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Bodily selves in relation: embodied simulation as second-person perspective on intersubjectivity

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This article addresses basic aspects of social cognition focusing on the pivotal role played by the lived body in the constitution of our experience of others. It is suggested that before studying intersubjectivity we should better qualify the notion of the self. A minimal notion of the self, the bodily self, defined in terms of its motor potentialities, is proposed. The discovery of mirror mechanisms for action, emotions and sensations led to the proposal of an embodied approach to intersubjectivity—embodied simulation (ES) theory. ES and the related notion of neural reuse provide a new empirically based perspective on intersubjectivity, viewed first and foremost as intercorporeality. ES challenges the notion that folk psychology is the sole account of interpersonal understanding. ES is discussed within a second-person perspective on mindreading.

1. Introduction

What we commonly mean by 'understand' coincides with 'simplify' [...]: with this purpose in view we have built for ourselves admirable tools in the course of evolution, tools which are the specific property of the human species – language and conceptual thought. [1, p. 36]

One of the core objectives of cognitive neuroscience is to understand the relationship between the functional mechanisms of our brain–body system and our social cognitive skills, shedding new light on the notion of intersubjectivity. However, the notion of intersubjectivity is intrinsically related to the notion of the self. Thus, the neuroscientific study of intersubjectivity cannot elude the issue of subjectivity and of the experiences constituting it. In this paper, I discuss the relation between intersubjectivity and a minimal notion of the self, the bodily self.

The second half of the twentieth century witnessed the enormous progress of cognitive neuroscience, also fostered by the development of new technologies like brain imaging, enabling for the first time a thorough non-invasive study of the human brain. Since then, cognitive neuroscience has started addressing topics related to social cognition, such as intersubjectivity, the self, empathy, free will, decision-making, ethics and aesthetics, many of which were traditionally the object of investigation of different disciplines, such as psychology, philosophy, economy and politics. These recent developments are stirring an ever-growing debate on the heuristic value of cognitive neuroscience when applied to these topics.

At this point, a crucial question is perhaps worth being asked: what is cognitive neuroscience after all? Cognitive neuroscience is first and foremost a methodological approach whose empirical results are strongly influenced by the assumptions posed by the theoretical framework inspiring its very same approach. The scientific investigation of single neurons and/or of brain areas does not necessarily prefigure either the questions cognitive neuroscience addresses to the brain or their answers.

Some quarters of cognitive neuroscience are still today strongly influenced, on the one hand, by classic cognitivism and, on the other, by evolutionary psychology. Broadly speaking, classic cognitive science endorses a methodologically solipsistic

view of the mind according to which focusing on the individual's mind is all one needs to define what the mind is and how it works. Indeed, according to classic cognitive science, the mind basically is a functional system whose processes can be described in terms of symbolic information processing, according to a series of formal syntactical rules. Understanding others would square with representing in propositional format in one's mind, the propositional contents of others' minds.

According to evolutionary psychology, the human mind can be conceived of as a conglomerate of cognitive modules, selected in the course of evolution because of their adaptive value. Prominent figures of evolutionary psychology like Leda Cosmides and John Tooby went as far as arguing that the brain is a physical system working like a computer [2], while according to Steven Pinker [3,4] our cognitive life can be reduced to the functioning of a series of modules, like the language module, the theory of mind module, etc.

On the basis of this composite theoretical framework, it is no surprise that many cognitive neuroscientists during the last 20 years, when investigating social cognition, mainly aimed at localizing in the human brain the above-mentioned cognitive modules, thus implicitly—when not even explicitly—relying on the views heralded by classic cognitive science and evolutionary psychology. This approach can be characterized as a form of ontological reductionism, which treats the individual—the self—as a mass of information-processing neural networks. Such a reduction also suffers from an excessive reliance on brain imaging as the sole method of investigation. The point is that functional magnetic resonance imaging (fMRI) by itself falls short of enabling a thorough picture of how the brain works, unless its correlational data are benchmarked with the more finely grained invasive sub-personal level of investigation, consisting in the recording of single neurons in non-human primates or—more rarely—in humans. Furthermore, if brain imaging is not complemented with a detailed phenomenological analysis of the perceptual, motor and cognitive processes it aims at investigating, and, most importantly, if brain imaging results are not interpreted on the basis of our knowledge of clinical neuropsychological cases, this approach loses much of its potential heuristic value (for similar views, see [5]).

