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The Brain — A Mediating Organ

Abstract: *Cognitive neuroscience has been driven by the idea that by reductionist analysis of mechanisms within a solitary brain one can best understand how the human mind is constituted and what its nature is. The brain thus came to appear as the creator of the mind and the experienced world. In contrast, the paper argues for an ecological view of mind and brain as both being embedded in the relation of the living organism and its environment. This approach is crucially dependent on a developmental perspective: the brain is conceived as a plastic system of open loops that are formed in the process of life and closed to full functional cycles in every interaction with the environment. Each time a new disposition of coherent neural activity is formed through repeated experience, structures of the mind are imprinted onto the brain. The brain becomes a mediating organ or a window to the mind, for it is structured by the mind itself.*

Key Words: brain, mind, embodiment, consciousness, hard problem

Introduction

Until now, cognitive neuroscience has mainly been driven by the idea that by reductionist analysis of mechanisms within an individual brain one can best understand the origin and nature of the human mind. Conscious experience came to be regarded as a by-product of the brain's activity as a symbol-manipulating machine. However, this view separates the brain not only from the living body, but also from its interactions with the environment. As a consequence, mind and world are treated separate from each other, with the outside world

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being mirrored by the mind as a representational system inside the head. As Thompson (2007, p. 36) remarked, this has yielded 'abstract and reified models of the mind as a disembodied and cultureless physical symbol system' in the brain of a solitary individual.

Similarly, current theories of intersubjectivity are also based on a representationalist view. Concepts such as Theory of Mind, mentalization or simulation all have in common that they conceive of social understanding as implying some kind of inner representations of others' presumed mental states that we then have to project onto them. Research into the 'social brain' has favoured a third-person paradigm of social cognition as a passive observation of others' behaviour, based upon an inner modelling process in the individual brain. One could even say that according to these concepts the person who perceives another does not actually interact with him or her, but deals with internal models or simulations of her actions.

This kind of neurobiological reductionism and solipsism is by no means an inevitable result of brain research. As I will argue, it is based on an overestimation of the brain as a god-like creator of mental life. The brain is certainly a central organ of the living being, but it is only an *organ* of the mind, not its seat. For the mind is not located in any one place at all; rather, it is an activity of the living being which integrates at any moment the ongoing relations between brain, body and environment. Assuming such an embodied, extended and dynamic view of the mind (Clark and Chalmers, 1998; Thompson and Stapleton, 2009), the brain loses its mythological powers and turns into a still fascinating, yet far more modest *mediator* of human experience, action and interaction.

This mediating role of the brain becomes all the more obvious if we look at it not only cross-sectionally, but include the developmental aspect. The structures of lived experience are inherently mental, i.e. they include spatial, temporal, logical, symbolical, and other patterns which in the course of organism-environment interactions are extracted and ingrained in microstructures of the brain. This results in the formation of neural networks that serve as dispositions for meaningful reactions to similar situations in the future. Thus, in fact *the brain is formed by mental life*; from early childhood on, mental structures come to be imprinted in the brain's structure, and the individual increasingly shapes his own brain through his actions and interactions. The brain may also be regarded as a matrix that transforms all experience into lasting dispositions of behaviour and experience. It constitutes a *system of open loops* that have been formed in the course of earlier interactions, and that are functionally closed each time the

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organism is interacting with a certain object or situation that it has dealt with before (Fuchs, 2008).

From this point of view, the brain is not a creator, but a relational organ: it is embedded in the meaningful interactions of a living being with its environment. It mediates and enables these interactive processes, but it is in turn also continuously formed and restructured by them. The mind may be regarded as a continuous process of relating to the environment which is constantly transformed into the more stable structures of neural networks and dispositions. This reciprocal relationship of *'process'* and *'structure'*, with each of the two poles enabling and modifying the other, is the foundation of the joint development of mind and brain. It also strongly contradicts any reductionist notions of the brain as the creator of the mind.

