleumier, P., 2004. Electrophysiological correlates of rapid spatial orienting towards fearful faces. Cereb. Cortex 14 (6), 619–633. https://doi.org/10.1093/cercor/bhh023.
Price, J.M., Landsverk, J., 1998. Social information-processing patterns as predictors of social adaptation and behavior problems among maltreated children in foster care. Child Abus. Negl. 22 (9), 845–858. https://doi.org/10.1016/S0145-2134(98)00072-6.
Prunty, J.E., Jenkins, R., Qarooni, R., Bindemann, M., 2023. Ingroup and outgroup differences in face detection. Br. J. Psychol. 114 (S1), 94–111. https://doi.org/10.1111/bjop.12588.
Rapee, R.M., Spence, S.H., 2004. The etiology of social phobia: Empirical evidence and an initial model. Clin. Psychol. Rev. 24 (7), Article 7. https://doi.org/10.1016/j.cpr.2004.06.004.
Rauchbauer, B., Jank, G., Dunbar, R.I.M., Lamm, C., 2023. Only empathy-related traits, not being mimicked or endorphin release, influence social closeness and prosocial behavior. Sci. Rep. 13 (1), Article 1. https://doi.org/10.1038/s41598-023-30946-9.
Reiter, A.M.F., Suzuki, S., O'Doherty, J.P., Li, S.-C., Eppinger, B., 2019. Risk contagion by peers affects learning and decision-making in adolescents. Article 9. J. Exp. Psychol.: Gen. 148 (9). https://doi.org/10.1037/xge0000512.
Reiter, A.M.F., Moutoussis, M., Vanes, L., Kievit, R., Bullmore, E.T., Goodyer, I.M., Fonagy, P., Jones, P.B., NSPN Consortium, NSPN consortium representative, Bullmore, E., NSPN Principle Investigators, Bullmore, E., Dolan, R., Goodyer, I., Jones, P., NSPN staff, Hauser, T., Neufeld, S., Dolan, R.J., 2021. Preference uncertainty accounts for developmental effects on susceptibility to peer influence in adolescence. Nat. Commun. 12 (1), Article 1. https://doi.org/10.1038/s41467-021-23671-2.
Reiter, A.M.F., Diaconescu, A.O., Eppinger, B., Li, S.-C., 2021. Human aging alters social inference about others' changing intentions. Neurobiol. Aging 103, 98–108. https://doi.org/10.1016/j.neurobiolaging.2021.01.034.
Reiter, A.M.F., Hula, A., Vanes, L., Hauser, T.U., Kokorikou, D., Goodyer, I.M., Fonagy, P., Moutoussis, M., Dolan, R.J., 2023. Self-reported childhood family adversity is linked to an attenuated gain of trust during adolescence. Nat. Commun. 14 (1), 6920. https://doi.org/10.1038/s41467-023-41531-z.
Research on social connectedness and isolation. (n.d.). NIMHD. Retrieved February 26, 2024, from ⟨https://nimhd.nih.gov/programs/extramural/investigator-initiated-research/research-on-social-connectedness-and-isolation.html⟩.
Reykowski, J., 1982. Social motivation. Annu. Rev. Psychol. 33 (1), Article 1. https://doi.org/10.1146/annurev.ps.33.020182.001011.
Rizzolatti, G., Craighero, L., 2004. The mirror-neuron system. Annu. Rev. Neurosci. 27 (1), 169–192. https://doi.org/10.1146/annurev.neuro.27.070203.144230.
Rom, E., Mikulincer, M., 2003. Attachment theory and group processes: the association between attachment style and group-related representations, goals, memories, and functioning. J. Personal. Soc. Psychol. 84 (6), 1220–1235. https://doi.org/10.1037/0022-3514.84.6.1220.
Roseman, I.J., 2011. Emotional behaviors, emotivational goals, emotion strategies: multiple levels of organization integrate variable and consistent responses. Emot. Rev. 3 (4), 434–443. https://doi.org/10.1177/1754073911410744.
Rösler, L., End, A., Gamer, M., 2017. Orienting towards social features in naturalistic scenes is reflexive. PLOS ONE 12 (7), e0182037. https://doi.org/10.1371/journal.pone.0182037.