Here, I propose an alternative—or, at the very least, complementary—approach to the study of social cognition, which focuses on the pivotal role played by the lived body in the constitution of the way we understand the world of others. Such a bottom-up approach can shed new light on the genesis of the self and intersubjectivity by relying on a methodological reductionism that does not sacrifice the rich experience we make use of in our daily transactions with the world. To solve the problem of what it means to be a human subject, a self-reflective self, we should not consider the brain in isolation, but focus on its tight interrelated connections with the body. We should also abandon the solipsistic stance and address the issue from a social point of view.

The hypothesis developed in this article rests on four premises: (i) the minimal notion of the self, the bodily self, tacitly presupposes ownership of an action-capable agentive entity. Hence, this primitive sense of the self primarily rests on the workings of the motor system. As it will be shown, empirical evidence supports the neural realization of this implicit aspect of selfhood in the brain's motor cortex. (ii) As minimal bodily selfhood rests neurally and psychologically on the motor system, it logically follows that characteristics of the latter are

defining for the former. That is, minimal bodily selfhood could be attributed to known features of the motor system, including its capacities and limitations. (iii) One of the relevant features of a prominent component of the motor system, the mirror neurons mechanism, is that it is active during both performance and perception of goal-directed action. This mechanism underpins one way—likely the most basic and direct one—of understanding the goals of others' motor behaviour. (iv) The motor aspects of the bodily self provide the means to integrate self-related multimodal sensory information about the body and the world it interacts with.

Resting on the above four premises, it could be inferred that the minimal bodily selfhood has a dual function. On the one hand, it constitutes the basic sense of the self. On the other, it shapes our perception and pre-reflective conception of others as other selves incarnated in a motorly capable physical body with capacities and experiences similar to ours. Through the bodily self's resonance, others become second selves, or second persons¹ and this is a more vivid experience of intersubjectivity, relative to the detached, propositional deliberation on the experiences of others.

I challenge the standard solipsistic theoretical account of intersubjectivity offered by classic cognitive science, capitalizing upon a new take on intersubjectivity, as defined by the second-person perspective. The second-person perspective offers a different and deflationary epistemic approach to the problem of other minds, by reducing the mental gap that supposedly separates them. Some wide-ranging implications of this model are briefly discussed.

In the following sections, I introduce motor cognition, mirror neurons and the mirror mechanism (MM) in humans. I discuss the role in intersubjectivity of a minimal notion of the self, the bodily self, and propose a second-person perspective of intersubjectivity. I conclude by briefly discussing some of the challenges this model is facing.

2. Motor cognition

For many years, the cortical motor system was conceived of as the neural controller of elementary physical features of movement, such as force, direction and amplitude. On a theoretical level, however, many scholars in the past emphasized the strict connection between movement and cognition. The German psychiatrist and philosopher Erwin Straus, for example, pointed out that even the apparently simplest form of human behaviour enabled by the motor system, like keeping an upright position, can be directly connected to its metaphorical extensions (e.g. 'an upright member of the community') [6]. Such connection is made possible by humans' structural project (*Bauplan*), that is, by human bodily nature. According to Straus, bipedalism and the conquest of the upright position not only redefined the function of human sensory organs, such as the eyes and the ears, and surrendered the hand from its role of supporting the body, enabling its fullest expressive power, but also deeply changed humans' stance towards the physical world, which could be finally viewed from a distance, henceforth objectified.

In spite of such theoretical anticipations, it took quite a while for neuroscience to even conceive of the possibility of assigning a cognitive role to the motor system. The classic picture of the motor system as a mere movement controller radically changed on the discovery that many cortical

motor neurons do not discharge during the execution of elementary movements, but are active before and during motor acts—movements executed to accomplish a specific motor goal—such as grasping, tearing, holding or manipulating objects [7–9]. The motor goal-relatedness of cortical premotor neurons is independent of the hand movements required to accomplish the goal [10,11]. Teleology made its way into the cortical motor system.

A further element of novelty about the functional properties of the cortical motor system concerns its role in perception, as we now know that it is indeed endowed with sensory properties. Several studies consistently showed that premotor and parietal areas contain neurons that perceptually respond to visual, auditory and somatosensory inputs [7,8,12–19]. Altogether, these findings led to the formulation of the ‘motor cognition’ hypothesis as a leading element for the emergence of social cognition [20,21]. According to this hypothesis, cognitive abilities like the hierarchical representation of action with respect to a distal goal, the detection of motor goals and action anticipation are possible because of the peculiar functional architecture of the motor system, organized in terms of goal-directed motor acts. The proper development of such functional architecture likely scaffolds more cognitively sophisticated social cognitive abilities.

