emerge from somewhere. It cannot simply be attributed to me experiencing your "mind." As Hurley (2008) recently argued, a lower level, non-Cartesian developmental model of social neuroscience would initially be based upon first-person plural experience. In our view, human infants become involved in interactions and get into the behavioural flow of shared activities, even though they are largely stage-managed by the adult. As a result, infants become naturally attentive to gestures that are intentional because they are repeated and become predictable. For example, they attend to a purposeful grasp but not a reach with the back of the hand (e.g., Woodward 1999). Such competence, which is evident before the child's first birthday, does not mean that human infants grasp "minds."

How can we explain the emergence of social skills and knowledge within this first-person plural experience? We feel that Schilbach et al. misinterpret our account (Carpendale & Lewis 2004; Stack & Lewis 2008) as supporting a second-person approach when really this and related ones (e.g., Barresi & Moore 1996) stress the infant's perspective on shared experience with others. From this perspective, early forms of awareness are sensorimotor and take place within practical activities like toy manipulation or social second-person interactions. Such actions make the infant able to attend to and then follow simple gestures expressing emotion, gaze, or bodily orientation. According to this approach, infants build gradually upon these actions to construct increasingly complex forms of knowledge. These provide the basis for reflective forms of social understanding and communication. The activity-based approach would never automatically assume that infants read or experience minds, as this is too rich an interpretation of their attention to human actions.

Evidence for our perspective comes from the errors of older children. We agree with the authors that some form of representational redescription may explain the process of transfer from simple to more complex understanding (sect. 4.2.1), but the target article is particularly vague about how this might take place, or what actually gets redescribed, and how. This might simply be an omission due to the ambitious scope of the article. However, such claims and the observation that individuals with autism have difficulties in social interactions (sect. 2.2.1, para. 4), make their second-person perspective yet more under-specified. According to an action-based approach, shared interactions enable the infant to *re-present* the world, anticipating the outcome of various intentional actions. Development is a protracted process because the inferences that transform actions into representations are dependent on hard won, small-scale achievements. Although infants seem to follow purposeful reaches (Onishi & Baillargeon 2005), they also make simple perceptual errors in such tasks, with inferences being based on the mere presence of others at set points within an event (Sodian & Thoermer 2008). This lack of an objective appreciation of another's perspective has been demonstrated across the third year (Moll et al. 2011; O'Neill 1996), extending into early childhood (Flavell et al. 1980; McGuigan & Doherty 2006). Such findings suggest that knowledge of what others have (and have not) experienced continues to be framed in terms of engagement with, and dis-engagement from, others. Even preschoolers do not simply "experience" the mind, as assumed in the target article.

In short, we feel that Schilbach et al.'s claim that we need to make social neuroscience truly social is well placed but the second-person perspective does not specify how humans acquire such skills. It is not sufficient to present simple diagrams showing that interactants' neural processes act in synchrony (Fig. 1D of the target article) or to state that early affective exchanges "pave the way" to later understanding without specifying how the paving is laid. An action-based theory originating within *first-person plural* interactions provides a more detailed, and more plausible, account of these developmental processes.

Merging second-person and first-person neuroscience

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Abstract: Schilbach et al. contrast second-person and third-person approaches to social neuroscience. We discuss relations between second-person and *first*-person approaches, arguing that they cannot be studied in isolation. *Contingency* is central for converging first- and second-person approaches. Studies of embodiment show how contingencies scaffold first-person perspective and how the transition from a third- to a second-person perspective fundamentally involves first-person contributions.

In developing their framework for second-person neuroscience, Schilbach and colleagues contrast their approach with what they consider third-person approaches, widespread in cognition and social neuroscience, in which participants simply observe (but do not interact with) others. Surprisingly, Schilbach et al. have less to say about the converse relation, between their second-person neuroscience and *first*-person approaches. Recent research has provided rich descriptions of the first-person experience of embodiment, the role of sensory and motor signals in forming such experiences, and their subsequent effects on cognition and behaviour. Here, we will discuss points of potential convergence between first- and second-person approaches and argue that the two cannot be approached in isolation from each other.

