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Some Remarks on Embodied-Embedded Social Cognition[1]

1. Paradigm shifts

Is human behaviour mainly determined by our emotions or by reason? This is a question which has concerned many philosophers for some time and, during the last three decades, there have been a number of passionate debates on the relationship between emotion and cognition between psychologists and cognitive scientists. Perhaps the most important adversaries in these discussions were Robert Zajonc and Richard Lazarus (cf. Zajonc, 1980; Lazarus, 1984). They were both convinced that the systems of affect and cognition are separate but they disagreed, however, about the priority of these systems in their effect on behaviour. Zajonc believed that emotions are primary with respect to cognition, while Lazarus opted for the primacy of cognition. According to the former, emotions are always accompanied by cognition (thinking), but cognition (thinking) does not always have an impact on our emotions. The latter believed that Zajonc's view could be accepted only if cognition is understood very narrowly – without the processes of attention and the interpretation of the recorded stimuli. Since detailed arguments on both

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sides are rather well known to psychologists, philosophers and cognitive scientists, in this work they will be omitted and we will focus on what this discussion has led to.

It seems that the final outcome of the debate between Zajonc and Lazarus was achieved thanks to research findings from neuroscience. In particular, Joseph LeDoux discovered and studied two pathways of inducing affect – the high (cortical) road and the low road (LeDoux, 1996). The latter is particularly important. It transpired that the phylogenetically older cognitive structures of our brains, such as the thalamus, are directly connected to the amygdala, which is one of the emotional centers of the brain. For this reason, the reaction to experienced stimuli is much faster in the low road than in the cortical pathway. In many cases the reaction is much faster than constructing a conscious representation.

It seems, therefore, that the above-mentioned discussion has ended with the adoption of Zajonc's approach. Nevertheless, this approach was modified or weakened since emotion can significantly affect cognition, but also – vice versa – cognition has an impact on emotion. Moreover, a considerable amount of other data, e.g. from lesion studies, indicates that prioritizing cognition or the emotions is rather a misguided strategy. This leads to a more general conceptual change: "cognitive processes" are not only traditional issues, such as memory and attention, but – at least implicitly – also concern emotions and decision-making. The study of their mutual influences and relationships serves to secure a better understanding of how the body works. Thus, one can certainly claim that we are dealing with a significant paradigm shift in this case.

Nonetheless, this was not the only paradigm shift that has taken place in inquiries on the nature of mind and cognition. From the 1980's, one can observe a move from a computational paradigm of cognitive science and cognitive neuroscience to the paradigm of the embodied-embedded mind. While the proponents of the computational paradigm treated the mind as software implemented in biological hardware, the followers of the embodied-embedded mind paradigm regard cognitive processes as products of motor processes and interactions, in which the individual enters the physical, social and cultural environment (Varela et al., 1993; Chemero, 2009; Johnson, 2007). In other words, the basic concepts "filling" our minds are generated on the basis of neural programs of motor control and express spatial relationships. More abstract concepts (e.g., concerning feelings and emotions) are created by "mental machinery" based on specific concepts and with the use of conceptual metaphors (as tools for understanding and action).

The embodied-embedded mind paradigm leads in turn to another revolution in the philosophy of mind, neurophilosophy and – last but not least – social cognition. This revolution concerns both cognition of one's own mind (self-knowledge) and the minds of other people. Generally speaking, the old view – dating back to Descartes – according to which knowledge of our own mental states is more primary than understanding the mental states of other people, gave way to an approach in which the cognition of other's minds is more primary than self-cognition and self-knowledge. We will try to explain what this paradigm shift is but will first present the scientific revolution which took place in social cognition through the development of a conceptual framework known as the embodied-embedded mind.

