

## Self-Other Distinction in Interpersonal Interaction: A Multilevel Exploration

**Authors:** Chenghui Tan, Shanshan Ma, Zhu Chuanlin, Zhao Yuan, Wang Xuanyi, Shu Deming, Liu Dianzhi, Shu Deming, Liu Dianzhi

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### Abstract

The fundamental challenge of interpersonal interaction concerns how we represent our own thoughts and feelings while simultaneously attempting to comprehend others' mental and emotional states in order to navigate complex social environments. Recent research has revealed that individuals primarily achieve understanding of others through simulating self-processing mechanisms; however, this self-processing and mental simulation partially conflate self and other. Therefore, to engage in successful interpersonal interactions, the brain must flexibly distinguish between self-related and other-related representations, a capability referred to as "self-other distinction" (SOD). By investigating the "self-other distinction" and corresponding research paradigms in social cognitive processes at various processing levels—including perception, action, cognition, and emotion—a more comprehensive and profound understanding of interpersonal interaction processes can be achieved, providing a foundation for improving interventions for social cognition, affective disorders, and autism. Based on this foundation, specific research prospects are proposed.

### Full Text

## The Self-Other Distinction in Interpersonal Interaction: A Multi-Level Exploration

Tan Chenghui<sup>1</sup>, Ma Shanshan<sup>1</sup>, Zhu Chuanlin<sup>2</sup>, Zhao Yuan<sup>1</sup>, Wang Xuanyi<sup>1</sup>, Shu Deming<sup>1</sup>, Liu Dianzhi<sup>1</sup>

<sup>1</sup> School of Education, Soochow University, Suzhou 215123, China

<sup>2</sup> School of Educational Science, Yangzhou University, Yangzhou 225002, China

## Abstract

The fundamental challenge of interpersonal interaction lies in how we represent our own thoughts and feelings while simultaneously attempting to understand others' mental and emotional states to navigate complex social environments. Recent research has found that individuals primarily understand others by simulating self-processing mechanisms, yet such self-processing and mental simulation can, to some extent, conflate self and other. Therefore, to engage in successful interpersonal interaction, the brain must flexibly differentiate between self- and other-related representations—a capability known as self-other distinction (SOD). By examining SOD across different processing levels of social cognition, including perception, action, cognition, and emotion, along with the corresponding research paradigms, we can achieve a more comprehensive and in-depth understanding of interpersonal interaction processes, providing a basis for improving interventions in social cognition, affective disorders, and autism. Building upon this foundation, we propose specific directions for future research.

**Keywords:** self-other distinction; perception; action; cognition; emotion

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Humans engage in various interactions with friends and strangers daily. Although these interaction contexts differ, successful navigators always seem to make appropriate responses—what we often call “talking to people in their own language” and adapting flexibly to circumstances. Research has found that when understanding others' thoughts and feelings, people rely at least partially on predictions of what they themselves might think or feel in similar situations (Nickerson, 1999; O' Brien & Ellsworth, 2012). Social neuroscience evidence indicates that considering others' thoughts or resonating with their feelings involves shared neural representations, supporting this claim (Jenkins et al., 2008; Lamm et al., 2011; Steinbeis & Singer, 2014). However, to achieve smooth interpersonal interaction and prevent shared neural representations from blurring the boundary between self and other, we must differentiate between our own and others' mental representations. This ability, known as self-other distinction (SOD) (Spengler et al., 2009), is the process by which we independently process and flexibly differentiate self- and other-representations (Shaw et al., 2017).

Inefficient self-other distinction leads to egocentricity bias or altercentric bias. The former refers to erroneously imposing one' s own thoughts or experiences onto others, while the latter means that others' thoughts and feelings influence our judgments of our own experiences (Banzhaf, 2018). Both biases cause inappropriate responses in interpersonal interaction (Lamm et al., 2016; Steinbeis, 2016) and may even trigger various neurodevelopmental disorders. For instance, impaired self-other distinction is a hallmark feature of social deficits in autism spectrum disorder (ASD) patients (Hoffmann et al., 2016). Similar impairments also appear in psychopathy (Lamm et al., 2016) and borderline personality disorder patients (Beeney et al., 2016), and may contribute to psychopathological conditions such as depression (Ladegaard et al., 2016) and addiction (Quednow,

2017; Tomei et al., 2017). This demonstrates that self-other distinction ability determines whether we can clearly recognize self and other in interpersonal interactions, respond to others appropriately, and maximize understanding of others' thoughts and feelings without compromising ourselves, thereby reducing social impairments.

