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Mechanisms and development of self–other distinction in dyads and groups

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This opinion piece offers a commentary on the four papers that address the theme of the development of self and other understanding with a view to highlighting the important contribution of developmental research to understanding of mechanisms of social cognition. We discuss potential mechanisms linking self–other distinction and empathy, implications for grouping motor, affective and cognitive domains under a single mechanism, applications of these accounts for joint action and finally consider self–other distinction in group versus dyadic settings.

In this opinion piece, we will offer a commentary on the four papers that address the theme of the development of self and other understanding with a view to highlighting the important contribution of developmental research to understanding of mechanisms of social cognition. While two of the papers [1,2] provide outlines for a key role of self–other distinction as a route to successful dyadic interaction within motor, cognitive and affective domains, the other two focus on group-level analyses of social cognition that highlight motivational [3] and evolutionary [4] themes. This piece will discuss three issues that arise from these papers. First, we will discuss the claim that distinguishing between self and other is crucial for empathy, and raise some questions about the potential mechanisms that could support this link. Second, we will reflect on the implications for grouping three distinct domains (motor, cognitive and affective) under a single mechanism, as has been suggested by de Guzman *et al.* [1], and consider self–other distinction in the context of joint action. Finally, we will discuss the potential for uniting what are currently relatively independent literatures on group versus dyadic interaction and clarifying whether the mechanisms suggested in each literature can inform research in the other field.

In the study reported by de Guzman *et al.* [1], participants who had performed a training task that required performing movements opposite to the ones performed by a model subsequently showed signs of increased empathy. As discussed by the authors, this finding seems to suggest that increasing control over self and other representations may increase empathy. One possibility, discussed in detail by Steinbeis [2], is that distinguishing between self and other is helpful because it serves to reduce egocentric bias. While this may be a plausible mechanism when it comes to appreciating differences in beliefs and perspectives, it is unclear how exactly making a distinction between one's own and another's actions could increase empathy. One possibility is that the key process involved is about increasing other-related activations, rather than the control of self and other representations as such. This interpretation is in line with findings suggesting that blurring self–other boundaries and increasing identification with another's body or actions can modulate social cognition [5]. For example, in a study by Maister *et al.* [6], implicit attitudes towards out-group members became more positive after participants underwent a rubber hand manipulation that made an out-group hand feel like their own. The more participants experienced ownership over the out-group hand, the more their implicit attitudes changed. It is possible that the training task used by de Guzman *et al.* had the effect of making participants pay more attention to the model's hand as they had to rely on the observed actions to prepare for performing opposite actions, while participants in the control group who were instructed to simply imitate observed movements might have

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performed the task by relying on spatial compatibility cues. This suggests further experimental manipulations to tease apart the role of changes in self-related representations and other-related representations in empathy.

Our second point pertains to de Guzman *et al*.'s claims that self–other distinction is an over-arching mechanism that links three domains of social cognition (motor, cognitive and affective), potentially through neural connectivity between temporo-parietal brain regions that have been linked to each domain. Steinbeis makes similar claims, although this account emphasizes dissociations between domains under a more general self–other distinction mechanism. Although these are clearly first steps towards evidencing a unified account, it is necessary to point out the need for further studies demonstrating the directionality of relationships and interactions between these domains. de Guzman *et al*. demonstrate that training in the motor domain can lead to improvement, not only within the motor domain but also in the affective domain, by increasing empathy as measured by both motor-evoked potentials and questionnaire measures. Previous research cited also found an effect of training in the motor domain on performance in the cognitive domain, on a visual perspective-taking task [7]. However, it remains to be seen whether these effects are multi-directional, so that training in affective or cognitive domains could impact upon each other or even impact on the motor domain. More generally, one may wonder whether a single mechanism of self–other distinction is plausible given that the problems to be solved within each domain may differ substantially. For instance, in the motor domain, actors sometimes have to determine whether action effects were caused by their own or by another's actions on a millisecond scale [8]. This fine-grained temporal scale is less important for distinguishing between one's own and others' beliefs or emotions. The literature on agency, the experience of controlling one's actions, indeed suggests that there may be unique mechanisms that serve to distinguish the (motor) actions of self and other [9]. Despite this word of caution, it does seem promising to try to identify a link between three domains that clearly share certain characteristics and phenomena (e.g. egocentrism) as well as neural correlates.