In what follows, I will first outline a concept of the life process as the unifying basis of organic and mental processes. To overcome dualistic predicaments, life is regarded as a unity of the *living body* (*Körper*) and the *lived body* (*Leib*). The one denotes the body as an autopoietic living system, the other the body as a centre of subjective experience. This means that processes of *living* and processes of *living through* (*Leben* and *Erleben*) are both aspects of the life process seen from two complementary points of view. On this basis, I will describe three essential cycles of the life process; namely (1) cycles of organismic homoestasis, (2) cycles of organism-environment interaction, and (3) cycles of social interaction. Finally, I will consider the developmental side of these cycles: the relation of lived and living body may also be regarded as an ongoing interaction of 'process' and 'structure', or of lived experience and sedimented dispositions. Thus, the organism's interaction with the environment constitutes the basis for the development of mind and brain.

A Dual Aspect Theory of Life

Cognitive neuroscience is still based on the principal divide between the 'mental' and the 'physical', or between the subjective mind and the objective body, the one only accessible from within, or from the so-called first-person perspective, the other only accessible from without, or from a third-person perspective. As a result, social cognitive neuroscience also assumes a disembodied sender-receiver relation between two Cartesian minds, with their bodies only serving as signal transmission devices. What is lost in the principal divide is the human person which essentially means *a living being*, an embodied subject. The person is neither pure subjectivity experienced from

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within, nor a complex physiological system observed from without; it is a living being interacting with others from a second-person or 'you'-perspective, and thus, as a unity of interiority and exteriority. When talking with another person, listening to his words, seeing him laughing, shaking hands with him, etc. we perceive him both as a conscious, experiencing being and as a physical, bodily being at the same time.

However, present philosophy of mind is mainly based on the assumption of a profound difference between consciousness and biological life — the one conceived as internal and purely mental, the other as an external, functional property of certain physical systems. Thus, the basis of the mind shrinks to the brain, and the body with its sensors and actors becomes a mere input-output device in the brain's service. Hence there is no way to close the gap between mind and life (Thompson, 2007, p. 222). Since mental processes and neuronal processes are conceived as detached from the living organism, they may only be directly related to each other, leading to a *short-circuit of mind and brain* and the manifold vain attempts to overcome the Cartesian divide — interactionism, parallelism, functionalism, epiphenomenalism, eliminative materialism, identity theory, emergence or supervenience. Whatever theory we choose, the so-called hard problem of consciousness (Chalmers, 1995) cannot be solved as long as mind and life are conceptualized in such a way that they intrinsically exclude one another.

A possible way out of this impasse is offered by the concept of *embodiment*, referring to both the embedding of mental processes in the living organism and to the origin of these processes in an organism's sensorimotor experience. The brain is primarily an *organ of the living being*, and only by this becomes an organ of the mind. For both life and mind are essentially related to what is beyond them, dependent on the continuous exchange with their environment. Just as respiration cannot be restricted to the lungs but only functions in a systemic unity with the environment, so the individual mind cannot be restricted to the brain. Consciousness is not a localizable object or state at all, but a *process of relating-to-something*: a perceiving-of, remembering-of, aiming-at, grasping-for, etc. In short, it is something that we *live and enact*.[1] This dynamic and intentional character of consciousness is not covered by the concept of single, 'mental events' that could be translated into corresponding brain states. Therefore the neurocognitive system cannot be grasped separately either; it exists

[1] See Noë, 2009, pp. 47ff., for a similar view on the dynamics of consciousness.

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only enmeshed in the world in which we move and live with others through our bodily existence.

On that condition, a rational option seems to take a mixed or dual-aspect approach to mind and brain which does not create an explanatory gap in an absolute sense (Figure 1). For this approach, the living organism is the common denominator, which may be regarded under two aspects: on the one hand, as a *lived body or subject-body*, on the other hand as a *living or object-body* (*Leib* and *Körper*; *cf.* Thompson, 2007; Fuchs, 2008). The first aspect corresponds to the first- and second-person perspective, the other to the third-person perspective. The one denotes the body as a centre of subjective and intersubjective experience, the other the body as an autopoietic living system, including the brain as a central mediating organ. Instead of a gap between two radically different ontologies (the mental and the physical), we are now faced with a duality of aspects within embodiment, a '*Leib-Körper problem*', so-to-speak, but with a common reference to the living being or the person. The question now is about the relation between one's body as subjectively lived and one's body as an organism in the world. And the answer must be in principle that processes of *living* and processes of *living through* (*Leben* and *Erleben*) are both aspects of the life process seen from two complementary points of view.