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*Corresponding authors: Shu Deming, E-mail: [8deming@163.com](mailto:8deming@163.com); Liu Dianzhi, E-mail: [liudzh@suda.edu.cn](mailto:liudzh@suda.edu.cn)*

Successful interpersonal interaction presupposes recognizing others' genuine intentions and feelings. Consequently, most research has focused on how individuals process other-related information during interaction, examining the encoding mechanisms underlying the understanding of others' thoughts and emotions. This has led to a general neglect of self-processing and the importance of self-other distinction in social cognitive processes (Nijhof & Bird, 2019). Meanwhile, an increasing body of empirical evidence demonstrates that the ability to accurately differentiate self- and other-representations is crucial for social cognition across multiple levels. For instance, at the action level, self-other distinction is needed to flexibly regulate imitation and prevent blind mimicry (Rauchbauer et al., 2016); at the cognitive level, it is required to infer others' thoughts and reduce egocentric biases and misattribution (Shaw et al., 2017). Some researchers have speculated that self-other distinction processes at different levels may rely on similar processing modes (Lamm et al., 2016; Santiesteban, White, et al., 2012), while other studies have reached opposite conclusions (Tomova et al., 2019). In other words, whether self-other distinction constitutes a domain-general cognitive process—that is, whether the mechanisms involved in self-other distinction across different levels of social cognition are domain-specific—remains an open question. If self-other distinction processes at different levels involve similar neural networks or processing mechanisms, it would be reasonable to believe that training self-other distinction ability at one level might improve difficulties with self-other distinction at other levels, thereby promoting interpersonal interaction to some extent.

Steinbeis (2016) reviewed the role of self-other distinction in understanding others' mental and emotional states and its developmental mechanisms in children and adults. However, that study focused primarily on the emergence and development of self-other distinction ability, lacking a systematic review of how it functions in social cognitive processes. Building upon this foundation, the present article incorporates recent research findings to examine self-other distinction in multi-level social cognitive processes in a hierarchical manner. By reviewing self-other distinction at the perceptual level (somatic sensation, interoception), action level (action imitation), cognitive level (theory of mind), and affective level (empathy), and based on their respective processing characteristics, we further discuss how commonly used paradigms in recent years

can be applied to research in this field, facilitating further exploration by domestic researchers. Finally, we propose current challenges facing research and future development directions, aiming to provide new perspectives and scientific evidence for clinical interventions in populations with deficits in this area, particularly special populations.

## 2 Perceptual-Level Self-Other Distinction

Perceptual-level self-other distinction primarily encompasses somatic sensation and interoception, involving the differentiation of spatial location, faces, and touch between self and other. Self-other distinction in somatic sensation determines individuals' visuotactile and visuospatial encoding, thereby influencing processes such as spatial location judgment and face recognition. In recent years, researchers have found that interoceptive processing appears crucial for self-other distinction, correspondingly affecting individuals' perception of bodily states. Furthermore, when connections with higher-level social cognitive and affective processes are required, perceptual-level self-other distinction directly determines the amount of information available for inferring others' thoughts and feelings, influencing how we understand others to some extent.