First, the key factor differentiating second-person from third-person approaches on Schilbach et al.'s view is *contingency*. Second-person others respond contingently to an observer's actions, whereas third-person others do not. Intriguingly, this idea of contingency is also central to recent approaches to studying first-person experiences of embodiment (for reviews see Longo & Haggard 2012; Tsakiris 2010). In the case of first-person experience, this plays out at both the perceptual and motoric levels. In terms of perception, our somatic experiences (e.g., of touch, pain, or position sense) are contingently related to our experiences in other sensory modalities (e.g., visual, auditory, or vestibular sensations). For example, my tactile experiences as I reach to pick up my coffee mug are exactly temporally and spatially congruent with my visual experience of seeing my hand grip the mug. This visual-tactile match is a strong cue that the hand I see is *my* hand, and can be manipulated to produce perceptual illusions of embodiments such as the rubber hand illusion (Botvinick & Cohen 1998), full-body illusions (Lenggenhager et al. 2007), or the body-swap illusion (Petkova & Ehrsson 2008). In the rubber hand illusion, for example, vision of touch applied to a prosthetic hand in temporal and spatial synchrony with felt touch on one's own hand creates the compelling illusion that the rubber hand actually is one's hand (the sense of *body ownership*) and corresponding proprioceptive biases (Botvinick & Cohen 1998; Longo et al. 2008; Tsakiris & Haggard 2005).

Contingency in first-person approaches also plays out in terms of action. The actions of our body are contingently related to our intentions. When I form an intention to lift my arm, it is *my* arm that lifts. The contingent relation between efferent motor commands and visual and proprioceptive feedback strongly influences our first-person experience of our body, over and above matches between vision and proprioception alone. This is another strong cue for body ownership, and creates an additional sense of *agency* over one's body (i.e., the feeling that I am in control of my body). Recent results have demonstrated that ownership and agency are distinct and separable components of the experience of embodiment (Longo et al. 2008) and have distinct functional consequences on behaviour (Kammers et al. 2009; Longo & Haggard 2009; Tsakiris

et al. 2006) and separable neural correlates (Tsakiris et al. 2010). Thus, contingency, both of perception and action, plays a critical role in structuring first-person experiences of our own body.

As Schilbach and colleagues point out, however, contingency also plays a fundamental role in differentiating our second-person experiences of immediate others from third-person experiences of more distant others. This raises a critical question: What differentiates contingent relations specifying first-person experiences from those specifying second-person experiences? This is an important question for future research, about which we can only speculate here. We wish to propose, however, that first-person experiences may be primary and possibly even necessary prerequisites for second-person experiences. For example, first- and second-person contingency differ in terms of their immediacy, both temporally and logically. When I form an intention to act, my own action follows immediately, whereas your response comes later. Any instance of contingency specifying second-person relations thus follows the sequence: *Intention → My Action → Your Action*, where the first arrow indicates the contingent relation specifying a first-person experience and the second arrow indicates the contingent relation specifying a second-person experience. The second-person contingency cannot exist without the first-person contingency, because the sequence: *Intention → Your Action* would not indicate that I am *interacting* with you (a second-person relationship), but would rather indicate that I *am* you (a first-person relationship).

Related to the preceding argument is the possibility that embodied interactions may alter self-other boundaries, which suggests that the transition from a third- to a second-person perspective may fundamentally involve, but also affect, first-person representations. This possibility has been explored by extending the known role of multisensory integration from body-awareness to self-other boundaries. In the "enfacement illusion" (Sforza et al. 2010; Tsakiris 2008), participants see someone else's face being touched at the same time as their own face, creating a situation that resembles the experience of looking at oneself into the mirror, albeit the "mirror reflection" of one's face is replaced by another individual. Synchronous interpersonal multisensory stimulation (IMS) between the two faces changes self-face recognition, as the other's face is perceived to be more similar to one's own face (Tajadura-Jimenez et al. 2012). Interestingly, and of particular relevance for our understanding of the second-person perspective, IMS also influences social cognition processes of inference and conformity (Paladino et al. 2010). Such findings support a model of first-person perspective according to which our sense of self is plastically affected by multisensory information as it becomes available during self-other interactions. Shared multisensory experiences might explain how the "I" comes to be identified with "me," allowing this "me" to be represented as an object for others, as well as for one's self.