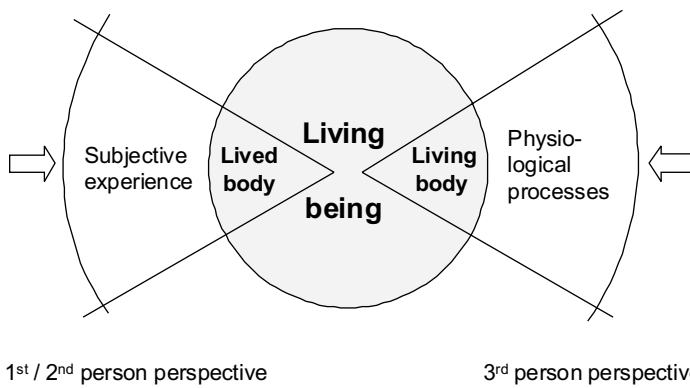

Figure 1: Dual aspect of life

The second-person perspective reminds us that only the living being as a whole may be regarded as the proper subject of feeling, thinking, speaking, laughing, acting, etc. Only while interacting with others in

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an empathic mode, within the common life world, are we getting access to the embodied mind. There is a fine observation made by the eighteenth-century German philosopher Lichtenberg when confronted with contemporary attempts to localize the soul in the brain:

> If in beholding the setting sun I take a step forward, I come nearer to it, how minimal this may be. However, it is quite different with the organ of the soul. It might well be possible that by an all too near approximation, as with the microscope, one *removes oneself* from what can be approached. (Lichtenberg, 1796/1973, p. 852)

Neuronal excitations or circumscribed brain structures are not the adequate scale to look for the basis of the mind. Consciousness, mind and life are not *micro-*, but *macro-phenomena* that only show themselves to others in co-existence, from the second-person perspective. Below a certain distance they just disappear.

Later on, we will see how the brain mediates between the microscopic world of physical processes and the macroscopic world of the living organism. For the moment, it is important to point out that the second-person perspective and its scale are essential for the *development* of mind and brain as well. Mothers interacting with their babies intuitively keep just the right distance that allows the babies to see them sharp (Papoušek and Papoušek, 1995). Imitation, affect attunement, joint attention and empathy — all processes of central importance for the early development of the brain as a social organ — depend on the right distance and the second-person perspective. It is only in the course of these embodied and meaningful interactions that the neural systems responsible for social cognition and other higher cognitive functions can mature. The resulting specialized neural networks should best be regarded as components of overarching interaction cycles: once formed in the course of these interactions, they serve as *open loops* for future situations presenting similar requirements to the individual. The brain then acts as a connecting and mediating organ, enabling the re-actualization of acquired dispositions through the functional closure of sensorimotor cycles comprising the whole system of organism and environment. Only this large-scale system of ongoing interactions may be regarded as the sufficient 'supervenience basis' for conscious life.

But the second-person perspective is not only prior genetically, but also *methodologically* for all research into consciousness, mind and brain. As Thompson (2001) has pointed out, the mind as a scientific object is an abstraction of our empathic cognition of each other in the life-world. Therefore the question 'How do we go from mind-

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independent nature to subjectivity and consciousness?' is misleading from the start. The 'hard problem of consciousness' or the 'explanatory gap' between consciousness and nature depends for its very formulation on the premise that the mind exists 'out there' as a natural entity. But this naturalistic account — equivalent to metaphysical realism — wrongly assumes that we could attain a viewpoint independent from our own cognition and lived experience in the second-person perspective. It fails to take into account that the mind as a scientific object can only be constituted as such from a personalistic perspective. Thus, empathy and social understanding are the precondition for any science of mind and brain.

Cycles of Embodiment

Having outlined some basic features of the embodied approach to mind and life, I will now take a closer look at the interactive cycles mediated by the brain. Following Thompson and Varela (2001), we can distinguish three intertwined modes of embodiment which form the basis of the human mind:

(1) *cycles of organismic self-regulation*, engendering a basic bodily sense of self;
(2) *cycles of sensorimotor coupling* between organism and environment, implying an 'ecological self';
(3) *cycles of intersubjective interaction*, resulting in what may be called a 'social self'.