### 2.1 Somatic Sensation

Somatic sensation primarily distinguishes self from other by strengthening self-encoding, involving aspects such as touch, spatial location, and face recognition. Previous studies have found that the primary somatosensory cortex (S1) not only processes tactile sensations from one's own body but also responds when observing others being touched (Bolognini et al., 2014; Holle et al., 2013). This shared tactile representation requires the brain to possess a computational mechanism capable of encoding the agent identity of tactile sources to achieve self-other distinction in visuotactile processing. Consequently, some researchers propose that self- and other-related tactile representations activate distinct locations within the broadly defined S1 region, enabling mutual differentiation (Chan & Baker, 2015; Sharma et al., 2018). Further research has revealed that  $\alpha$ -wave connectivity within the frontoparietal pathway determines self-other distinction ability in visuotactile processing, detectable only during self-received touch, thereby controlling and differentiating shared tactile representations in S1 (Pisoni et al., 2018).

Moreover, the continuous updating and integration of somatic signals facilitate the encoding of others' spatial locations, encompassing geometric transformations such as viewpoint translation and rotation (other-centered visuospatial encoding), as well as mental simulation based on multisensory integration of one's own vision, proprioception, and vestibular information (self-centered visuospatial encoding) (Deroualle & Lopez, 2014). The existence of these two encoding mechanisms enables self-other distinction in visuospatial processing (Thirioux et al., 2014) and can further influence self-other face recognition. However, it primarily promotes self-face recognition by enhancing the visual representation

of one's own face, without affecting other-face recognition (Apps, Tajadura-Jiménez, et al., 2015). Conversely, self-other face recognition can alter self-centered visuospatial encoding through self-other distinction, but does not affect other-centered visuospatial encoding (Thirioux et al., 2016). This not only demonstrates the self-face advantage effect in face recognition (Sui et al., 2015) but also indicates that visuospatial encoding and face recognition promote self-other distinction primarily by strengthening self-representation, thereby achieving mutual influence and facilitation.

In recent years, researchers have developed a “double mirror” paradigm for studying self-other distinction (Thirioux et al., 2016). The procedure is as follows: two individuals, A and B, sit facing a semi-transparent double-sided mirror, with five white LEDs placed on each side. If the LEDs on A's side are turned on while those on B's side are off, A can see his/her own facial mirror image but not B's face, whereas B can see A's face through the mirror but not his/her own mirror image, and vice versa. If LEDs on both A and B sides are turned on simultaneously and flash alternately at 8 Hz, the facial mirror images of A and B merge in the mirror, creating an illusory effect. This paradigm creates visual stimuli of interpersonal interaction for participants, manipulating self-other face recognition to reflect the magnitude of self-other distinction. In social interaction, resolving conflicts between self- and other-representations in somatic sensation forms the basis for further inferring and understanding different mental states between self and other. Recent research has found that interoception appears to play an important bridging role in this process.

## 2.2 Interoception

Interoception refers to the awareness and processing of bodily signals originating from visceral organs (Craig, 2002), including hunger, body temperature, heart rate, and blood glucose levels, reflecting our perception of internal bodily states (Murphy et al., 2017). The importance of interoception for maintaining physical health has been widely recognized (Garfinkel et al., 2015). However, recent research has revealed that it also plays a significant role in the psychological representation of the self. Palmer and Tsakiris (2018) propose that self-representation is formed through the integration of top-down “predictions” about bodily states and bottom-up “prediction errors” (PEs) from interoceptive and exteroceptive inputs. The more stable the self-representation, the better one can differentiate self from other and the less susceptible one is to others' influence (Ainley et al., 2016; Seth & Friston, 2016). With attentional engagement, the stability of the self-representation model is determined by the accuracy of interoceptive predictions. Empirical studies have also found that enhancing attention to interoception can improve the rubber-hand illusion (Sel et al., 2017; Zeller et al., 2016), whereas lower interoceptive awareness makes one more vulnerable to bodily illusions (Palmer & Tsakiris, 2018). Furthermore, more accurate perception of one's own mental and bodily states through interoception leads to better understanding and grasp of others' emotional states (Shah et al., 2017). This

suggests that interoception, by influencing the stability of self-representation, not only enhances self-other distinction in somatic sensation but also facilitates the attribution of mental states or emotions, avoiding difficulties with self-other distinction in higher-level cognitive processes (Fotopoulou & Tsakiris, 2017).