Together, these considerations suggest that there are important points of connection between the first- and second-person perspectives, meaning that neither can be investigated in isolation from the other. In particular, it will be critical for future research to investigate how contingency alters both the relation of the self to its "self" or body (first-person neuroscience), and the relation of the self to the other (second-person neuroscience).

A second-person approach cannot explain intentionality in social understanding

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Abstract: A second-person approach that prioritizes dyadic emotional interaction is not well equipped to explain the origins of the understanding of mind conceived as intentionality. Instead, the critical elements that will deliver the understanding of self and other as persons with intentionality are shared object-centered interactions that include not only emotional engagement, but also joint attention and joint goal-directed action.

The second-person approach advocated by Schilbach and colleagues may be seen as one of a group of theoretical approaches that avoid the "simulation theory" and "theory theory" horns of the dilemma of understanding other minds. Like other relational approaches (e.g., Barresi & Moore 1996; Carpendale & Lewis 2004; Hobson 2002; Moore 2006; Zlatev et al. 2008), Schilbach et al. argue that minds are known within and through interaction with others. As a viable theory, however, their second-person approach has a number of significant drawbacks. Here we focus on two – its over-reliance on emotional engagement and its over-emphasis of dyadic, rather than triadic, interaction. We believe that a significant reason for these shortcomings is that Schilbach et al. appear not to have a coherent account of what it means to understand mind; certainly they never actually define what that means. Obviously they want to avoid the standard representational theory of mind account of mental understanding. But instead of a structured analysis, they seem to assume that the understanding of mind is immanent in a variety of different social phenomena, including contingent social interaction and emotional reactivity to others.

Our position, consistent with a long intellectual tradition in philosophy of mind (e.g., Brentano 1874/1973), is that understanding mind entails understanding intentionality. We take intentionality to cover all of its myriad forms, ranging in complexity from simple object-directed action to complex embedded mental states (see Barresi & Moore 1996), and ranging across a variety of psychological qualities, including not only emotional, but also epistemic, and conative forms.

For Schilbach et al., there are two key features to the second-person approach: emotional engagement and social interaction. We address the limitations of these two features of their account in reverse order.

All relational approaches to social understanding place social interaction at the core. Knowledge of minds happens through interaction with others. For some authors, social interaction is seen primarily as the solution to the problem of other minds (e.g., Carpendale & Lewis 2004; Hobson 2002). For others, it is the solution not only to that problem, but also necessarily to the problem of how the self's own intentionality comes to be known (Barresi & Moore 1996). Schilbach et al. argue for the primacy of a particular form of social interaction – face-to-face or what is often termed in the developmental psychology literature, "dyadic." For them, second-person appears to mean primarily the kind of social stimulation available within dyadic interaction. Certainly dyadic interactions can have special dynamic properties, such as contingency of the actions of self and other, and particular characteristics, such as full-face gaze. Yet, although it is true that these properties and characteristics are key attractants to young infants, the processing of this information does not necessitate any awareness of the other *as being another* – or being a person of the same kind as the self. Indeed, empirical evidence has suggested that these phenomena could be subserved by "subpersonal" attentional and sensorimotor mechanisms (Moore & Barresi 2009; Paulus 2011).

The same problem holds for their view on motor resonance in the Mirror Neuron System when observing others' actions. While we agree that these motor processes may support social interaction either by predicting the future effect of the other's action or by directly preparing a timely response, the activation of a motor program alone need not lead to an awareness of another's mind in any conceptual sense (Paulus 2012). There is a conceptual gap between the activation of one's own motor system through the perception of another person's action and the ascription of an intention to this person or to the self (Jacob 2009).

The problem with purely dyadic interactions is that there is no obvious way for the intentionality of action – its object-