Furthermore, it may help to consider how particular types of social interaction affect processes of self–other distinction. In particular, joint action, where several actors coordinate their actions to achieve common goals, requires both keeping one's own and others' contributions apart and planning one's own part in relation to others' [10]. This research has drawn attention to phenomena that do not clearly fit into one distinct category, such as task co-representation. This is the phenomenon that participants acting jointly together on a task often demonstrate interference from the other person's role in the task, even if this is completely irrelevant to their own role [11]. Four- to five-year-old children have also been shown to produce these effects [12,13], although 2- to 3-year-olds did not do so [12]. This phenomenon has been subject to debate over the last decade, partly due to discussion over what exactly is being represented during these tasks. One possibility is that the action being performed by the partner is represented, which results in motor mirroring by the actor. However, this may not be the whole story, as co-representation occurs when a partner is absent but believed to be acting in another room [14] and when the partner's actions are hidden from view ([12], experiments 1 and 2), suggesting a more cognitive representation of the task rather than direct perception-action links only. Additionally, one suggestion from Wenke *et al*. [15] is that participants represent not *what* their partner is doing (either through a direct perception-action link or through a cognitive representation of the action or goal required for the task), but *when* it is their turn to act, highlighting the importance of self–other distinction in avoiding interference from a joint actor. More recent data [16] have found further support for the role of self–other distinction in co-representation in an individual difference study looking at the relationship between children's co-representation in a joint task and their performance on measures of general executive function and Theory of Mind. Results show a positive relationship between performance on explicit Theory of Mind tasks and the ability to avoid interference from a partner during a joint task, which is argued to show a role of the self–other conflict resolution component of Theory of Mind [17]. This relationship was independent of a relationship between general inhibitory control capacity and interference avoidance, suggesting a specific role of self–other conflict resolution on joint task performance over and above general inhibitory control. This highlights the need to consider the demands different types of social interactions create for processes of self–other distinction, and in particular, to consider the real-time coordination demands that come with joint action, which may involve input from motor, cognitive and even affective domains in unison.

Our last point aims to open up discussion based on all four papers regarding the link between studies of dyadic interaction versus group interaction. Whereas the research cited and carried out by de Guzman *et al*. and Steinbeis focuses on mechanisms and their development between two individuals, Over [3] and McAuliffe & Dunham [4] place social cognition in a group setting, highlighting the importance of considering mechanistic explanations of social cognition within a societal framework including motivational and evolutionary factors. Over argues that much of our social cognitive behaviour stems from a need to belong, which is clearly in place from early in ontogeny. This raises an interesting question regarding the need for self–other distinction, as posited by de Guzman *et al*. and Steinbeis. Whereas these authors have underlined the importance of being able to keep self and other separate, Over's paper raises the question of whether this is always optimal in social interaction. Instead, it may be that under certain circumstances we need to experience less of a distinction between ourselves and our social group, in order to feel a sense of belonging to that group [18]. This could apply in any of the three domains mentioned above. In the cognitive domain, if all members of a group take the same perspective on a scenario, it may be easier to reach a joint decision regarding a course of action. Clearly, this will not work in all cases and in some circumstances it may be more beneficial to have multiple viewpoints within a group, raising questions about self–other distinction, conformity and group decision-making [19]. Likewise, in the affective domain, a breakdown of self–other discrimination may have effects on group cohesion in that if all members feel the same emotion simultaneously they may feel a greater sense of belongingness and act in more coordinated ways [20]. In this case, we may wish to discriminate between empathy and emotion contagion, the difference between which may in fact rely on self–other distinction. Our understanding of the role of self–other distinction for group cohesion would benefit from investigation within larger-scale interactions.

We may also question how the mechanisms outlined for dyadic interactions may be situated within group scenarios.

For example, do group interactions consist of many different relations between individuals, or does the group have its own mechanisms for interacting with other groups? McAuliffe & Dunham argue for a 'mere preferences' account of group dynamics, whereby we are inclined to like and consequently give preferential treatment to members of our own social groups because we have a preference in general for things that are associated with ourselves. This would mean that others in our social group are merely extensions of our representation of our self, and thus are just another part of the information that needs to be kept separate from representations of the 'other' (presumably members of an out-group). However, it could also be the case that the group is represented as an entity of its own, so that representations of relations between groups dominate over representations of inter-individual relations. For example, Tsai *et al.* [21] demonstrated a phenomenon known as the GROOP effect, whereby participants experience a tendency to imitate observed movements of two hands performing a finger-tapping routine on a computer screen. However, this imitation tendency only occurred when the number of actors on the screen (i.e. one person using both hands versus two people each using one hand) corresponded with the number of participants acting on the task, suggesting that participants entered a 'we-mode' [22], whereby they identified themselves with the individual when acting as an individual but as a group when acting as a group (see also [23]). This could provide an interesting avenue for linking self–other distinction on a dyadic level with the same or similar mechanisms on a group level. Future research would benefit from further investigation into whether this could be a shared mechanism and under what circumstances an individual might switch from individual- to group-level processing within each of the three domains discussed.