A peculiar example is offered by macaque monkeys’ ventral premotor area F4 [22], part of a parieto-premotor cortical network mapping specific sensory events in the space near the body onto the neural representation of arm and head motor acts [23]. F4 neurons not only control orienting/avoidance movements of the head and reaching movements of the upper limb, they also respond to tactile stimuli applied to the same body parts whose movements they control, and to visual and auditory stimuli, provided they occur within the monkey’s peripersonal space. F4 neurons’ visual and auditory receptive fields are somatocentred, that is, they are anchored to body parts and move along with them. Thus, perceiving a visual object or hearing a sound within peripersonal space evokes the motor simulation of the most appropriate actions towards that very same spatial location [24,25].

Most interestingly, several studies identified a putative human homologue of monkey area F4 in the premotor cortex. Bremner *et al.* [26] demonstrated that the ventral aspect of human premotor cortex responds to tactile stimuli applied to the face and to visual and auditory stimuli presented within its peripersonal space. Furthermore, repetitive transcranial magnetic stimulation (TMS) over premotor cortex interferes with the processing of multisensory stimuli within the hand’s peripersonal space [27]. These results show that the cortical motor system both in non-human primates and humans maps the body’s motor potentialities and that such mapping enables the multisensory integration of self bodily related stimuli affecting the body and its surrounding space.

Let us now address some of the neural mechanisms enabling intersubjectivity and mutual understanding, by introducing mirror neurons in macaques, MMs in humans and embodied simulation (ES).

3. Mirror neurons, mirror mechanisms in humans and embodied simulation

Mirror neurons are another class of multimodal motor neurons. They were originally discovered in ventral premotor area F5 of

macaque monkeys [28–30]. Mirror neurons are activated not only when a monkey performs a particular object-related action, but also when observing someone else performing the same action. Also for macaques’ mirror neurons, what really matters are not specific movements, but the motor goal that movements are supposed to accomplish [29]. Neurons with similar properties were also found in regions of the inferior parietal lobe [31,32], reciprocally connected with area F5 [23]. The intensity of mirror neurons’ discharge is significantly stronger during action execution than during action observation [11]. Thus, the MM is not opaque to the issue of agency, that is, it implicitly discriminates between *who* is the agent and *who* is the observer.

Since their very discovery, mirror neurons were interpreted as enabling a direct form of understanding others’ motor behaviour [28–30], while arguing that the mere visual description of others’ motor behaviour cannot account for its goal-relatedness [33]. According to the same proposal, the relational character of behaviour as mapped by the cortical motor system would enable the appreciation of purpose without relying on explicit inference.

Many studies employing different methodologies, including fMRI, positron emission tomography (PET), magnetoencephalography (MEG), electroencephalography (EEG), TMS and single neurons recordings, revealed also in humans a MM mapping the perception of others’ motor behaviour onto motor representations of the observers’ brain [34–37]. A distinctive feature of the MM for movement in humans consists in its much wider scope. Differing from macaques, motor resonance in humans can be evoked not only by the execution/observation of goal-directed motor acts, but also by simple movements, like raising one’s arm, jumping or flexing one’s finger. This wider ‘motor palette’ likely played a role in fostering the distinctive mimetic nature of the human species. Indeed, in order to imitate someone else’s behaviour, one needs to copy not only the motor goal of the observed behaviour but also its means, that is, the movements allowing its accomplishment. The MM for movement in humans can do both.

Very early on, it was hypothesized that the MM for movement might have been just the tip of a much bigger iceberg [38,39]. Indeed, numerous neurophysiological, neuroimaging and behavioural studies confirmed the initial hypothesis that a similar MM could underpin the social perception of others’ bodily experiences and mental states [38]. Indeed, the same cortical regions underlying the experience of emotions and sensations are also activated when witnessing others’ emotions [40–43] and sensations, such as touch [44–48], pain [49–53] and pleasant touch [54]. Furthermore, it has been recently shown that action and emotion are not segregated domains, as the emotion dynamically expressed by the face of an observed agent modulates the cortical motor circuits activated during the perception of her/his grasping action [55]. These results show that the MM is modulated by the affective state of others: the emotional context is combined with the motor representation of the observed action at the level of the cortical motor system. The observed dynamic facial expression of others thus modulates the ES of the observed action.