2. From brain maps to simulation

For a number of years Antonio Damasio has argued that one of the most important features of our brains is the ability to create maps (Damasio, 2010, chapter 3). In Damasio's view, maps are neural patterns created when the body *interacts* with the objects of the world (environment) as well as the minds of others. These maps are not only used in the unconscious self-regulatory activities of the body, but also play a major role in conscious cognition. The basic object of mapping is the body. As Damasio states:

> The human brain maps whatever object sits outside it, whatever action occurs outside it, and all the relationships that objects and actions assume in time and space, relative to each other and to the mother ship known as the organism, sole proprietor of our body, brain, and mind. The human brain is a born cartographer, and the cartography began with the mapping of the body inside which the brain sits (Damasio, 2010, p. 66).

The mechanism of creating brain maps explains how conscious body images, as well as body schemas related to sensory-motoric processes, are formed. Advocates of the embodied mind idea attach great importance to the latter (Gallagher, 2007).

It is not only cortical structures but also the phylogenetically older subcortical structures (such as the geniculate bodies, the colliculi, the nucleus tractus solitarius, and the parabrachial nucleus) which are able to create maps with especially the last two of these structures involved in body mapping (Damasio, 2010, chapter 3). A cerebral representation of what is happening at any given time to our body is important not only for motor activities undertaken in the physical environment. In the later part of this work we will show that this mechanism is involved in the formation of more complex content "inhabiting" our minds. The process of mapping the body is intricate, not only on the purely biological level – it also comprises all of the interactions between the body and the environment and, therefore, human activity in the physical and social setting. Damasio writes that

> Signals sent by sensors located throughout the body construct neural patterns that map the organism's interaction with the object. The neural patterns are formed transiently in the varied sensory and motor regions of the brain that normally receive signals coming from specific body regions. The assembling of the transient neural patterns is made from a selection of neuron circuits recruited by the interaction (Damasio, 2010, p. 74).

Nevertheless, generating maps of the current state of the body does not exhaust the possibilities of the brain. Indeed, the brain is able to transform created maps and simulate possible states. This brain-body communication is carried out in both directions. Cognitive processes and conscious representations can be causes of emotions that “engulf” the whole body. On the other hand, the body – in a particular emotional state – forms mental states. Moreover, in such mechanisms of mutual communication (referred to as resonant loops) Damasio sees the sources of self-consciousness:

> I envision these responses as initiating a tight two-way, resonant loop between body states and brain states. The brain mapping of the body state and the actual body state are never far apart. Their border is blurred. They become virtually fused. The sense that events are occurring in the flesh would arise from this arrangement. A wound that is mapped in the brain stem (within the parabrachial nucleus), and that is perceived as pain, unleashes multiple responses back to the body. The responses are initiated by the parabrachial nucleus and executed in the nearby periaqueductal gray nuclei. They cause an emotional reaction and a change in the processing of subsequent pain signals, which immediately alter the body state and, in turn, alter the next map that the brain will make of the body (Damasio, 2010, p. 105).

Let us return to the above-mentioned simulation. Damasio goes a step further by claiming that the brain is able to quickly generate a variety of alternative maps of the body. Thus, the maps of the states in which the body could find itself if it had been under the influence of a given emotion are also simulated. The simulation of an emotion can anticipate its actual appearance, or even completely replace the appearance of this emotion. A simulation of this type is called by Damasio ‘as-if body loop’ and involves both the structures responsible for the operation and somatosensory system structures. An example of the ‘as-if body loop’ is a connection of emotion and compassion centers, such as the amygdala and ventromedial prefrontal cortex, to the structures responsible for the state of the body processing, such as the insular cortex, SII, SI, and the somatosensory association cortices (Damasio, 2010, chapter 3–4). In addition (or, perhaps, above all), mechanisms of simulations are supported by the mirror neuron system. It allows us to feel, or to put our bodies in states in which we actually would find ourselves while experiencing a given emotion or performing a specific gesture. Damasio proposes an evolutionary scenario for explaining the formation of the mirror neuron system:

> I suspect that the system developed from an earlier as-if body loop system, which complex brains had long used to simulate their own body states. This would have had a clear and immediate advantage: rapid, energy-saving activation of the maps of certain body states, which were, in turn, associated with relevant past knowledge and cognitive strategies. Eventually the as-if system was applied to others and prevailed because of the equally obvious social advantages one could derive from knowing the body states of others, which are expressions of their mental states (Damasio, 2010, p. 109).