(1) Organismic Self-Regulation

As is well known, the integrity and self-preservation of the organism depend on regulatory cycles involving brain and body at multiple levels. However, organismic regulation also has an affective and conscious dimension. Affective neuroscience, represented by authors like Damasio (2000) and Panksepp (1998a,b), has emphasized the dependence of a *background consciousness* on the homeodynamic regulation of the whole body: various centres in the brain stem, hypothalamus, and insular and medial parietal cortex process the neuronal and humoural signals from the body and integrate them into a 'body landscape' that is constantly changing. This landscape includes the present state of the inner milieu (hormone concentration, glucose, oxygen, carbon dioxide, pH-value of the blood, etc.), interoceptive signals from the viscera, and proprioceptive signals from the whole musculoskeletal system including the heart, vessels, skin and vestibular system. Brain and body are therefore most intimately connected

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and influence each other in constant circular feedback. This interaction results in a background feeling of being alive, a basic self-affection which lends a sense of mineness to all our experiences. Processes of life and processes of mind are thus inseparably linked: every conscious state is ultimately rooted in the homeodynamic regulation between brain and body, and, in a sense, integrates the present state of the organism as a whole.

Similarly, all *affects* as the core of our subjective experience are bound to the constant interaction of brain and body. Moods and emotions are states of the organism as a whole, involving nearly all subsystems: brain, autonomous nervous system, endocrine and immune system, heart, circulation, respiration, and expressive muscular system. Each feeling is inseparably linked to the physiological alterations in the body. Only when these alterations are signalled to somatosensory areas of the brain, feelings in the full sense may arise.[2]

This already makes it clear that the unity of brain and organism on the vital level also encompasses the higher brain functions. All conscious activities such as perceiving, thinking and acting are not based only on neural activities in the neocortex, but also on the continuous vital and affective regulatory processes involving the whole organism. Thus, the brain centredness of cognitive neuroscience is ultimately based on a Cartesian separation of mind and body that is inadequate to a systemic view of the organism. Neither consciousness nor the brain may be separated from the living body as a whole.

(2) Cycles of Sensorimotor Coupling Between Organism and Environment: Embodied Cognition and Action

Now apart from inner regulation, the main task of the nervous system is to mediate the sensorimotor cycles that connect organism and environment. Here embodiment implies the inherent connection of perception and bodily action, as already developed in the concepts of Uexküll's (1920/1973) *Funktionskreis* and Weizsäcker's (1940/1986) *Gestaltkreis*. What the organism senses is a function of how it moves, and how it moves is a function of what it senses. Living beings do not

[2] *Cf.* Damasio (2000, pp. 279ff.) — granted, Damasio presents his concept in traditional representationalist terms, characterizing the relevant brain regions as 'body maps' and even distinguishing first-order from second-order maps (*ibid.*, pp. 133ff.). However, according to his own account, there is (a) a moment-to-moment, and (b) a circular interaction between brain and body, that means a constant repercussion of neural activities in somatosensory and emotional brain areas on the state of the body (*ibid.*, pp. 154, 283f.). Therefore the concept of representation seems too static and detached from the interaction to adequately describe these processes. For a more detailed critique of representationalism, see below p. ??

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just passively receive information from their environment; rather, they actively participate in the generation of perception and cognition. This even applies for basic categories such as space. In a classical experiment, Held and Hein (1963) investigated two groups of newborn kittens which are blind at first. One group was carried around in their environment in a basket, thus only passively receiving visual stimuli, while the other group could move around freely. When released after six weeks, the first group was incapable of any spatial perception, only stumbling around helplessly, while the other kittens had learnt to perceive and move in space perfectly. This shows that perceptual space is not a pre-given external container, but rather a medium or working-space, moulded by our sensing and moving bodies from undifferentiated visual stimuli. In other words: *interacting with the environment induces the brain to develop the structures necessary for its adequate perception*. The enactive approach to cognition first put forward by Varela *et al.* (1991) takes this generally: a cognitive being's world is not a pre-given external realm, represented internally by the brain, but a relational domain created by that being's agency and coupling with the environment. In other words: living systems *enact their world* as inseparable from their own structure and actions.

