Embodied Simulation: A Paradigm for the Constitution of Self and Others

A Reply to Christian Pfeiffer

Vittorio Gallese & Valentina Cuccio

The main criticism Pfeiffer advances in his commentary is that our proposal is too narrow. Embodied simulation (ES), in his view equated to motor resonance, is not a sufficiently primary mechanism on which we can base a unified neurobiological theory of the earliest sense of self and others. According to Pfeiffer, motor resonance needs to be complemented by other more basic and primary mechanisms. Hence, as an alternative to our proposal, he suggests that multisensory spatial processing can play this role, primarily contributing to the earliest foundation of the sense of self and others. In our reply we stress on the one hand that identifying ES only with motor resonance is a partial view that may give rise to fallacious arguments, since ES also deals with emotions and sensations. We also show, on the other hand, that ES and multisensory integration should not be seen as alternative solutions to the problem of the neural bases of the bodily self, because multimodal integration carried out by the cortical motor system *is* an instantiation of ES. We conclude by stressing the role ES might have played in the transition from bodily experience to symbolic expression.

Keywords
Attention schema theory | Bodily self | Embodied simulation | Language | Motor resonance | Multimodal integration | Paradigm | Peri-personal space | Social cognition

Authors

Vittorio Gallese
vittorio.gallese@unipr.it
Università degli Studi di Parma
Parma, Italy

Valentina Cuccio
Università degli Studi di Palermo
Palermo, Italy

Commentator

Christian Pfeiffer
christian.pfeiffer@epfl.ch
Ecole Polytechnique Fédérale
Lausanne, Switzerland

Editors

Thomas Metzinger
metzinger@uni-mainz.de
Johannes Gutenberg-Universität
Mainz, Germany

Jennifer M. Windt
jennifer.windt@monash.edu
Monash University
Melbourne, Australia

1 An overview of Pfeiffer's criticisms

We would like to thank Christian Pfeiffer for his very well-articulated commentary on our paper "The paradigmatic body: Embodied Simulation, Intersubjectivity, the Bodily Self, and Language" (Gallese & Cuccio this collection). His comments and criticisms offered us the opportunity to further reflect on some of the ideas proposed in our piece. The aim of our paper was to discuss the role of the body in the constitution of the earliest and primary sense of self and others and, also, to emphasize the constitutive role of the body in a specifically human modality of intersubjectivity: language. To be more precise, we identified a biological mechanism, embodied simulation (ES), as a primary source of intersubjectivity, the sense of self, and language. The mechanism of ES is widely described in the paper and its role in human cognition is explained by also resorting to the Aristotelian notion of *paradeigma*.

The commentary offered by Christian Pfeiffer is focused on a partial aspect of our much wider proposal. In fact, the author only discusses the constitutive role motor resonance has for the sense of self and for social cognition. However, motor resonance is just one dimension of the mechanism of ES. As argued in our paper and elsewhere (see Gallese & Sinigaglia 2011a; Gallese 2014) the mechanism of simulation is widespread in the brain and it also characterizes the nervous structures involved in the experience of emotions and sensations. All these dimensions of ES should be taken into account. To identify ES only with motor resonance is a partial view that may give rise to fallacious arguments.

The main criticism Pfeiffer advances in his commentary is that our proposal for the constitutive role of motor resonance is too narrow. ES, in his view equated to motor resonance, cannot be the primary neurobiological mechanism at the basis of both the sense of self and others. According to Pfeiffer, motor resonance needs to be complemented by other more basic and primary mechanisms. Hence, as an alternative to our proposal, he suggests that multisensory spatial processing can play this role, primarily contributing to the earliest foundation of the sense of self and others. To support this claim, he provides theoretical arguments and presents empirical data structured in three different sections. Each of these sections supposedly provides evidence of the role of multisensory spatial processing in the foundation of a bodily sense of self and others.

In the first section Pfeiffer addresses the issue of intersubjectivity and presents the Attention schema theory (AS). In his proposal, our ability to understand others is primarily based on a mechanism more primitive than ES-as-motor-resonance: spatial coding of attention. AS predicts that we understand the current state of awareness of our conspecifics by means of schematic representations of their states of attention (Pfeiffer this collection, p. 4). In other words, according to AS, by using a representation of the spatial relationship between the individual we are observing and the spatial focus of her/his attention we can likely predict his intentions and, as a consequence, his actions. Pfeiffer (this collection, p. 4) also discusses recent empirical findings on the neural structures underlying the AS. It seems that the neural structures for the spatial coding of attention are based in the right temporo-parietal junctio (TPJ) and in the superior temporal sulcus (STS). These neural structures do not overlap with the neural circuits involved in ES.