Thus, correctly weighting interoceptive and exteroceptive predictions is crucial for maintaining self-other distinction. The more accurate an individual's predictions about their own interoceptive states, the better they can differentiate their own bodily or mental states from those of others, understand the causes of these states, and thereby provide a foundation for self-other distinction in higher-level cognitive processes using these signals. Moreover, although we can promote self-other distinction in somatic sensation and interoception by strengthening self-encoding, in real life, the tendency toward automatic imitation often leads to altercentric bias, which is detrimental to self-other distinction. Among these, research on imitation inhibition at the action level is the most classic and fundamental, often used to reflect low-level self-other distinction ability.

### 3 Action-Level Self-Other Distinction

Action-level self-other distinction refers to the experience of sense of agency (SoA)—the ability to perceive that an action is initiated or generated by oneself. Similar to the mechanism of the somatosensory cortex, observation of others' actions and execution of one's own actions share a common representational basis (Brass & Heyes, 2005). However, when observed and executed actions are inconsistent, this shared neural representation may lead to confusion between self and other. To avoid blind mimicry, the brain must differentiate between self-related signals and simulated signals of others (Lamm et al., 2016; Lamm et al., 2019). Steinbeis (2016) suggests that this distinction primarily manifests as prioritizing processing of input information that can achieve expected goals to enable appropriate responses.

Researchers have adapted existing imitation inhibition paradigms to measure self-other distinction in action imitation, namely the stimulus-response compatibility (SRC) procedure (Brass et al., 2001; Brass et al., 2000), which has been widely applied in self-other distinction research in recent years (de Guzman et al., 2016; Hogeveen et al., 2014; Tomova et al., 2014). In this task, a horizontally presented left hand serves as the observed hand, and participants are required to respond with their right hand, as if viewing their own hand in a mirror. Participants must respond according to stimulus signals between the fingers of the observed hand ("1" for index finger lift, "2" for middle finger lift). The observed hand's actions and the participant's response actions create two conditions: congruent, where the participant's required response matches the observed finger movement, and incongruent, where the observed and response fingers differ. Participants are instructed to lift their fingers quickly and accurately according to the stimulus signals in congruent conditions. The resulting congruency effect is automatic imitation (AI). In incongruent conditions, this automatic imitation tendency must be inhibited to accurately differentiate self-

and other-action representations (Brass et al., 2009; Lamm et al., 2016; Steinbeis, 2016). In other words, the more automatic imitation participants exhibit in incongruent conditions, the poorer their self-other distinction ability; the less automatic imitation, the stronger their self-other distinction ability. Based on this, the magnitude of automatic imitation in this task can serve as a measure of self-other distinction. However, because the observed and response hands are mirror images, automatic imitation under these conditions may be driven by both imitative and spatial congruency between observed and executed actions, raising concerns about whether task performance reflects self-other distinction or general response inhibition processes (Marsh et al., 2016; Steinbeis, 2016). Neuroscience research has found that, compared to spatially congruent actions, actions with imitative congruency between observation and execution show greater functional connectivity with the mirror neuron system (Cross et al., 2013; Sowden & Catmur, 2015). This partially demonstrates that action-level self-other distinction is primarily modulated by imitative congruency rather than spatial congruency.

To exclude the influence of spatial congruency, some researchers have rotated the observed hand stimulus counterclockwise, making the observed and executed finger movements orthogonal to each other (de Guzman et al., 2016; Hogeveen et al., 2014; Obhi et al., 2014). However, this manipulation introduces another spatial confound: the orthogonal-compatibility effect. To examine whether such spatial factors affect the measurement of action-level self-other distinction ability, Shaw et al. (2017) compared action-level and cognitive-level self-other distinction. Action-level self-other distinction included two types: one where observed and executed finger actions had both imitative congruency and orthogonal compatibility, and another where stimuli had only imitative congruency. They compared the correlation between each type and cognitive-level self-other distinction (i.e., perspective-taking).