To illustrate this, let us look at perception from a representationalist approach: there is an object 'out there', say a knife, whose features are transmitted to the retina, then further processed by the brain using an internal representation of the object; once this is activated, a conscious representation of the object is created. Instead of this linear model, the dynamic sensorimotor approach put forward by O'Regan and Noë (2001) regards the object as being constituted through sensorimotor cycles: perceptual experience is not an inner state of the brain but an ongoing skillful activity constituted by the perceiver's implicit, practical knowledge of the object and of the way sensory stimulation varies with movement. In vision, for example, when the eyes rotate, the sensory stimulation on the retina shifts and distorts in precise ways, similarly when the body moves forward or backward, etc. In touch, the sensorimotor interdependence is evident as well. Moreover, objects are always perceived as affording possible actions, or in Heidegger's terms, as objects 'ready-to-hand', as is obvious in the case of the knife. The object can indeed only be perceived by an embodied agent capable of somehow interacting with it, e.g. by having suitable limbs to walk towards the knife, grasp it, etc.

Thus, the world is constituted by us in the course of a living interaction, in which our ongoing perceptual and motor experiences are

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always already linked to each other. In these interactions, the brain works as a mediating organ, not as the sole producer of perception. Instead of inner maps or models it is equipped with neuronal networks shaped by earlier sensorimotor experiences that underlie the complementary skills of perceptually interacting with situations and objects. These networks serve as open loops that are closed to full functional cycles through the body's dealing with suitable counterparts of the environment. This is supported by the discovery of so-called *canonical neurons* in the premotor cortex that are activated both when handling tools and when only looking at them (Grafton *et al.*, 1997; Gallese and Umiltà, 2002). The knife is perceived as 'ready-to-hand' in an embodied sense, because the motor system is actually involved in its perception (see also Tucker and Ellis, 2001). Therefore neural states should be described not as mere correlates of mental states, but rather in terms of how they participate in dynamic sensorimotor patterns involving the whole organism. Perception 'evokes' these patterns, or in other words: *to recognize a thing is to know how to deal with it*.

This embodied account applies for motor action as well. My actions are not somehow triggered by an inner mind, but they are enacted by me as an embodied subject. When I am writing a letter, for example, there is no point in the unity of action where my 'self' ends and the 'world' begins, no border that separates 'inner' and 'outer world'. Neural networks, muscular movements of my hand, pencil and paper synergically work together to put my thoughts down, and the whole body-environment system creates my experience of agency. Being able to write a letter is obviously a capacity not of the brain, but of an embodied subject connected to an environment which provides pencils, paper, words and script. I am not a pure consciousness outside of my own writing, but an '*ecological self*' whose borders do not stop at my skin (Neisser, 1988). In the skillful handling of tools, in playing piano or driving a car, I incorporate these instruments. Thus, I feel the paper scratching at the top of the pencil, and being an experienced driver, I feel the roughness of the street below the wheels of my car, just as the blind man feels the ground at the top of its stick, not in his hand. As living bodies, we are extended into the world — always up to the locus where the actual interaction with the world is going on.

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(3) Cycles of Intersubjective Interaction: Embodied Intersubjectivity

If cognition is the activity of an embodied subject, this applies in particular to the domain of social cognition or the perception of the other. According to the enactive approach, social cognition is based on a special form of action, namely *social interaction*.

Currently, social cognitive neuroscience is still largely based on representational concepts. Social cognition is regarded as something the brain does by means of certain social modules. Similarly, present concepts of so-called mind-reading, mentalization or simulation take social cognition to be a matter of how we infer or model unobservable mental states from outward behaviour. We are hidden to each other in principle, therefore understanding others must be based on internally mapping or modelling their actions and thus explaining or predicting their behaviour. Moreover, current research paradigms in cognitive neuroscience focus on one-way, detached social situations and are biased towards localizing social cognition in one participant, or in his brain only. However, our primary and everyday encounters with others are not solitary observations, but interactions within the second-person perspective. In these, we normally don't use any imaginative, introspective simulation or inference; instead, we immediately perceive the other's intentions and emotions in his expressive behaviour as related to a meaningful context (Scheler, 1923/1954; Merleau-Ponty, 1945/1962, pp. 215ff.; Gallagher, 2001; 2008).