Rossignac-Milon, M., Higgins, E.T., 2018. Epistemic companions: shared reality development in close relationships. Curr. Opin. Psychol. 23, 66–71. https://doi.org/10.1016/j.copsyc.2018.01.001.
Ruff, C.C., Fehr, E., 2014. The neurobiology of rewards and values in social decision making. Nat. Rev. Neurosci. 15 (8), Article 8. https://doi.org/10.1038/nrn3776.
Russell, D., Peplau, L.A., Ferguson, M.L., 1978. Developing a measure of loneliness. J. Personal. Assess. 42 (3), 290–294. https://doi.org/10.1207/s15327752jpa4203_11.
Rutishauser, U., Tudusciuc, O., Neumann, D., Mamelak, A.N., Heller, A.C., Ross, I.B., Philpott, L., Sutherling, W.W., Adolphs, R., 2011. Single-unit responses selective for whole faces in the human amygdala. Curr. Biol. 21, 1654–1660. https://doi.org/10.1016/j.cub.2011.08.035.
Samuel Centre For Social Connectedness. (n.d.). Retrieved October 13, 2023, from ⟨https://www.socialconnectedness.org/⟩.
Saulin, A., Ting, C.-C., Engelmann, J.B., Hein, G., 2024. Connected in bad times and in good times: empathy induces stable social closeness. J. Neurosci. 44 (23). https://doi.org/10.1523/JNEUROSCI.1108-23.2024.
Scheffer, D., Heckhausen, H., 2018. Trait Theories of Motivation. In: Heckhausen, J., Heckhausen, H. (Eds.), Motivation and Action. Springer International Publishing, pp. 67–112. https://doi.org/10.1007/978-3-319-65094-4_3.
Schilbach, L., Timmermans, B., Reddy, V., Costall, A., Bente, G., Schlicht, T., Vogeley, K., 2013. Toward a second-person neuroscience. Behav. Brain Sci. 36 (4), 393–414. https://doi.org/10.1017/S0140525X12000660.
Schmidt, R.C., O'Brien, B., 1997. Evaluating the dynamics of unintended interpersonal coordination. Ecol. Psychol. 9 (3), 189–206. https://doi.org/10.1207/s15326969eco0903_2.
Scholl, B.J., Gao, T., 2013. Perceiving animacy and intentionality: Visual processing or higher-level judgment? In: Rutherford, M.D., Kuhlmeier, V.A. (Eds.), Social perception: Detection and interpretation of animacy, agency, and intention. The MIT Press. https://doi.org/10.7551/mitpress/9780262019279.001.0001.
Schultz, W., 2007. Multiple dopamine functions at different time courses. Annu. Rev. Neurosci. 30 (1), 259–288. https://doi.org/10.1146/annurev.neuro.28.061604.135722.
Schurz, M., Radua, J., Tholen, M.G., Maliske, L., Margulies, D.S., Mars, R.B., Sallet, J., Kanske, P., 2021. Toward a hierarchical model of social cognition: a neuroimaging meta-analysis and integrative review of empathy and theory of mind. Psychol. Bull. 147 (3), 293–327. https://doi.org/10.1037/bul0000303.
Schwartz, E., Litwin, H., 2019. The reciprocal relationship between social connectedness and mental health among older European adults: A SHARE-based analysis. J. Gerontol.: Ser. B 74 (4), 694–702. https://doi.org/10.1093/geronb/gbx131.
Semin, G.R., Cacioppo, J.T., 2008. Grounding social cognition: Synchronization, coordination, and co-regulation. In: Smith, E.R., Semin, G.R. (Eds.), Embodied Grounding: Social, Cognitive, Affective, and Neuroscientific Approaches. Cambridge University Press, pp. 119–147. https://doi.org/10.1017/CBO9780511805837.006.
Shteynberg, G., 2015. Shared attention. Perspect. Psychol. Sci. 10 (5), 579–590. https://doi.org/10.1177/1745691615589104.
Shteynberg, G., 2018. A collective perspective: shared attention and the mind. Curr. Opin. Psychol. 23, 93–97. https://doi.org/10.1016/j.copsyc.2017.12.007.