The results indicated that a correlation between action-level and cognitive-level self-other distinction exists only when stimuli have imitative congruency alone; when stimuli contain spatial factors, no correlation is found. This demonstrates that spatial factors in this paradigm—whether spatial congruency or orthogonal compatibility—confound the measurement of self-other distinction in action imitation, while imitative congruency truly reflects the self-other distinction process. This suggests that researchers wishing to use this paradigm to measure self-other distinction must ensure that stimuli and responses have only imitative congruency, excluding any spatial interference. However, this is based on the premise that the two tasks at action and cognitive levels can reflect consistent self-other distinction ability, which requires further empirical verification. Because compared to self-other distinction at perceptual and action levels, social cognitive processes at cognitive and affective levels demand more cognitive resources for judgment and decision-making, requiring individuals not only to correctly infer others' mental states and emotional experiences but also to make appropriate responses according to context, avoiding the adverse effects of excessive egocentricity or altercentricity.

## 4 Cognitive-Level Self-Other Distinction

Cognitive-level self-other distinction involves inferring others' mental states during interpersonal interaction, namely Theory of Mind (ToM). ToM refers to the process of reasoning about and inferring others' beliefs, thoughts, or emotions, forming abstract, propositional knowledge about others' mental states (Mitchell, 2005; Saxe & Kanwisher, 2003), and serves as the foundation for smooth interpersonal interaction. When interpreting others' mental states, we must avoid imposing our own thoughts onto others. Unlike action imitation inhibition, this situation requires distinguishing between both representations (Santiesteban, White, et al., 2012)—clearly knowing one's own thoughts while simultaneously inferring what others might think. Currently, the primary experimental paradigms used to measure self-other distinction in theory of mind are the Director Task (DT) and the Sandbox Task.

The Director Task (DT) (Keysar et al., 2000; Santiesteban, Banissy, et al., 2012) requires participants to move objects in a shelf grid according to a “director's” instructions. The grid is designed with two different perspectives: the positions of items seen by the participant from the front differ from those seen by the director from the back. To follow the director's instructions, participants must inhibit their self-perspective representation and respond according to the director's perspective. Although controversy remains regarding whether DT task performance reflects mentalizing (Apperly et al., 2010; Dumontheil et al., 2010) or submentalizing processes (Heyes, 2014; Santiesteban et al., 2015), avoiding egocentric errors requires flexibly distinguishing between competing self- and other-representations. From this perspective, the DT task can reflect cognitive-level self-other distinction ability.

The Sandbox Task (Begeer et al., 2016; Bernstein et al., 2017; Coburn et al., 2015; Mahy et al., 2017) is an adaptation of the false belief task (Wimmer & Perner, 1983). The false belief task only requires participants to indicate which of two locations an object might be in, yielding either correct or incorrect responses. It cannot reveal whether participants encode information obtained by different agents during mental state inference; thus, task results do not reflect participants' self-other distinction ability. The adapted Sandbox Task requires participants to make continuous rather than binary responses. Specifically, an object is hidden in a sink or sandbox and then moved to a second location within the sandbox while the experimenter is absent. Participants must indicate where they believe the experimenter thinks the object is located in continuous space. The distance between the original and new locations reflects self-other distinction ability. Empirical studies have found that inferring others' beliefs makes self-other distinction more difficult compared to indicating the original location from one's own memory, showing an egocentric bias (Bernstein et al., 2017; Coburn et al., 2015; Samuel et al., 2018a). Recent studies using this task have required participants to reason under three conditions (others' memory, others' false beliefs, and actions based on false beliefs). Results revealed no differences in participants' self-other distinction performance across the three

conditions, with no greater egocentric bias shown when reasoning about others' beliefs (Samuel et al., 2018b).

This may reflect low task sensitivity or indicate that inferring others' memory, beliefs, and actions relies on consistent self-other distinction mechanisms that differ from self-related inference. Future research could add a self-memory condition for further investigation. Ereira et al. (2018) combined magnetoencephalography with computational modeling to demonstrate that the mentalizing process primarily achieves self-other distinction by encoding the agent identity inherent in basic learning signals. That is, when inferring and understanding others' mental states, we distinguish self- and other-mental states by employing different neural activity patterns to encode signals from self and other. However, successful interpersonal interaction requires not only perceiving that others' thoughts differ from our own but more often demands that we maximize our understanding of others and share their emotional experiences without compromising ourselves.