To illustrate this, let us imagine a football play in which one player sees his teammate raise his arms in joy over a goal. According to representationalism, he will internally represent the other's body, but now combined with a theory of mind or simulation mechanism which tells him: 'he is happy'. Instead of this linear concept, the enactive approach looks at the circular dynamics within the dyad of embodied agents. Both partners are linked to form a common system through mutual perceptions and reactions. Grasping, pointing, handing-over, moving-towards, smiling, crying, etc. — all these are not just external behaviours that we have to furnish with meaning by way of inference, but they are inherently meaningful and goal-directed actions. Thus, the footballer will immediately perceive the other as cheering, and, empathically sharing his pleasure, he will also perceive him as someone 'ready-to-hug', as it were. His understanding is interactive from the start, and might easily result in spontaneously embracing his teammate. No simulation or introspection is necessary to share the pleasure — the

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embrace is just the manifestation of both player's *interaffectivity* and, to use Merleau-Ponty's term, *intercorporality* (Merleau-Ponty, 1985).

Accordingly, phenomenological analyses of intersubjectivity are grounded on the idea that we recognize each other first and foremost as interacting embodied subjects, not as inner spectators of another's impenetrable body surface. I immediately see the triumph in my teammate's face and in his raised arms; I see the shame in another's blushing, the grief in his tears, the anger in his glowering gaze or in his bodily tension. This is based on a circular sensorimotor process in which each partner constantly influences the other by his actions (Fuchs and De Jaegher, 2009). The other's angry face will elicit an expressive response in my own face and body which in turn finds resonance in his body, etc. Thus, we feel the other's affect by the resonance it elicits in our own body. Understanding is jointly created in the moment-to-moment process of interaction, with both partners being engaged in what has been called 'participatory sense-making' (De Jaegher and Di Paolo, 2007). This includes processes of synchronization and resonance, rhythmic co-variation of gestures, facial or vocal expression, complementary or antagonistic behaviour, etc. In other words: we perceive the other's embodied mental states through our embodied interaction. To understand others means primarily *to know how to deal and to interact with them*. It is only in situations of detached observation or ambiguity that we resort to more sophisticated cognitive procedures like imaginary transposition, deliberation or inference in order to make sense of their behaviour.

A Developmental Perspective

This intercorporal concept is confirmed when we take a look at the development of social cognition in early childhood. Infant research has shown that even newborn babies are able to imitate the facial expressions of others (Meltzoff and Moore, 1977; 1989). By the mimetic capacity of their body, they transpose the seen gestures and expressions of others into their own proprioception and movement. Perception, proprioception and action are integrated within a common sensorimotor space. The infant does not need to carry out any process of inner simulation or inference. Its body schema is characterized by a transmodal openness that immediately allows it to imitate others. So what primary intersubjectivity starts with is not mind-reading, but embodied interaction or intercorporality.

Since bodily mimesis evokes corresponding feelings as well, a mutual affective resonance gradually develops within the dyad. 6- to

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8-week-olds already engage in proto-conversation with their mothers by smiling and vocalizing (Trevarthen, 1979; 1993). They both exhibit a finely tuned coordination of movements, rhythmic synchrony and mirroring of expressions, that has been compared to a couple dance. Stern has emphasized the temporal flow patterns and vitality affects that are shared by both partners (Stern, 1985/1998). Infants perceive affects as the intermodal extract of rhythmic, melodic, vocal, facial and gestural characteristics. These intermodal characters and contours are one of the main bridges of intercorporeal resonance, and with it, of primary understanding. Affect attunement and mutual resonance create *dyadic affective states* (Tronick, 1998), often an intense pleasure or joy: the emerging affect during a joyful playing situation between mother and infant may not be divided and distributed among them. It arises from the 'between', or from the overarching common situation in which both are immersed. The origin of emotional life lies in interaffectivity.

Let us take a look at the brain side of this development. Research into the mirror neuron system has supported the linkage between perception and action also in social cognition, namely a close functional coupling between actions produced by the self and actions perceived in others (Gallese, 2002; Gallese *et al.*, 2004). The movement of the other is already understood as a goal-directed action because of its match to a self-performed action. This seems to apply for the emotional coupling or empathy as well: the perceived expression of pain, disgust or fear activates corresponding brain areas linked to one's own emotional experience (Wicker *et al.*, 2003; Singer *et al.*, 2004). Thus, proprioceptive, kinaesthetic and emotional self-awareness is tacitly implied in perceiving the face and expression of another person. The neural systems involved in mutual understanding and empathy appear to be of a practical nature, rather than inferential, for they involve the dynamic pairing of the bodies of self and other.