The theory of ES [25,37,39] provides a unified theoretical framework for all of these phenomena. It proposes that our social interactions become meaningful by means of reusing our own mental states or processes in functionally attributing them to others. In this context, simulation is conceived of as a non-conscious, pre-reflective functional mechanism of the

brain–body system, whose function is to model objects, agents and events. This mechanism can be triggered during our interactions with others, but is also plastically modulated by contextual, cognitive and personal identity-related factors. ES theory challenges the notion that the sole account of intersubjectivity consists in explicitly attributing to others propositional attitudes, such as beliefs and desires, mapped as symbolic representations. As previously argued, before and below mindreading is *intercorporeality* as the main source of knowledge we directly gather about others [56].

As pointed out by De Preester [57], following the French philosopher Merleau-Ponty, the body of intercorporeality is primarily perceived as a systematic means to go towards objects. This is the reason why, argues De Preester, ‘the other is seen as a behavior and the “I” is primarily a “motor I”’ [57, p. 137]. This perspective on simulation holds that the same neural structures involved in our own bodily self-experiences are also reused when facing others, enabling the pre-reflective understanding of their behaviours and of some of their mental states, thus introducing a novel conceptualization of simulation with respect to its standard account in the philosophy of mind [58].

What and who are the selves relating to one another in the course of human interpersonal relationships? To address these questions, we should focus upon the multilevel notions of the self.

4. From the bodily self to intersubjectivity

The Danish psychiatrist Josef Parnas, building upon a phenomenological perspective, identified three levels specifying the self [59,60]. The first level consists in the implicit awareness that any of our experiences are ‘ours’, defined as ‘ipseity’. The second level consists of the more explicit awareness of being the invariant subject of experience and action. Finally, the third level pertains to the social or narrative self. The first level has been variously identified with the notions of ‘core self’ or ‘minimal self’. A bottom-up approach to intersubjectivity could thus benefit from the empirical investigation of the elements allowing the emergence of implicit and pre-reflective self-knowledge.

Most research on the self employs the notions of body ownership, sense of agency and first-person perspective. Body ownership refers to the perceptual status of one’s own body, which makes bodily sensations seem unique to oneself [61]. Empirical evidence shows that the experience of our body as our own mainly relies on multisensory integration, which, however, is conditioned by the possibility—or not—to perform actions with a given body part [62,63]. Sense of agency refers to the sense of being the one who generates the action. We recognize ourselves as agents when we experience congruence between self-generated movements and their expected consequences. However, as argued by Marc Jeannerod [64], the sense of agency also arises in situations where action representation is formed, but no movement is executed. As frequently actions in our daily life remain covert, the existence of overt behaviour should not be a prerequisite for self-identification. This form of motor simulation occurs, for example, in the case of mental motor imagery [65], when perceiving perceptual events within our peripersonal space with the activation of F4 neurons or of their human homologue, or during the observation of others’ actions with the activation of the MM as its neural counterpart. First-person perspective, finally, refers to

the fact that the world appears to be constrained by a mobile bodily self, that is, by the situated point of view, the orientation and the attitudes proper of the self’s sensorimotor background capacities [66]. Thus, many notions adopted to answer the question of how we distinguish ourselves as bodily selves from other human bodies refer to a crucial role of the motor system.

Indeed, it was proposed that there is a sense of body, enactive in nature, which enables one to capture the most primitive sense of self as bodily self [67,68]. Our body is primarily given to us as source or power for action. Our body is experienced as specifying the variety of motor potentialities defining the horizon of the world we interact with. This is what Straus’s notion of *Bauplan* refers to [6]. Such a primitive sense of self as bodily self is conceived of as being antecedent to the distinction between senses of agency and ownership.

One may easily argue that not all self-experiences tap into action. Indeed, sensations like being hungry or thirsty are certainly experienced as belonging to ourselves, in spite of their not being directly related to action. The point is that in order to experience these sensations as ours we must presuppose a sense of self as bodily self to whom these experiences belong.

The relationship between this minimal sense of self and the cortical motor system was recently revealed. It was shown that the motor experience of one’s own body, even at a covert level, allows an implicit and pre-reflective bodily self-knowledge to emerge, leading to a self/other distinction, as measured by participants’ faster responses during a mental rotation task to pictures of their dominant hand, with respect to others’ hands [69]. The same study also showed that when participants were requested to explicitly discriminate between their hands and the hands of others, the self-advantage disappeared. Implicit and explicit recognition of the bodily self dissociate: only implicit recognition of the bodily self, mapped in motor terms, facilitates implicit bodily self processing. A subsequent fMRI study [55] based on a similar hand mental rotation task showed that a bilateral cortical network formed by the supplementary and pre-supplementary motor areas, the anterior insula and the occipital cortex activated during processing of participants’ own hands. Furthermore, the contralateral ventral premotor cortex was uniquely and specifically activated during the mental rotation of participants’ own dominant hand. The authors of this study concluded that the ventral premotor cortex might represent one of the essential anatomical and functional bases for the motor aspect of bodily selfhood, also in the light of its role in integrating self-related multisensory information. This hypothesis is corroborated by clinical and functional evidence showing its systematic involvement with body awareness [70–72]. Thus, there seems to be 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 behaviour and the implicit awareness one entertains of one’s body as one’s own body and of one’s behaviour as one’s own behaviour.