In conclusion, the papers in this section highlight some interesting avenues for future research and provide a demonstration of how links can and should be made between different areas of study, specifically how developmental work can inform our understanding of mechanisms by looking at changes over lifespan which can betray structural information about which aspects of social cognition are linked and how they are organized. That being so, we argue that there still lacks a clear picture of how self–other distinction develops over early childhood, which would help to clarify how this mechanism can interact with representations within and between different domains. Work on early self–other distinction has centred around the mirror self-recognition task [24], which may not be the best measure of a true concept of self [25]. By 4 years old, explicit Theory of Mind tasks that present conflicting information regarding mental states of self and other are purported to measure self–other distinction. However, it is not clear how these two measures are linked, if at all, and if so how a child might progress from one step to another. A promising avenue may be to look at the development of self–other distinction in the context of joint action development, both in interactions among peers and in adult–child interactions [26–28]. It may be, for example, that self–other distinction originates in the motor domain, where children first learn about self and other from automatic mimicry or mirroring of a carer, which develops into mirror self-recognition and later generalizes to higher level domains such as explicit perspective-taking (see [29]). Alternatively, self–other distinction could develop in parallel in each domain, so that early behaviours such as implicit perspective-taking, emotion contagion and motor mimicry feature a more blurred representation of self and other, and later develop into more complex abilities such as explicit perspective-taking, empathy and task sharing and coordination.

Although research has looked at development of self–other distinction in cognitive and affective tasks over later childhood [30,31], these studies have produced mixed results, and we cannot assume the same pattern of results for early development. Further investigation of the development of brain connectivity between areas involved in these kinds of tasks in children younger than the 6-year-olds tested by Steinbeis *et al.* [32] might shed some light on such stages of development. Furthermore, future work should attempt to investigate the directionality of training effects between domains. If training is unidirectional from the motor domain to cognitive and affective domains, this leaves open the possibility that a hierarchy is in place whereby higher level self–other distinction emerges bottom-up from the need to keep the actions of self and other apart. However, if training is bidirectional, this lends force to the argument that self–other distinction is an umbrella mechanism for successful processing in all social domains. Likewise, within domains a hierarchy might be in place which requires different self–other processing at different stages. For example, in the motor domain it is possible that representations of actions and effects are first formed in an agent-neutral format and only later are agent roles assigned if necessary for the task [33].

Investigation of the structure of self–other processing within and between domains could provide important theoretical information not only within Cognitive and Social Psychology, but also in other fields in which self–other distinction is relevant. For example, there is a clear link with Evolutionary Biology and Comparative Psychology which has followed a similar route to developmental research, focusing on mirror self-recognition [34,35] and cognitive perspective-taking [36] as measures of self–other distinction. More recent studies have begun to look at performance in task-sharing paradigms [37,38], which should provide a new avenue of research looking at self–other monitoring within interactive, coordinated tasks rather than more passive scenarios involving longer time-scales. Additionally, certain aspects of self-representation are thought to be factors in psychiatric conditions that come with deficits in social cognition, such as schizophrenia. In one study, schizophrenic patients failed to show a task co-representation effect, unlike typical controls [39], which was explained as being due to a lack of self–other integration. This suggests that not only self–other distinction but also self–other integration is important for social cognition. This raises a question as to where the sweet spot lies at which integration and distinction are optimally balanced. Alternatively, it could be that the lack of a task co-representation effect in these patients was not due to a lack of self–other integration, but a failure to represent the other at all. A distinction should be made between formation of representations of self and other versus distinction between or integration of such representations.

In conclusion, this commentary has attempted to unite four papers on self–other distinction by identifying ways in which developmental and training studies can inform mechanistic explanations of social cognition which could in turn have implications for applications in Psychiatry and Clinical Psychology. It has highlighted the potential for an

interesting exchange between research focusing on dyadic versus group cognition, the latter of which could benefit from generalization of dyadic self–other distinction theories to groups. It has also suggested avenues for future work on self–other distinction between and within domains, which could provide a structural framework linking work in these domains and providing a basis for practical applications such as training. In sum, this topic has an exciting scope for future work and the potential to reach beyond the field of Social and Cognitive Psychology.

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