## 5 Affective-Level Self-Other Distinction

Affective-level self-other distinction is primarily manifested in empathy. Empathy refers to the ability to understand others' emotional feelings and resonate with them (Lockwood, 2016; Singer & Lamm, 2009), forming the basis for sharing others' emotional experiences. However, empathy can also lead to maladaptive responses, such as personal distress (PD), which negatively affects both oneself and others (Klimecki et al., 2016; Singer & Klimecki, 2014). To avoid such adverse effects, one must differentiate between one's own emotions and the resonant emotions evoked by others (Preckel et al., 2018). Using affective visuotactile stimulation can assess self-other distinction ability in empathy. Paired participants are selected, and two experimenters simultaneously apply positive or negative material stimuli to each participant. Participants are then informed about the nature of the material the other participant touched. This creates consistent experiences (both participants touch positive or negative materials) or inconsistent experiences (participants touch positive and negative materials, respectively). After the experiment, participants evaluate their own feelings and what they believe the other person might feel. The degree of participants' emotional attribution errors can reflect their self-other distinction ability (Silani et al., 2013).

This paradigm examines self-other distinction in empathy by combining low-level visuotactile processing, reflecting to some extent the interaction between cognitive processes at different processing levels.

According to the two-stage model of empathy—comprising an early automatic emotional resonance stage and a later controlled cognitive evaluation stage (Groen et al., 2013)—Luo et al. (2015) proposed a new research paradigm. One task requires participants to judge whether the emotional state of a face image is sad or neutral (other-task), while another task requires participants to

evaluate whether their own emotional response to the face image is sad or neutral (self-task). ERP results showed that in the other-task, women exhibited higher resonance and recognition abilities for others' emotions than men; in the self-task, men showed higher self-other distinction when viewing face images, meaning their judgments of self-emotions were less influenced by others' emotions. This distinction existed not only in the early automatic resonance stage but also in the later controlled stage (Luo et al., 2015). Evidently, self-other distinction plays an important role in enabling individuals to recognize others' feelings and resonate with them. Women have stronger understanding and resonance with others' feelings but are also more susceptible to negative effects from others' negative emotions, thus requiring more cognitive effort to regulate their own emotions. Men, conversely, allocate more cognitive resources to monitoring the self while distinguishing self from other, making them less affected by others' sadness. This may explain gender differences in empathy abilities.

In recent years, researchers have improved upon this paradigm by requiring participants to first watch scary or neutral scene videos and listen to brief scary or neutral audio recordings in which the subject is either oneself or "J." For example, a scary recording might state, "You/J see a human face in the window of an empty building," while a neutral recording might state, "You/J see a boy riding a bicycle on the road." Participants are then asked to rate three conditions on a four-point Likert scale: imagining how they would feel in this situation (self-condition), imagining how "J" would feel (other-condition), and how they themselves feel after hearing about J's situation (self-other condition) (Sethi et al., 2018). Such improvements more accurately differentiate between self- and other-emotional feelings, as well as the emotional feelings generated by resonance with others in empathy, enabling more precise assessment of self-other distinction ability in empathy.

Existing research has found that action-level self-other distinction ability correlates with performance on cognitive- and affective-level self-other distinction tasks, indicating certain connections between self-other distinction processes across different levels (Genschow et al., 2017; Shaw et al., 2017). Neuroimaging studies have shown that the temporoparietal junction (TPJ) is generally functionally involved in self-other distinction processing, with the dorsal portion primarily responsible for perceptual-action and affective-level self-other distinction, while the ventral portion mainly handles cognitive-level self-other distinction (Quesque & Brass, 2019).