Siette, J., Pomare, C., Dodds, L., Jorgensen, M., Harrigan, N., Georgiou, A., 2021. A comprehensive overview of social network measures for older adults: a systematic review. Arch. Gerontol. Geriatr. 97, 104525. https://doi.org/10.1016/j.archger.2021.104525.
Steele, H., Steele, M., Croft, C., 2008. Early attachment predicts emotion recognition at 6 and 11 years old. Attach. Hum. Dev. 10 (4), 379–393. https://doi.org/10.1080/14616730802461409.
Stehlé, J., Voirin, N., Barrat, A., Cattuto, C., Isella, L., Pinton, J.-F., Quaggiotto, M., Broeck, W.V., den, Régis, C., Lina, B., Vanhems, P., 2011. High-resolution measurements of face-to-face contact patterns in a primary school. PLOS ONE 6 (8), e23176. https://doi.org/10.1371/journal.pone.0023176.
Stein, M.B., Stein, D.J., 2008. Social anxiety disorder. The Lancet 371 (9618), 1115–1125. https://doi.org/10.1016/S0140-6736(08)60488-2.
Steiner, R.J., Sheremenko, G., Lesesne, C., Dittus, P.J., Sieving, R.E., Ethier, K.A., 2019. Adolescent connectedness and adult health outcomes. Pediatrics 144 (1), e20183766. https://doi.org/10.1542/peds.2018-3766.
Stellar, E., 1954. The physiology of motivation. Psychol. Rev. 61 (1), 5–22. https://doi.org/10.1037/h0060347.
Stephens, G.J., Silbert, L.J., Hasson, U., 2010. Speaker–listener neural coupling underlies successful communication. Proc. Natl. Acad. Sci. 107 (32), 14425–14430. https://doi.org/10.1073/pnas.1008662107.
Suzuki, S., Jensen, E.L.S., Bossaerts, P., O'Doherty, J.P., 2016. Behavioral contagion during learning about another agent's risk-preferences acts on the neural representation of decision-risk. Proc. Natl. Acad. Sci. 113 (14), Article 14. https://doi.org/10.1073/pnas.1600092113.
Tajfel, H., Billig, M.G., Bundy, R.P., Flament, C., 1971. Social categorization and intergroup behaviour. Eur. J. Soc. Psychol. 1 (2), 149–178. https://doi.org/10.1002/ejsp.2420010202.
Todd, A.R., Tamir, D.I., 2024. Factors that amplify and attenuate egocentric mentalizing. Nat. Rev. Psychol. 1–17. https://doi.org/10.1038/s44159-024-00277-1.
Todorov, A., Said, C.P., Engell, A.D., Oosterhof, N.N., 2008. Understanding evaluation of faces on social dimensions. Trends Cogn. Sci. 12 (12), 455–460. https://doi.org/10.1016/j.tics.2008.10.001.
Treiman, R., Clifton, C., Meyer, A.S., Wurm, L.H., 2003. Language comprehension and production. In: Weiner, I.B. (Ed.), Handbook of Psychology. John Wiley & Sons, Inc, pp. 1–18. https://doi.org/10.1002/0471264385.wei0419.
Turner, J.C., Hogg, M.A., Oakes, P.J., Reicher, S.D., Wetherell, M.S., 1987. Rediscovering the Social Group: A Self-Categorization Theory. Basil Blackwell.
Turner, J.C., Oakes, P.J., Haslam, S.A., McGarty, C., 1994. Self and collective: cognition and social context. Personal. Soc. Psychol. Bull. 20 (5), 454–463. https://doi.org/10.1177/0146167294205002.
Tusche, A., Bas, L.M., 2021. Neurocomputational models of altruistic decision-making and social motives: advances, pitfalls, and future directions. WIREs Cogn. Sci. 12 (6), e1571. https://doi.org/10.1002/wcs.1571.
Vrtička, P., Sander, D., Vuilleumier, P., 2012. Influence of adult attachment style on the perception of social and non-social emotional scenes. J. Soc. Pers. Relatsh. 29 (4), 530–544. https://doi.org/10.1177/0265407512443451.
Wallace, S., Coleman, M., Bailey, A., 2008. An investigation of basic facial expression recognition in autism spectrum disorders. Cogn. Emot. 22 (7), 1353–1380. https://doi.org/10.1080/02699930701782153.