After having clarified some basic aspects of a minimal notion of the self as bodily self, I turn now to a second-person perspective to intersubjectivity.

5. I and you: a second-person perspective to intersubjectivity

When meeting others, we can relate to them in the detached way, typical of an external observer. We can ‘objectively’

explain others, reflect, and formulate judgements, categorize their actions, emotions and sensations by adopting a third-person perspective, aimed at objectifying the content of our perceptions and predictions. The purpose of such cognitive operations is the deliberate categorization of an external state of affairs, that is, the mental representations of others.

However, we do not only mentally entertain an 'objective' third-person account of what others are, do to us and with us. When relating to others, we also experience them as bodily selves, similar to how we experience ourselves as the owners of our body and the authors of our actions. When exposed to others' expressive behaviours, reactions and inclinations, we simultaneously experience their goal-directedness and intentional character, as we experience ourselves as the agents of *our* actions, the subjects of *our* affects, feelings and emotions, the owners of *our* thoughts, fantasies, imaginations and dreams.

All of these peculiar qualities of our social transactions qualify as ingredients of the so-called second-person perspective on intersubjectivity.² This approach differs from the third-person approach because it specifies a radically different and deflationary epistemic approach to the problem of other minds, as it greatly reduces the mental gap supposedly separating us from others.

The three minimal requirements any epistemic approach should meet in order to be qualified as second-person were recently outlined by the German philosopher Michael Pauen [73, pp. 38–39]. First, it has to draw on a replication or imagination of the mental state to be recognized; second, it must include a self/other distinction, so that the epistemic subject is aware that the state being replicated belongs to the other; third, it must allow the epistemic subject to recognize his epistemic situation as different from that of the other person. It must be emphasized that these requirements do not presuppose any explicit awareness. Indeed, as pointed out by Pauen [73], 'it seems that they are automatic and sub-conscious to a large extent' (p. 43). I posit that all three requirements are compatible with the neuroscientific account of the basic aspects of intersubjectivity outlined here. As briefly reviewed in the previous sections, ES and its underpinning MMs provide, on the one hand, a sub-personal characterization of what enables an empathic sharing of others' states based on vicarious brain activity in the sensorimotor and visceromotor systems while, on the other, they are sensitive to self-other discrimination (see also below).

All of our social relationships can be lived and experienced in different ways. What changes is our attitude towards others. The German philosopher and theologian Martin Buber (1878–1965), a precursor of the second-person perspective on intersubjectivity, in his seminal book *I and Thou* (*Ich und Du*, [74]) posited that human interpersonal relations can be third-person relations, i.e. *I-it* (and *I-She*, *I-He*) or second-person relations, i.e. *I-you*. We can relate to the same individual like a thing among other things or like our beloved one. Even our beloved one, though, occasionally can be for us a 'She' or 'He' or even an 'it', an object. The other can in fact be conceived of as an instrument, for example by informing us about some state of affairs in the world, or by helping us through those affairs. In other words, one can relate to another human being similarly to when one relates to inanimate objects. Thus, the choice is not between a second- and third-person perspective, because as human beings we clearly entertain both. We are beginning

to understand what are the sub-personal neural mechanisms enabling the former, while we still know very little about those enabling the latter.

According to Buber [74], the full-blown I only emerges once one perceives oneself as a you, when interpersonal dialogue turns into a self-centred inner dialogue. Indeed, as infant research clearly demonstrated, the rhythm, synchronicity and asynchronous engagements humans systematically experience from the very beginning in every inter-human relationship mark the birth of intersubjectivity ([75–78], see also [79]). It should be added that Buber's account of intersubjectivity prefigures Stein Bråten's notion of alter-centric participation, that is, the innate capacity of experiencing what the other is experiencing, as being centred in the other [80–82].