Furthermore, regarding perceptual- and action-level self-other distinction, Kahl and Kopp (2018), from the perspective of somatosensory and motor systems, propose that we differentiate self- and other-actions by integrating unpredictable information about others based on the predictability of our own bodies while synthesizing simulation results from different perceptual and action-generation scenarios. For action- and cognitive-affective-level self-other distinction, recent fMRI studies have found (Apps, Lesage, et al., 2015; Lockwood et al., 2015) that when participants observe others interacting with the environment, they

encode not only others' actions but also simulate others' reinforcement learning processes, establishing relationships between intentions, behaviors, and outcomes. Self-other distinction enables this simulation to play a learning role in social interaction. Moreover, research has found that action imitation inhibition training can enhance participants' performance in perspective-taking and empathy tasks (Santesteban, White, et al., 2012; de Guzman et al., 2016), suggesting that training self-other distinction ability at the action level can influence cognitive- and affective-level self-other distinction. To clarify connections between self-other distinction at different levels, further investigation is needed into whether their cognitive resource utilization and corresponding neural activation patterns are identical. After this review, we propose that self-other distinction can be viewed as a domain-general ability, but with differing mechanisms of action. Low-level self-other distinction may primarily be achieved by strengthening self-representation to inhibit other-representation, whereas high-level self-other distinction mainly highlights other-representation. Meanwhile, in actual interpersonal interaction, high-level self-other distinction relies to some extent on low-level self-other distinction ability, though this awaits further empirical verification.

## 6 Summary and Outlook

As an essential ability for interpersonal interaction, self-other distinction plays important roles in both low-level processing such as perception and action and high-level processing such as cognition and emotion. Self-awareness and perception of the body require encoding visuospatial mechanisms or visuotactile stimuli to better identify the self and differentiate self- and other-related representations. Inhibiting the tendency to automatically imitate others' actions facilitates self-other distinction. When understanding others' mental states, self-other distinction ability is needed to avoid misattribution due to egocentric bias. When resonating with others' emotions, self-other distinction ability can increase empathic concern while preventing personal distress or even antisocial behavior (Klimecki et al., 2016). Research has found that individuals with alexithymia merely lack the ability to automatically apply self-other distinction; if given relevant cues to guide them in distinguishing self- and other-representations, their self-other distinction function can improve substantially, further enhancing their empathic ability (Saito et al., 2016). This suggests that individuals' self-other distinction ability may be enhanced through training, consequently improving their social cognitive processes, which is significant for interpersonal interaction.

Therefore, we believe future research on self-other distinction can be improved in the following areas. First, refine the corresponding research paradigms. Although the classic SRC procedure and DT task are widely used in self-other distinction research, whether these paradigms can accurately measure the magnitude of self-other distinction ability in practice remains questionable. By contrast, combining perceptual-action-level and cognitive-affective-level self-other distinction may provide clues for assessing the validity of measurement indices

—for example, by attempting to compare performance in the double mirror paradigm with that in the DT task. Additionally, the recently developed Sandbox Task has issues with general applicability, yielding inconsistent results across different participant populations (Bernstein et al., 2017; Samuel et al., 2018b). Therefore, future research could develop more universally applicable paradigms by integrating findings from neuroscience research.

Second, thoroughly investigate the internal mechanisms of mutual influence between self-other distinction processes at different levels. Although the TPJ region is generally involved in self-other distinction, the brain regions engaged in self-other distinction processing at different levels are not entirely identical. In particular, when complex social interactions require the participation of multi-level self-other distinction processes, the resulting neural activation patterns remain unknown. Furthermore, the specific connections between self-other distinction at different levels require further exploration. Although existing studies have modeled self-other distinction at action and cognitive levels (Ereira et al., 2018; Kahl & Kopp, 2018), current models only cover partial domains. It is necessary to combine findings from neuroimaging research to integrate multi-level self-other distinction models and construct more comprehensive cognitive computational models to deepen understanding of self-other distinction mechanisms in higher-level social cognition. Combining recent multi-person interactive synchronization techniques (Wheatley et al., 2019) may provide clues for studying social cognitive processes that neuroscience has not yet been able to elucidate. Simultaneously, it may reveal how self-other distinction across multi-level cognitive processes influences one another—that is, whether training can holistically improve individuals' self-other distinction ability.