Wang, S., Jiang, M., Duchesne, X.M., Laugeson, E.A., Kennedy, D.P., Adolphs, R., Zhao, Q., 2015. Atypical visual saliency in autism spectrum disorder quantified through model-based eye tracking. Neuron 88 (3), Article 3. https://doi.org/10.1016/j.neuron.2015.09.042.

Wass, S.V., Whitehorn, M., Haresign, I.M., Phillips, E., Leong, V., 2020. Interpersonal neural entrainment during early social interaction. Trends Cogn. Sci. 24 (4), 329–342. https://doi.org/10.1016/j.tics.2020.01.006.

Waters, E., Posada, G., Crowell, J., Lay, K.-L., 1993. Is attachment theory ready to contribute to our understanding of disruptive behavior problems? Dev. Psychopathol. 5 (1–2), 215–224. https://doi.org/10.1017/S0954579400004351.

Weber, M., 1978. Selections in Translation. University Press.

Weiß, M., Gutzeit, J., Rodrigues, J., Mussel, P., Hewig, J., 2019. Do emojis influence social interactions? neural and behavioral responses to affective emojis in bargaining situations. Psychophysiology 56 (4), e13321. https://doi.org/10.1111/psyp.13321.

Weisz, E., Cikara, M., 2021. Strategic regulation of empathy. Trends Cogn. Sci. 25 (3), 213–227. https://doi.org/10.1016/j.tics.2020.12.002.

West, G.L., Anderson, A.A.K., Ferber, S., Pratt, J., 2011. Electrophysiological evidence for biased competition in V1 for fear expressions. J. Cogn. Neurosci. 23 (11), 3410–3418. https://doi.org/10.1162/jocn.2011.21605.

Whalen, D.H., Benson, R.R., Richardson, M., Swainson, B., Clark, V.P., Lai, S., Mencl, W. E., Fulbright, R.K., Constable, R.T., Liberman, A.M., 2006. Differentiation of speech and nonspeech processing within primary auditory cortex. J. Acoust. Soc. Am. 119 (1), 575–581. https://doi.org/10.1121/1.2139627.

Wickens, C.D., Carswell, C.M., 2021. Information processing. In: Salvendy, G., Karwowski, W. (Eds.), Handbook of human factors and ergonomics, 1st ed. Wiley, pp. 114–158. https://doi.org/10.1002/9781119636113.ch5.

Wickramaratne, P.J., Yangchen, T., Lepow, L., Patra, B.G., Glicksburg, B., Talati, A., Adekkanattu, P., Ryu, E., Biernacka, J.M., Charney, A., Mann, J.J., Pathak, J., Olfson, M., Weissman, M.M., 2022. Social connectedness as a determinant of mental health: a scoping review. PLOS ONE 17 (10), e0275004. https://doi.org/10.1371/journal.pone.0275004.

Willis, J., Todorov, A., 2006. First impressions: making up your mind after a 100-ms exposure to a face. Psychol. Sci. 17 (7), 592–598. https://doi.org/10.1111/j.1467-9280.2006.01750.x.

Wit, A.P., Wilke, H.A.M., 1992. The effect of social categorization on cooperation in three types of social dilemmas. J. Econ. Psychol. 13 (1), 135–151. https://doi.org/10.1016/0167-4870(92)90056-D.

Wühr, P., Huestegge, L., 2010. The impact of social presence on voluntary and involuntary control of spatial attention. Soc. Cogn. 28 (2), Article 2. https://doi.org/10.1521/soco.2010.28.2.145.

Xu, X., Mishra, G.D., Holt-Lunstad, J., Jones, M., 2023. Social relationship satisfaction and accumulation of chronic conditions and multimorbidity: a national cohort of Australian women. Gen. Psychiatry 36 (1), e100925. https://doi.org/10.1136/gpsych-2022-100925.

Yarkoni, T., Poldrack, R., Nichols, T., 2011. Large-scale automated synthesis of human functional neuroimaging data. Nat. Methods 8 (8), 665–670. https://doi.org/10.1038/NMETH.1635.

Zajonc, R.B., 1965. Social facilitation: a solution is suggested for an old unresolved social psychological problem (Article). Science 149 (3681), 3681. https://doi.org/10.1126/science.149.3681.269.

Zaki, J., Ochsner, K., 2009. The need for a cognitive neuroscience of naturalistic social cognition. Ann. N. Y. Acad. Sci. 1167 (1), 16–30. https://doi.org/10.1111/j.1749-6632.2009.04601.x.

Zhou, Y., Han, S., Kang, P., Tobler, P.N., Hein, G., 2024. The social transmission of empathy relies on observational reinforcement learning. Proc. Natl. Acad. Sci. 121 (9), e2313073121. https://doi.org/10.1073/pnas.2313073121.

Zimet, G.D., Dahlem, N.W., Zimet, S.G., Farley, G.K., 1988. The multidimensional scale of perceived social support. J. Personal. Assess. 52 (1), 30–41. https://doi.org/10.1207/s15327752jpa5201_2.