As the longing for relation is primary, as infant research has copiously shown, the you of the interpersonal dyad could be initially viewed as the outcome of the appetitive motivational (or seeking) system,³ conceptualized as the functional network evoking appetitive eagerness [83,84], coupled with a relationally programmed motor system [8,85]. This basic 'package' would enable the parallel genesis of the I and of his/her objects. In sum, currently available neuroscientific evidence seems to allow a sub-personal description—albeit a still sketchy one—of some of the neural mechanisms enabling and underpinning basic forms of intersubjectivity, based on partly shared brain circuits. These circuits can allow for vicarious experience of the other as another self, while at the same time preserving the self/other distinction.

6. Embodied simulation as reuse, bodily self and bodily other: challenges and answers

The present hypothesis faces several challenges. First, because it proposes a primacy of the bodily self in social cognition, a discussion of alternative perspectives that emphasize the primacy of social cognition on the development of the self is in order. Second, the MMs and ES are interpreted as instantiations of neural reuse, that is, as the dual firing pattern/activation profile of a given group of mirror neurons/brain areas, which occurs in different situations, like executing an action and witnessing its execution by others. As such dual firing is not an exclusive property of mirror neurons (e.g. it is shown also by canonical neurons, motor neurons firing both during object manipulation and object observation), one should clarify what the neural reuse notion entails. Third, the present hypothesis proposes the centrality of action and of the motor system in generating the bodily self. However, MMs and ES are not confined to the domain of action, because they can be detected also with emotions and sensations. How can this evidence be reconciled with the centrality of motor cognition? Finally, how and why are the MMs and ES relevant to the specific issue of self/other similarity and difference?

Let us address first the debated primacy either of the self or of intersubjectivity in social cognition. It was proposed that the perception of the other is what leads to a sense of embodied selfhood; in other words, according to this view, it would be the other to model the self and not the self to model the other. Tomasello [86], among others, when proposing the notion of 'shared intentionality', seems to endorse this perspective and explicitly advocate the primacy of social

cognition on the cognitive development of the individual. According to Tomasello, social interactions leading to affiliative and cooperative behaviours are distinctively human and experienced as intrinsically rewarding, because of the uniquely human drive to cooperate and share goals and intentions.

I do not see Tomasello's views as potentially contradicting the hypothesis being discussed here. Indeed, as previously argued, I think we constantly inhabit a we-centric space [39], out of which we build, day by day and in constant relation with others, our own personal identity. In order to share goals and cooperate, one must understand and discern others' goals and realize how one's behaviour affects others' actions, emotions and sensations. I think ES is well equipped to guarantee that, at least at a basic level. Thus, one might argue that the problem of the primacy either of the self or of intersubjectivity in social cognition be a false alternative, a sort of chicken-egg question. Indeed, one of the distinctive features of mammals in general, and of primates in particular, is to be born inside the other and with the other. Self and other are two self-contrasting notions: there is no self without the other and vice versa.

Furthermore, the MMs for movement, emotions and sensations can enable a bi-directional, chiasmatic-like relation between the self and the other. The phenomenon of social referencing is a good example. When facing a stressful situation, infants look at their adult carer and quite often the emotional reaction of the former is modelled upon and mirrors that of the latter. As the British paediatrician and psychoanalyst Donald Winnicott famously wrote: 'What does the baby see when he or she looks at the mother's face? I am suggesting that, ordinarily, what the baby sees is himself or herself. In other words, the mother is looking at baby and what she looks like is related to what she sees there' ([87], p. 151).

A similar, although different emphasis on the centrality of social interactions in social cognition has been advanced by some proponents of so-called 'radical enactivism' (for a review and thorough criticism of this approach, see [88]). Briefly, according to this view of social cognition, mental representations are entirely superfluous. Social interactions would not be based upon the sub-personal processes of the individuals participating to the interaction, but would be themselves constitutive of individuals' capacity to understand others' behaviours, intentions and feelings [89,90].⁴ Clearly, in contrast with this version of radical enactivism, my proposal actually presupposes that social understanding—at least at a basic level—constitutively depends on the sub-personal representations in bodily format people entertain of others' actions, emotions and sensations.

I turn now to the relation among the MM, ES and neural reuse. For quite a few years [85], I have advocated a role for exaptation [91] as a key explanatory element of the phylogenesis of human social cognition. Exaptation refers to the shift in the course of evolution of a given trait or mechanism, which is later on reused to serve new purposes and functions. According to this view, intentionality, the aboutness of our representations is—in the first place—an exapted property of the action models instantiated by the cortical motor system (see [85], p. 34). The motor system not only houses causative but also content properties.