Third, examine the factors influencing self-other distinction ability. Although self-other distinction processes at different levels are interconnected, actual processing may be affected by different factors. Research has found that self-other distinction ability changes with age development (Riva et al., 2016). Although children already possess neural networks similar to adults that are suitable for multi-level self-other distinction processing (Steinbeis et al., 2015), actual development may require corresponding functional maturation, yet the factors influencing this maturation remain unclear. Moreover, considering symptom improvement in special populations, it is necessary to investigate factors affecting self-other distinction processes at different levels. For example, recent research has found that oxytocin (OXT) can enhance cognitive-level self-other distinction but has no effect on action-level self-other distinction or attentional reorienting tasks in non-social cognitive processes (Tomova et al., 2019). Additionally, some researchers have hypothesized whether other executive functions such as cognitive flexibility might influence self-other distinction processes at different levels (Czekóová et al., 2019). Therefore, future research could deeply investigate factors affecting self-other distinction at different levels to provide more scientific evidence for improving and enhancing self-other distinction ability.

Finally, future research should focus more on interventions for special populations, combining training of self-other distinction abilities at different levels to provide new intervention protocols for these groups. Simultaneously, using special populations as research subjects can better illuminate the essence and structure of social cognitive processes, providing more empirical evidence for existing theories (Happé et al., 2017). Research has found that for individuals with alexithymia, interoceptive abnormalities may be the root cause of their emotional symptoms (Brewer et al., 2016; Longarzo et al., 2015). Recent studies on individuals with autism have also begun to examine the relationship between perceptual abnormalities and higher-level cognitive functions (Foster et al., 2019; Hayes et al., 2018; Robertson et al., 2017), which may provide new perspectives for understanding self-other distinction in autism interpersonal interactions. This also suggests that we could develop interoception-focused self-other distinction training interventions for special populations (Kuehn et al., 2018). However, research in this area remains in its infancy. Future intervention studies are expected to reveal whether training perceptual-action-level self-other distinction ability can improve cognitive-affective-level self-other distinction deficits in special populations. Correspondingly, training focused on cognitive-affective-level self-other distinction ability might also reciprocally promote perceptual-action-level self-other distinction. Therefore, addressing various issues in the domain of self-other distinction will facilitate a more comprehensive understanding of social cognition and interpersonal interaction processes, enrich current theoretical achievements, and provide effective intervention measures for individuals with affective disorders and autism, helping to improve their social functioning.

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### The self-other distinction in interpersonal interaction: A multi-level exploration

TAN Cheng-hui<sup>1</sup>; MA Shan-shan<sup>1</sup>; ZHU Chuan-lin<sup>2</sup>; ZHAO Yuan<sup>1</sup>; WANG Xuan-yi<sup>1</sup>; SHU De-ming<sup>1</sup>; LIU Dian-zhi<sup>1</sup>

<sup>1</sup> School of Education, Soochow University, Suzhou 215123, China

<sup>2</sup> School of Educational Science, Yangzhou University, Yangzhou 225002, China

**Abstract:** The fundamental problem with interpersonal interaction is how we can understand others' mental and emotional states while characterizing our own concurrent thoughts and feelings to navigate the complex social world efficiently. Recent studies have showed that individuals understand others mainly by simulating self-processing processes; however, such self-processing and mental simulations confuse the self with others to some extent. Therefore, the brain needs to be able to differentiate between the representation of self and others flexibly to carry out successful interpersonal interactions. This ability is known as self-other distinction (SOD). In the present study, various cognitive operations at different processing levels that require SOD, such as perception, action, cognition, and emotion, as well as the research paradigm applicable to the corresponding field, were reviewed. The study of SOD may be more conducive to comprehensively understand the interpersonal interaction process. Furthermore,

it can be a useful intervention to improve social cognition, affective disorder, and people with autism. In addition to focusing on the paradigm, internal mechanism, and influencing factors, this study puts forward the prospects for further research emphasizing interventions for special populations.

**Key words:** Self-other distinction; Perception; Action; Cognition; Emotion

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