The issue of mirror neurons and their involvement in social cognition will be examined more closely in the following paragraphs.

3. Through the looking-glass: mirror neurons

Damasio's view indicates that the mapping of our bodily states by our brains is an important factor in the development of cognition. Our cognitive abilities depend largely on the motor actions of our bodies. Mapped bodily states are not in a vacuum, but are formed in response to the challenges posed to organisms by the surrounding environment – the natural, social and cultural environment.

A number of neuroscientists from Parma played an extremely important role in the study of the influence of motor skills on cognitive processes: Giacomo Rizzolatti, Giuseppe Di Pellegrino, Vittorio Gallese, Leonardo Fogassi, Marco Iacoboni and Luciano Fadiga. By studying the activity of neurons in the F5 motor cortex area of macaques, they obtained three surprising results about the action of understanding (Di Pellegrino et al., 1992; Fogassi and Gallese, 2002). It was known that nerve cells belonging to this cerebral structure coded the movement of a macaque's hand which accompanied the manipulation of objects (e.g. food). Firstly, it turned out that some neurons belonging to F5 are also activated when the macaque grasps food not only with his hand, but also directly with its mouth. The neuroscientists from Rizzolatti's team concluded that the neurons in the F5 area encode abstract representations of manipulation of objects, ignoring the part of the body which performs the action. Secondly, in this structure they indicated "canonical neurons" that respond only to objects with specific shapes and properties. Nevertheless, the true revolution came with the third result.

Studies have shown that some of the neurons in the F5 area are activated both when the motor system is used and in the case of utilizing visual representations of certain operations. The activity of nerve cells called "mirror neurons" can be registered in both cases – when a macaque manipulates an object (such as food) and when he sees that another macaque or experimenter executes such an operation. For example, some F5 area cells are activated both when a macaque grabs a peanut and when he sees that another individual perform a similar movement, subordinated to the same purpose (object manipulation). In summary, the experiments conducted by Rizzolatti and his team provided a strong basis to believe that mirror neurons encode not only the movements, but also the goals that these movements are meant to achieve. The F5 area is probably the only structure in the brain of macaques which is equipped with mirror neurons.

Nowadays they believe that there are many cerebral structures in which one can observe the phenomenon of the multi-modal resonance of neurons. While many neuroscientists accept mirror neurons as a "hard scientific fact" on which you can base hypotheses about human nature (Ramachandran, 2010; Gazzaniga, 2009), it should be noted that there is still an ongoing debate over the "nature" of mirror neurons. For example, it is still unclear whether a particular neuron is capable of resonance due to ultimative specialization and its structure or whether it is due to the role it plays in a particular network. In the latter case it can be expected that every – or virtually every – neuron in our brain is "potentially" capable of multi-modal resonance (Winkielman et al., 2009, p. 239).

Despite the problem mentioned above, the convergence of data collected from various sources suggests that there are also mirror neurons in human brains. It is believed that they are located, inter alia, in the 44 Brodmann area, which is the human equivalent of F5 area in the cerebral cortex of macaques. Although (mainly for ethical reasons) it is difficult to demonstrate their existence with single-cell recording, the hypothesis of the existence of a mirror system in the human cerebrum is supported by data obtained with EEG, MEG, TMS, PET and fMRI (Rizzolatti et al., 2002). For example, PET imaging indicates that in such structures of the human brain as the upper parieto-occipital sulcus, lower parietal lobe and a lower angular gyrus there are mirror neurons that are activated both during object manipulation and the observation of such operations performed by another individual (Rizzolatti et al., 1996). What is important for the hypotheses posed later in the article is that it is assumed that cells capable of multi-modal resonance are located in the emotional structures of the brain such as the insula, anterior cingulate, somato-sensory cortex, superior temporal sulcus, the extrastriate body area and the dentate of the cerebellum (Dacety and Jackson, 2004).