I subsequently introduced the notions of 'neural exploitation' and 'neural reuse' [92,93] to refer to the newly acquired

commitment of sensorimotor neural resources to language and conceptual thought. Sensorimotor systems, originally evolved to guide our interactions with the world, once decoupled from the common final motor pathway and dynamically reconnected with other cortical areas—like, among others, the prefrontal regions of the brain—can be put into the service of newly acquired cognitive skills.

This perspective is gaining growing consensus as epitomized by Dehaene's 'neuronal recycling' hypothesis [94], or by Anderson's hypothesis on 'neural reuse' [95]. How do these three hypotheses relate to one another? The 'neuronal recycling' hypothesis was prompted by the discovery of a cortical visual area in the human occipito-temporal region (the visual word form area, VWFA, see [96]) specifically activated by early perceptual stages of the reading process. Such specificity is clearly reading-dependent, as it does not show up in individuals who never learned to read. In these individuals, VWFA is activated by other non-language-related visual stimuli. As reading and writing are very late cognitive acquisitions of our species, VWFA specificity for reading cannot be genetically pre-determined, but it rather exemplifies an instantiation of reuse or 'recycling'.

This notion of reuse holds that a given brain area's neural specialization for processing a certain type of sensory stimuli can also instantiate a novel use-dependent functional specialization for different stimuli of the same sensory modality. Such a hypothesis does not make any strong evolutionary claim, as reuse is basically conceived of only at the ontogenetic level. Novel cultural habits, such as writing and reading, have the potentiality to remodel in use-dependent way a given regional brain function in the course of one individual's life by amplifying the set of stimuli *belonging to the same sensory domain* it can process.

I applied the notion of neural reuse in relation to the MM and ES as a general principle of brain function and applied it to social cognition in general, and to language and conceptual thought in particular [92,93]. A similar and more systematic view was proposed by Anderson [95]. According to Anderson, by neural reuse different brain areas participate in different functions through their dynamical engagement with different brain circuits. Furthermore, a given cognitive function can be subserved by a variety of brain circuits; the newer in evolutionary term a cognitive function is, the wider is the brain circuit underpinning it.

Differing from Dehaene, both Anderson's and my hypotheses do make strong evolutionary claims as they deal with the phylogenesis of human cognitive functions, challenging the strict adaptationism heralded by evolutionary psychology. According to my hypothesis, neural reuse not only enables the cortical motor system to process and integrate perceptual stimuli, hence instantiating novel cognitive functions, but also sheds new light on the phylogenesis and ontogenesis of the vicarious experiences characterizing human intersubjectivity.

Having clarified the notion of neural reuse here adopted, let us now address the apparent contradiction between the vicarious experience of others it supposedly enables and the fact that neural reuse is also instantiated by macaques' canonical and F4 neurons and by their human homologues. Does this entail that when looking at the coffee mug positioned on the table within my arm's reach I implicitly assign to it the status of another bodily self, or worse, that I identify with the coffee mug? Does this mean that we do have a second-person

perspective of inanimate objects as well? Clearly this is not the case, unless one subscribed to a sort of neo-Romantic pansychism. As neural reuse and ES instantiate a general principle of brain functional organization, they may serve different purposes. Being a bodily self requires distinctive biological features inanimate objects are patently devoid of. That said, it should be added that it is just because of neural reuse and ES that the space around us and the objects populating it are constituted as the horizon of our motor potentialities. As aptly put by Merleau-Ponty, our body ‘provides us with a way of access to the world and the object, with a praktognosia, which has to be recognized as original and perhaps as primary’ ([97], p.140)

A similar argument can be used to address the apparent contradiction between the proposed centrality of action in generating the bodily self by means of ES and the fact that ES also applies to emotions and sensations. Centrality does not actually mean sufficiency. I would rather propose that action is necessary but not sufficient to generate a full-blown bodily self. As argued in the Introduction and as testified by empirical evidence, the motor aspects of the bodily self enable the integration of self-related multimodal sensory information about the body and about the world the body interacts with. It is also worth noting that emotions are motorically expressed and, when observed, they may generate motor resonance in the beholder, both at the levels of the face and body. Furthermore, the fact that somatosensory areas, such as SI and SII, show evidence of ES during the first-person experience of touch and its observation in others [44–48] shows how actions and their sensory consequences are multimodally integrated within a variety of brain areas whose unimodal specialization and vocation is clearly challenged, if not totally disproved (for a lengthier discussion of this point, see [98]).