In the second section Pfeiffer addresses the issue of the bodily foundation of the sense of self. The experience of being a bodily self can be decomposed into four different aspects (Pfeiffer this collection, p. 5): body ownership, self-location, first-person perspective, and agency. According to Pfeiffer, motor resonance can account only for body ownership and agency, directly contributing to these (non-spatial) aspects of the bodily self. However, for the two spatial components of the bodily self we need a different account. In fact, according to Pfeiffer, empirical evidence suggests that these spatial aspects of the bodily self, which imply multisensory spatial representations, are encoded in a brain region, the TPJ, not characterized by motor resonance. Hence, motor resonance, while being still necessary for the bodily foundation of some basic aspects of the self, is not a sufficiently primary mechanism, since different neural structures are also needed for the bodily foundation of the self. In support of this claim, Pfeiffer discusses data from neurological patients with out-of-body experiences and other kinds of altered states.

Finally, in the third section the constitutive role of the vestibular system to the bodily foundation of both the consciousness of self and others is discussed. It is proposed that this system, which encodes gravity and head motion and is associated with multisensory spatial processing, significantly and primarily contributes to our ability to distinguish between motions of our own body and motions of other people's bodies, in this way contributing to both the foundation of the sense of self and social cognition. Empirical studies are reported to support these claims. In addition, empirical data showing that the vestibular cortical network overlaps with neural structures underlying the bodily foundation of both the sense of self and others, as discussed in the two previous sections, are presented.

In the light of the empirical evidence discussed in his commentary, Christian Pfeiffer concludes that ES-as-motor-resonance is not a sufficiently primary mechanism on which we can base a unified neurobiological theory of the earliest sense of self and others. In the next section we answer these criticisms.

2 Responses

First, we would like to point out that ES is not confined to motor resonance of others' actions, like that instantiated by macaques' mirror neurons, as in humans ES also encompasses the activation of somatosensory areas during the observation of others' tactile experiences, the activation of pain-related areas like the anterior insula and the anterior cingulate cortex during the observation of others' pain, and the activation of the anterior insula and limbic structures like the amygdala during the observation of others' emotions like disgust and fear (see our paper, p. 9 and Gallese & Sinigaglia 2011a). Thus, motor resonance only describes one partial aspect of ES.

Two distinct arguments can be used to explain why we do not think that AS constitutes a valid alternative to ES, as argued by Pfeiffer. We certainly agree with Pfeiffer that shared attention, that is, the capacity to direct the gaze to an object gazed by someone else, is a basic ingredient of social cognition. Indeed, as maintained by Colwyn Trevarthen (1977), shared attention marks in human infants around 9 months of age the transition from primary to secondary intersubjectivity. However, shared attention constitutes only one aspect of intersubjectivity and social cognition, thus AS at best only covers a partial aspect of social cognition and therefore appears to be more limited than ES in this respect. Furthermore, and most importantly, shared attention can be linked to motor resonance. Shepherd, Klein, Deaner, and Platt 2009) discovered in macaques a class of mirror neurons in the lateral intraparietal (LIP) area involved in oculomotor control, signaling both when the monkey looked at a given direction in space and when it observed another monkey looking in the same direction. These authors suggested that LIP mirror neurons for gaze might contribute to the sharing of observed attention. This evidence shows that shared attention is not divorced from motor resonance, but actually requires it.

A further argument in our opinion demonstrates that ES and AS should not be seen as alternative solutions to the problem of social cognition. Multisensory integration is a pervasive feature of parieto-frontal centers involved in sensory-motor planning and control. Indeed an influential theory about attention, the "Premotor Theory of Attention" (see Rizzolatti et al. 1987; Rizzolatti et al. 1994) states that spatial attention results from the activation of the same "pragmatic" circuits that program oculomotor behavior and other motor activities, even if such activation does not produce any overt motor behavior, thus qualifying as motor simulation.