4. Embodied simulation and peripersonal space

The discovery of mirror neurons not only strengthened the conviction of a relationship between cognitive processes and emotions with the motor actions of the body, but it also led to the consolidation of the embodied-embedded mind paradigm. It became the basis for various theories constructed in the framework of this paradigm. The idea of *embodied simulation* formulated by Vittorio Gallese seems to be one of the most important (Gallese, 2005). The following quote captures its essence succinctly:

> I employed the term simulation as an automatic, unconscious, and pre-reflexive functional mechanism, whose function is the modeling of objects, agents, and events. Simulation (…) is therefore not necessarily the result of a willed and conscious cognitive effort, aimed at interpreting the intentions hidden in the overt behavior of others, but rather a basic functional mechanism of our brain. However, because it also generates representational content, this functional mechanism seems to play a major role in our epistemic approach to the world. It represents the outcome of a possible action, emotion, or sensation one could take or experience, and serves to attribute this outcome to another organism as a real goal-state it is trying to bring about, or as a real emotion or sensation it is experiencing. Successful perception requires the capacity of predicting upcoming sensory events. Similarly, successful action requires the capacity of predicting the expected consequences of action. As suggested by an impressive and coherent amount of neuroscientific data (…), both types of predictions seem to depend on the results of unconscious and automatically driven neural states, functionally describable as simulation processes.

Gallese also points out that

> (…) Simulation is not conceived of as being confined to the domain of motor control, but rather as a more general and basic endowment of our brain. It is mental because it has content, but it is sensory-motor because its function is realized by the sensory-motor system. I call it "embodied" – not only because it is neurally realized, but also because it uses a pre-existing body-model in the brain, and therefore involves a non-propositional form of self-representation (Gallese, 2005, pp. 41–42).

The mechanism of embodied simulation is based on the phenomenon of the multimodality of neurons. In particular, numerous studies indicate that the same neurons that are responsible for sensory information processing also play an important role in the motor control. Gallese carefully examines the properties of the cortical premotor-parietal network F4-VIP in macaques' brain. The F4 area occupies the posterior sector of the ventral premotor cortex, yet the structure of the VIP occupies the fundus of the intraparietal sulucus. This structure is involved in the control of purposeful movements of the head and forearm.

Single-cell recording shows that, apart from visual neurons, bimodal visual-tactile cells are located in the VIP structure. Cells belonging to this structure fire in response to both visual and tactile stimuli and the receptive field of these cells are related to the face and merged with the touch field creating peripersonal space. VIP area lesions result in the neglect of contralateral peripersonal space, which is one of the symptoms of hemispatial neglect (Darby and Walsh, 2005, chapter 6).

In the F4 area, apart from unimodal (sensory) neurons, there are also bimodal cells encoding both visual and somatosensory representations as well as trimodal cells which additionally encode auditory representations. The receptive fields of these neurons also participate in the formation of peripersonal space. The receptive fields of most F4 cells are independent of eyeball movements which, according to Gallese, "indicates that the visual responses of F4 do not signal positions on the retina, but positions in space relative to the observer" (Gallese, 2005, p. 25). In the embodied simulation theory, peripersonal space, which is an important element of a sense of corporeality, is closely associated with the motor processes. Research on brain damage indicates that the frontal lobe and inferior paritetal lobule play an important role in maintaining the body schema as well as identifying and raising awareness of the features of objects in peripersonal space.

5. Foundations of social cognition

The embodied simulation theory applies not only to the structure of physical space, but also – metaphorically speaking – to social space. In this way we come to the application of embodied simulation theory to embodied social cognition (Gallagher, 2008; Gallese, 2009). Gallese points out that social cognition has an intentional character and its aim is to predict the beliefs, feelings, desires, and intentions of other individuals. In his view:

> From a first-person perspective, our dynamic social environment appears to be populated by volitional agents capable of entertaining, similarly to us, an agentive intentional relation to the world. We experience other individuals as directed at certain target states or objects, similarly to how we experience ourselves when doing so (Gallese, 2005, p. 31).