Let us finally see how to reconcile the relationship between ES and the vicarious experience of others as bodily selves it supposedly generates and the necessity to keep self and other distinct. The possibility of entertaining a pre-reflective, experiential understanding of others by reusing our own neural resources should not engender any confusion between self and other. Indeed, others’ experiences, no matter how they are shared and understood, are experienced as belonging to others and not to the self. This poses no problem to the model here delineated. First, the MM for movement actually shows an asymmetric response profile during movement execution and observation, with the former evoking stronger activity ([11]; see also [99]). Second, an asymmetry in terms of incomplete overlap between areas activated by the first-person experience and the observation of others was observed also in the domain of touch [47,48]. Actually, when self–other distinctions blur, as in the case of first-episode schizophrenic patients, such asymmetry is lost, as demonstrated by the lack in deactivation of posterior insula these patients show during the observation of affective touch on others’ bodies [48]. Third, asymmetry in terms of brain connectivity discriminating between self and other was also revealed in the domain of emotions [100]. All this evidence demonstrates that ES and neural reuse do not imply self–other confusion. Intersubjectivity requires, on the one hand, shared neural networks grounding an implicit understanding of others’ behaviours and mental states, and, on the other, processes enabling one to maintain a coherent and unique sense of self, allowing for self–other discrimination. Intersubjectivity rests on the possibility to conjugate identity and alterity.

7. Conclusion

The solution to the hotly debated issue of intersubjectivity cannot be a forced choice between a third- and a second-person perspective, because we constantly switch between these two modes of inter-personal relation. If this holds to be true, we should oppose the idea that a theoretical meta-representational approach to the other is the sole/main key to intersubjectivity. It appears more fruitful to explore the possibility that the term ‘mindreading’⁵ might qualify a variety of epistemic approaches to the other. My proposal is to consider mindreading, as conceived of in a broad sense, as a non-meta-representational way of understanding others, basically sharing a common crucial feature: the mapping of the other onto the self, reciprocated by the mapping of the self on the other. Mindreading as conceived of in a narrow sense should instead qualify the type of explicit third-person form of understanding we refer to when others’ behaviours or mental states are opaque and ambiguous, thus requiring explanations. Unfortunately, the classic approach to mindreading is to date unable to convincingly explain why a series of brain areas, such as medial frontal areas and the temporo-parietal junction, systematically activate during explicit mentalizing tasks, besides making the tautological claim that mindreading happens to be located there (for a detailed discussion of this point, see [101], pp. 3–6). As argued by Erwin Straus [6], Cartesian solipsism—and, one could add, its contemporary heir, classic cognitivism—not only divides the mind from the body, but also divides the self from the world, perception from action and the I from the Thou.

Understanding others is a complex enterprise. At the very least, it requires to represent which proximal and distal goals others’ behaviour is directed to, others’ emotional state, the identification of the beliefs, desires and intentions specifying the reasons explaining why a given behaviour occurred and the understanding of how those reasons are linked to agents and to their behaviour. I posit that ES and the underpinning MMs by means of neural reuse can constitutively account for the representation of the motor goals of others’ actions by reusing one’s own bodily formatted motor representations, as well as of others’ emotions and sensations by reusing one’s own visceromotor and sensorimotor representations. ES can provide a unified explanatory framework for mindreading as conceived of in the broad sense specified above. Our bodily acting and sensing nature appears to constitute the real transcendental basis upon which our experience of the social world is built.

In conclusion, I think it is fair to say that the discovery of mirror neurons and the huge empirical research such discovery generated in the following two decades allowed the start of explaining basic aspects of intersubjectivity, like mindreading in the broad sense as delineated here, on the basis of well-documented neurophysiological mechanisms. The discovery of mirror neurons, within the broader context of a new account of the motor system demonstrating its cognitive role, allowed the possibility to conceive intersubjectivity and social cognition from a novel neuroscientific perspective that emphasizes the crucial role of the acting body. Such a new perspective, in turn, greatly contributed to revitalizing the notion of empathy and the philosophical tradition that originally identified empathy as a key element of human social intelligence, long forgotten in the debate on human cognition. I am afraid much work has still to be done to shed new light on the neural mechanisms enabling cognitively more sophisticated

ways of understanding others. Perhaps a bottom-up approach also could be fruitfully pursued in this domain.

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Endnotes

¹The notion of second person is used here compositionally and not in the linguistic sense of being the addressee of our linguistic output.

²For a thorough discussion of this topic, see Pauen [73] and Schilbach *et al.* [102].

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