We would like to emphasize even more strongly than we did in the paper that a crucial role of the cortical motor system is precisely that of integrating multiple sources of body-related sensory signals, like tactile, visual and auditory stimuli (see our paper, pp. 10–11; see also Gallese & Sinigaglia 2010, 2011b; Gallese 2014). The ventral premotor cortex (vPMC) might represent one of the essential anatomo-functional bases for the motor aspect of bodily selfhood, specifically because of its role in integrating self-related multisensory information. This hypothesis is corroborated by clinical and functional evidence showing the systematic involvement of vPMC with body awareness (Ehrsson et al. 2004; Berti et al. 2005; Arzy et al. 2006). This evidence demonstrates a tight relationship between the bodily self-related multimodal integration carried out by the cortical motor areas specifying the motor potentialities of one's body and guiding its motor behavior and the implicit awareness one entertains of one's body as one's own body and of one's behavior as one's own behavior.

The vPMC is anatomically connected to visual and somatosensory areas in the posterior parietal cortex and to frontal motor areas and for this reason it is plausible to assume that vPMC activity reflects the detection of congruent multisensory signals related to one's own body parts: this mechanism could be responsible for the feeling of body ownership. The motor aspects of the bodily self-enable the integration of self-related multimodal sensory information about the body and about the world with which the body interacts, as epitomized by the properties of macaques' premotor neurons in area F4 (see Fogassi et al. 1996; Rizzolatti et al. 1997) and the analogous functional properties displayed by the human homologue of area F4 (see Bremmer et al. 2001). The same neurons controlling the movement in space of the head or of the upper limb also respond to tactile, visual, and auditory stimuli, provided they are applied to the same body part, like tactile stimuli, or they occur in the body-part-centered peri-personal space, like visual and auditory stimuli. Thus, we think that ES and multisensory integration should not be seen as alternative solutions to the problem of the neural bases of the bodily self, because multimodal integration carried out by vPMC *is* an instantiation of ES. We agree with Pfeiffer, however, that other brain areas, like TPJ, might contribute to a coherent sense of one's own body. It must be added that TPJ is part of a network (including the posterior parietal cortex, and the premotor cortex) implicated in multisensory integration during self-related and other-related events and experiences. Indeed, as shown by Ebisch et al. (2011), the observation of others' affective tactile experiences leads to the activation of observers' vPMC and second somatosensory area and to the inactivation of observers' posterior insula. Functional connectivity revealed a significant interaction between the posterior insula, right TPJ, left pre-central gyrus, and right posterior parietal cortex during the observation of other's affective touch. These data suggest that TPJ might be involved in mapping the self–other differentiation, by means of lower-level computational mechanisms for generating, testing, and correcting internal predictions about external sensory events.

Last, we agree with Pfeiffer that the vestibular system might contribute to the bodily foundation of both the consciousness of self and others and we thank him for having pointed this out, thus integrating our perspective.

3 Conclusions

It seems that the data discussed in the previous section allow us to come to the conclusion that ES is the primary and earliest mechanism contributing to the foundation of the sense of self and others. That said, in conclusion, we would like to stress again the issue of the cognitive role ES has in relation to language. Though the aspect of the relation between ES and language was not addressed in Pfeiffer's commentary, this was a central point of our proposal. The relation between ES and language is two-sided. On the one hand, empirical evidence has shown the role ES plays in language comprehension. These data (for an overview see Gallese & Cuccio this collection, p. 13) suggest that the bodily, sensory, and motor dimensions play a constitutive role in language, both ontogenetically and phylogenetically. On the other hand, being linguistic creatures, we humans are the only living species able to fix and relive specific aspects of our bodily experiences by means of symbols. Words or other forms of symbolic representations such as art, for example, allow us to activate and relive our bodily experiences. In this way, by means of symbolic representations, we can share our bodily experiences, enacted by ES, even with people far away from us in time and space. As argued in our paper, ES is a model of our own experiences and its defining features are best explained by resorting to the Aristotelian notion of *paradeigma*. ES-as-*paradeigma* (and not just as motor resonance) provides a neurobiologically-based new perspective on human social cognition and ultimately on the very definition of human nature.

Acknowledgments

This work was supported by the EU Grant Towards an Embodied Science of InterSubjectivity (TESIS, FP7-PEOPLE-2010-ITN, 264828) and by the KOSMOS Fellowship from Humboldt University, Berlin to VG.