In the philosophy of mind there is a clichéd scheme according to which either the problem of other minds (Searle, 1992) arises due to the inviolable first-person ontology of mental states, or those states are completely eliminated (Churchland, 1981). In contrast to this scheme, people constantly – and to a large extent independently of their will – engage in mind-reading. Nevertheless, scientists still argue about the mechanism responsible for this cognitive ability (Kurek, 2013). Proponents of the concept known as the theory-theory believe that the reading of other minds is possible through reasoning (Meltoff, 2005). More recent versions of the theory-theory differ from the classical "analogical" approach according to which people reason with the usage of the principle: "if I find myself in a particular state and behave thus and so, then I can suppose that someone else behaving in the same manner feels the way I do."

Simon Baron-Cohen identifies four stages of reading the minds of others (Baron-Cohen, 1997). The so-called Intentionality Detector works during the first period of ontogeny. It interprets the behavior of potential agents recorded in all modalities (visual, auditory, tactile) as intentional and volitional. At the second stage, the Eye-Direction Detector starts functioning. It comprises the detection of eyeballs, monitoring gaze direction and reasoning (based on experience) that if someone's gaze is focused on an object, she can see it. At the first two stages, dyadic relations between 'I' and an object are formed. In 9–18 month old infants the Shared-Attention Mechanism is developed. It allows one to construct triadic relations between 'I', 'you' and an object. Almost every play in which mother and child draw attention to the same object can serve as its example. At the fourth stage, healthy 3–4 year old children develop the Theory-of-Mind Mechanism. As Baron-Cohen writes, "ToMM is a system for inferring the full range of mental states from behavior – that is, for employing a 'theory of mind'" (Baron-Cohen, 1997, p. 51). It provides the possibility of representing epistemic states of mind such as thinking, knowledge, belief, imagining, guessing and cheating and combines volitional, perceptual and epistemic states into a coherent theory of how mental states and actions are linked. Thanks to this, children with a properly developed ToMM are able to pass a false belief task. As Baron-Cohen points out:

> (…) Children use their mentalistic knowledge in highly theory-like ways (…). Children probably could also affirm a long list of axioms that constitute the core of their theory of mind, though as yet only a fraction of these have been explicitly stated and tasted (such as 'seeing leads to knowing,' 'appearance is not necessarily the same as reality,' 'people are attracted to things they want,' and 'people think that things are where they last saw them') (Baron-Cohen, 1997, pp. 54–55).

Proponents of embodied simulation does not agree that mind reading consists of carrying out reasoning that results in the transition from "first-person" to "third-person" state. According to Gallese, reading other minds is immediate and intrusive:

> We are just *attuned to the intentional relation displayed by someone else* (…). We are not alienated from the actions, emotions and sensations of others, because we entertain a much richer and affectively nuanced perspective of what other individuals do, experience, and feel. What makes this possible is the fact that *we own* those same actions, emotions, and sensations (Gallese, 2005, p. 31).

Most advocates of the theory-theory believe that a certain type of reasoning serves as a "bridge" between one's own mental states and the cognition of mental states of others. The starting point of this approach is subjectivity, namely the 'I' perspective. The adoption of a 'you' perspective is something secondary. The embodied simulation assumes the existence of primary intersubjectivity, which can be called metaphorically the sphere of 'we'. Thanks to this, the minds of others are no less accessible than one's own mind. Moreover, Gallese tries to convince us that on both the phylogenetic (evolutionary) and ontogenetic level, primary intersubjectivity is prior to the ability to distinguish between the 'I' and 'other'. This idea is formulated in Gallese's *shared manifold hypothesis*:

> The shared blended space enables the social bootstrapping of cognitive and affective development. Once the crucial bonds with the world of others are established, this space carries over to the adult conceptual faculty of socially mapping sameness and difference ("I am a different subject") (…). The shared space provides an incredibly powerful tool for detecting and incorporating coherence, regularity, and predictability in the course of an individual's interactions with his or her environment. The shared space is progressively joined by perspectival spaces defined by the establishment of capacities to distinguish the self from others while self-control is developing. Within each of these perspectival spaces information can be further segregated in discrete channels (visual, somatosensory, etc.), making our perceptual view of the world more finely grained. The concurrent development of language probably contributes to further separating

> out of single characters or modalities of experience from the original multimodal perceptual world, but the shared intersubjective space does not disappear. It progressively acquires a different role: to provide our self with the capacity simultaneously to entertain self–other identity and difference (…). My proposal is that the "selfness" quality we readily attribute to others, the inner feeling of "being like me" triggered by our encounter with others, is the result of this preserved blended intersubjective space. Self–other physical and epistemic interactions are shaped and conditioned by the same body and environmental constraints (Gallese, 2005a).

Gallese argues that the neural substrate of tuning in to the mental states of others is the mirror neuron system described above. That description should now be supplemented with a few details, to which Gallese draws more attention (Umiltà et al., 2001). Later studies on mirror neurons show that those cells not only fire when macaques see the entire course of operation (the entire sequence of movements, which leads to the goal), but also when the ape observes an object and the initial movements, yet the final steps and the goal achievement are covered. This result strongly supports the hypothesis according to which the cells of the F5 area encode goals. Gallese adds that this experiment reveals the mechanism of embodied simulation. Covering the goal achievement induces a "perceptual gap" in macaque's mind. It is a simulation which is responsible for filling the gap. Although the achievement of the goal (e.g., a result of object manipulation) is not directly observed, the simulation assigns it to the general pattern, which under normal circumstances would comprise both observed and unseen events (Gärdenfors, 2006).

Another example relates to certain neurons in the F5 ventral premotor cortex, whose function is to encode the movements of the macaque's mouth (Ferrari et al., 2003). These neurons show activity in both cases – when the macaque itself performs some operations and when it observes grasping, biting, chewing or licking the food. Moreover, the F5 area also contains mirror neurons that are activated during acts of communication manifested in gestures and movements of the lips and tongue. This is important for social cognition because, as Gallese points out: “It is therefore plausible to propose that communicative mirror neurons might constitute a further instantiation of a simulation-based social heuristic” (Gallese, 2005, p. 34).

6. Embodied-embedded emotional mind

Proponents of applications of embodied simulation pay special attention to the role of emotion and empathy in social cognition. In the course of phylogeny, primary emotions mainly appeared in order to regulate the behaviour of individuals and to enhance the survival chances of their genes. Nevertheless, in socialized species such as Homo sapiens higher order emotions have evolved and they play an entirely new role. Joseph LeDoux indicates the difference between those two types of emotion:

> Basic emotions (fear, anger, joy, disgust, etc) are believed to be innately organized in humans, conserved to some degree across mammalian species, automatically or unconsciously elicited, expressed in characteristic ways in the body of all humans independent of culture, and mediated by distinct neural systems. Higher order emotions (e.g. empathy, jealousy, guilt) are often considered to be less conserved across species, cognitively mediated rather than automatically elicited, less rigidly expressed in the body, mainly due to learning and social factors, and can be different in different cultures (LeDoux, 2011).

In species with highly developed brains, emotions that are the holistic responses of the body to a stimulus may also have their internal aspects ("The bodily changes follow directly the perception of the exciting fact, an d that our feeling of the same changes as they occur is the emotion" [James, 1884, p. 189]). Typically, they are referred to as feelings (Damasio, 2010). Emotions may and may not be conscious. For example, we are sometimes unaware of the content of our emotions until somebody asks "why are you mad at me?". Your partner can recognize your emotional state earlier than you and she makes it on the basis of the observation of states of the body, such as facial expressions.