References

Arzy, S., Overney, L. S., Landis, T. & Blanke, O. (2006). Neural mechanisms of embodiment: Asomatognosia due to premotor cortex damage. *Archives of Neurology*, *63* (7), 1022-1025. Neural mechanisms of embodiment: Asomatognosia due to premotor cortex damage

Berti, A., Bottini, G., Gandola, M., Pia, L., Smania, N., Stracciari, A., Castiglioni, I., Vallar, G. & Paulesu, E. (2005). Shared cortical anatomy for motor awareness and motor control. *Science*, *309* (5733), 488-491. 10.1126/science.1110625

Bremmer, F., Schlack, A., Shah, N. J., Zafiris, O., Kubischik, M., Hoffmann, K., Zilles, K. & Fink, G. R. (2001). Polymodal motion processing in posterior parietal and premotor cortex: a human fMRI study strongly implies equivalencies between humans and monkeys. *Neuron*, *29* (1), 287-296. 10.1016/S0896-6273(01)00198-2

Ebisch, S. J. H., Ferri, F., Salone, A., d'Amico, L., Perucci, M. G., Ferro, F. M., Romani, G. L. & Gallese, V. (2011). Differential involvement of somatosensory and interoceptive cortices during the observation of affective touch. *Journal of Cognitive Neurosciences*, *23* (7), 1808-1822. 10.1162/jocn.2010.21551

Ehrsson, H. H., Spence, C. & Passingham, R. E. (2004). That's my hand! Activity in premotor cortex reflects feeling of ownership of a limb. *Science*, *305* (5685), 875-877. 10.1126/science.1097011

Fogassi, L., Gallese, V., Fadiga, L., Luppino, G., Matelli, M. & Rizzolatti, G. (1996). Coding of peripersonal space in inferior premotor cortex (area F4). *Journal of Neurophysiology*, *76* (1), 141-157.

Gallese, V. (2014). Bodily Selves in Relation: Embodied simulation as second-person perspective on intersubjectivity. *Philosophical Transactions of the Royal Society, London. Series B Biological Sciences*, *369* (1644), 20130177-20130177. 10.1098/rstb.2013.0177

Gallese, V. & Cuccio, V. (2015). The Paradigmatic Body. In T. Metzinger & J. M. Windt (Eds.) *Open MIND* (pp. 1-23). Frankfurt a. M., GER: MIND Group.

Gallese, V. & Sinigaglia, C. (2010). The bodily self as power for action. *Neuropsychologia*, *48* (3), 746-755. 10.1016/j.neuropsychologia.2009.09.038

——— (2011a). What is so special with Embodied Simulation. *Trends in Cognitive Sciences*, *15* (11), 512-519. 10.1016/j.tics.2011.09.003

——— (2011b). How the body in action shapes the self. *Journal of Consciousness Studies*, *18* (7-8), 117-143.

Pfeiffer, C. (2015). Multisensory Spatial Mechanisms of the Bodily Self and Social Cognition. In T. Metzinger & J. M. Windt (Eds.) *Open MIND* (pp. 1-14). Frankfurt a. M., GER: MIND Group.

Rizzolatti, G., Riggio, L., Dascola, I. & Umiltá, C. (1987). Reorienting attention across the horizontal and vertical meridians: evidence in favor of a premotor theory of attention. *Neuropsychologia*, *25* (1a), 31-40.

Rizzolatti, G., Riggio, L. & Sheliga, B. M. (1994). Space and selective attention. In C. Umiltá & M. Moscovitch (Eds.) *Attention and performance XV* (pp. 231-265). Cambridge, MA: MIT Press.

Rizzolatti, G., Fadiga, L., Fogassi, L. & Gallese, V. (1997). The space around us. *Science*, *277* (5323), 190-191. 10.1126/science.277.5323.190

Shepherd, S. V., Klein, J. T., Deaner, R. O. & Platt, M. L. (2009). Mirroring of attention by neurons in macaque parietal cortex. *Proceedings of The National Academy of Sciences USA*, *106* (23), 9489-9494. 10.1073/pnas.0900419106

Trevarthen, C. (1977). Descriptive analyses of infant communicative behavior. In H. R. Schaffer (Ed.) *Studies in mother-infant interaction* (pp. 227-270). London, UK: Academic Press.