Empathy, one of the higher order emotions, is a special case of compassion. According to Frans de Waal, it is one of the two main pillars of morality (the other being reciprocity and fairness) (de Waal, 2006, 2010, 2013). Michael Arbib and Jean-Marc Fellous argue that the mechanisms of empathy are associated with the activity of the mirror neuron system and embodied simulation:

> Clearly, human emotions are greatly influenced by our ability to empathize with the behavior of other people. Indeed, some have suggested that mirror neurons can contribute not only to 'simulating' other people's actions as the basis for imitation, but also 'simulating' other people's feelings as the basis for empathy (Arbib and Fellous, 2004).

The strong relationship between empathy and simulation is indicated by various studies on responses to pain. Single-cell recordings show that certain cells of the cingulate cortex fire when a person experiences a painful stimulus caused by a pinprick on herself as well as when she sees the other person suffering from a pinprick (Hutchison et al., 1999). The simulation of pain has also been confirmed by experiments with neuroimaging (fMRI). They both show that the first-person experience of pain and the observation of another person experiencing pain activate the anterior cingulate and insula (Singer et al., 2006).

It is widely known that the responses of the motor system not only accompany, but are embedded within the emotional states in which organisms find themselves. In this way Zajonc and Markus answer the persistent question of "why do people who are angry squint their eyes and scratch their shoulders?" (Zajonc and Markus, 1984). The face is the part of the body that reveals our emotions most expressively. Gallese, citing a study conducted by Carr et al. (2003) notes that an important argument for the relationship of embodied simulation and experiencing emotions are the data from neuroimaging studies using fMRI on people observing and imitating facial expressions specific for different emotions. These studies indicate that imitating emotions causes the activation of such brain structures as the ventral premotor cortex, insula and amygdala. The fact that those structures are involved in emotion processing is additionally confirmed by lesion studies. Damage to these areas results in a reduced ability to imitate and experience the emotions of others.

Gallese also refers to his own research with fMRI aiming to demonstrate a common neural architecture for emotions experienced from both the first-person and third-person perspective. His subject of interest was disgust, which is one of the basic emotions. The subjects' brains were scanned in two cases – when they inhaled an unpleasant scent arousing disgust and when they watched various faces expressing disgust. In both cases the left anterior insula was active (Wicker et al., 2003).

Another argument for the application of embodied simulation is the fact that the imitation of the facial expressions of others helps us to recognize their emotional state. In an experiment conducted by Niedenthal et al. subjects were asked to detect the offset of a sad facial expression changing into a happy expression and vice versa (Niedenthal et al., 2001). In doing this task one group of participants held a pen between their lips and teeth, which blocked the possibility of imitating the observed facial expressions. They found that people who were allowed to freely mimic the faces detected a change from a sad to a happy expression much faster than those who had fewer possibilities for imitation. In a more advanced exercise, this result was reaffirmed by Oberman, Winkielman and Ramachandran (2007).

Gallese points out, however, that the mere imitation of facial expressions does not always cause a conscious experience (feeling) associated with the imitated emotion (Gallese, 2005, p. 37). Nevertheless, the lack of a complete awareness of an imitated mental state does not necessarily mean that it is not utilized in the action or social cognition. This constitutes an argument for the thesis that some pre-reflective mechanism of simulation of state of the body which is common for a person experiencing the emotion and her observer/imitator works in the background and correlates with the neural structures mentioned above. This is an argument against the theory-theory – empathy does not involve any form of reasoning by analogy, but consists of entering into a direct resonance with another person. Piotr Winkielman, Paula M. Niedenthal, and Lindsay M. Oberman aptly sums up this thread:

> Theories of embodied cognition suggest that engagement of sensory-motor processes is part and parcel of the process of emotional perception, understanding, learning, and influence. On that account, the vicarious recreation of the other's state provides information about the stimulus meaning and can go beyond the previously established associations. If so, manipulation (inhibition or facilitation) of somatosensory resources should influence the perception and understanding of emotional stimuli. Evidence for this interpretation has been now obtained in multiple domains (Winkielman et al., 2009).

7. Conclusions: paradigms shifts again

At the beginning of this article we argued that in the last few decades there have been a few paradigm shifts in cognitive science research. It is argued that in the discussion between Lazarus and Zajonc on the primacy of cognition and emotion the view of the latter prevailed. It should be stressed, however, that relations between emotion and cognition are more complicated. We believe that the paradigm shift that has occurred thanks to the embodied-embedded mind approach consists of the adoption of the primacy of action. Both cognition and emotion – mutually connected on various levels of the complexity of brain and mind – are subordinated to generate a response that solves the problem facing the organism, and solves it in the most optimal way. This includes problems facing the organisms in real time, as well as problems in the evolutionary context. (One can assume that selection mechanisms favour the cognitive and affective systems being connected at different levels).

The second paradigm shift, which took place in the cognitive sciences in the 1980's, consisted of a transition from a computer-like vision of the mind to the embodied-embedded mind approach. One can claim that this vision, according to which the mind is software implanted in cerebral hardware, is close to the psychophysical dualism advanced by Descartes (Searle, 1992). In this interpretation "software" recalls *res cogitans*, while the "hardware" is similar to *res extensa*. Although computationism still plays an important role in some parts of cognitive science (e.g., in the thesis of Massive Mental Modularity accepted by evolutionary psychologists), the embodied-embedded mind approach introduces strongly non-dualistic vision. This vision is supported by various data sets from neuroscience and cognitive linguistics (Gallese and Lakoff, 2005; Lakoff and Johnson, 2009).

The resignation of a computational paradigm of cognitive science in favour of the embodied-embedded mind approach is connected with another (already mentioned) revolution. It consists of the purification of the 'mind' sciences of "Cartesian leftovers", which were still present in social cognition. Cartesianism assumed that we can only be sure of our own mental states and the cognition of other minds is secondary. Hence, we are involved in the other minds problem. In philosophy of mind this problem is solved by the idea of estimating the mental states of others by analogy to one's own mental states or by eliminating the entire realm of subjectivity. (The former account had been developed later in the theory-theory.) Embodied simulation breaks the scheme and seems to be much more credible solution supported by data from studies on the functioning of the brain.

Advocates of the embodied-embedded mind approach claim that the mind is created by the interactions with physical, social and cultural environment that the body enters. They assume that the mind of the individual can "resonate" with the minds of others. In brief, people are constantly reading the minds of others. The embodied simulation theory eliminates the difference between the subjectively received self and other minds. Moreover, according to the shared manifold hypothesis, the formation of the first-person perspective is secondary and subsequent to the prior intersubjectivity that our biological equipment provides. This is the genuine revolution, because one can say that in such a view the cognition of one's own mind seems to be at least as problematic as the old problem of other minds.

Embodied simulation allows us not only to predict the behaviour of others and feel empathy for them, but also to create an intersubjective community of language and culture. According to convincing studies conducted i.a. by Michael Tomasello and Merlin Donald, the human ability that underlies culture is the ability to imitate (Tomasello, 1999; Donald, 2005), which is based on a simulation mechanism. Imitation is defined as the precise replication of goals and the means which lead to their achievement and the precise replication of such patterns is possible thanks to the well-developed mirror neuron system. Thus, it seems concepts such as "cognition" and "emotion" and also "culture" and "nature" are not as contrasting as previously thought ("[…] imitation seems to be the key to understanding rule-following in particular, and the social practices which contribute to the development of culture in general. From the neuroscientific viewpoint it is the mirror neuron mechanism that lies at the heart of pattern-recognition and – indirectly – pattern-propagation. Evolutionary theory, on the other hand, suggests that we tend to imitate others due to our mutualism" [Brożek, 2013, p. 217]).

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