However, brain mechanisms such as the mirror neuron system can hardly be taken as a sufficient basis for mutual understanding. First, 'mirrors' certainly do not exist in physical nature. A mirror on the wall does not mirror anything except for a subject who is able to take its reflections *as* a mirror image. Thus, the infant first has to learn that others are 'like me' in the course of mutual exchange and interaction. Moreover, assuming an embodied and developmental view of mirror neurons, infants are not expected to understand others' action goals by means of the mirror system before they can perform the action themselves. There is increasing evidence that the neuronal mirror system has to be 'trained' through sensorimotor experience in order to

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adequately react to social situations.[3] Hence, a merely cross-sectional view misses the embedded and biographical character of social brain systems. They, too, serve as 'open loops' which only develop and function within in a common space of embodied and meaningful interactions.

Owing to the singular plasticity of the human brain, the history of the interactions continuously influences the infant's dispositions and skills. The patterns of interaction are sedimented in their implicit memories, resulting in what Lyons-Ruth *et al.* (1998) have called *implicit relational knowing*. This means a pre-reflective knowledge or skill of how to deal with others — how to share pleasure, elicit attention, avoid rejection, re-establish contact, etc. The infant acquires specific interactive schemes ('*schemes of being-with*', Stern, 1985/1998) and body micropractices that are needed for the respective interaction. Implicit relational knowing is a temporally organized, 'musical' memory for the rhythm, dynamics and affects that are present in the interaction with others. It may also be regarded as an *intercorporal memory* which shapes the actual relationship as a procedural field that encompasses both partners (Fuchs and De Jaegher, 2009).

To illustrate this, let us take the example of the football players once more: the interaction cycle is based on neural networks that work as open loops which are functionally closed by the actual situation. These loops are the result of similar interactions mainly experienced in early childhood: embracing the partner still re-actualizes, though unconsciously, the first embraces between mother and child. Both partners' implicit or body memories are re-enacted in their encounter, mediating the specific 'feel' of the interaction, its timing and affective loading. However, this shared affective state does not arise in their individual brains, but from the intercorporal system constituted by both players. Understanding is achieved through the interaction itself, and no independent inner states are transmitted to the other through certain cues that he would first have to figure out and interpret in order to go on.

What does this mean on the neural level? Explanations of social cognition by means of special brain modules only single out certain pieces or fragments of the whole cycle of organism-environment

[3] *Cf.* Catmur *et al.* (2007); Grossmann and Johnson (2007). Accordingly, studies of anticipatory eye movement during observation of a goal-directed action showed that it is present in 12-month-olds but not in 6-month-olds (Falck-Ytter *et al.*, 2006). Moreover, there is evidence from ERP studies that situations of joint attention have an effect on the infant's brain structures, particularly in the prefrontal cortex, associated with the allocation of attentional processing resources (Striano *et al.*, 2006).

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interaction. Without these cycles, the specialized brain areas necessary for social understanding would not even have developed. After all, the brain is not inserted into the world as a prefabricated apparatus, but it is structured epigenetically by the continuous interaction of organism and environment. As we have already seen in the case of the newborn kittens, *interactive functions create their corresponding brain structures*, which in turn modify future interactions. In other words, the environment induces the development of the organic conditions necessary for interacting with it.[4] This applies in particular to the social environment which becomes the crucial 'ontogenetic niche' for the brain's development. In its course, customs, habits and cultural techniques are acquired by imitation and cooperative learning. The embodied mind is intersubjectively constituted at the most fundamental level. Correspondingly, the human brain is essentially adapted to develop within a social context.

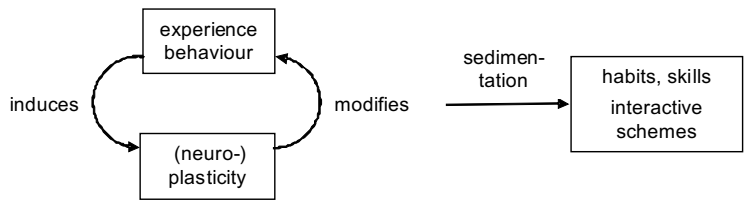

Figure 2: Learning as a transformation of experience and behaviour into organically sedimented habits, skills or schemata

These learning processes are illustrated once more by the above schema (Figure 2): each subjective experience and behaviour induces changes in the plastic neural memory structures, which in turn results in altered experience or action. In other words, there is a continuous interaction between *experiential process* and *brain structure*. Over time, experiences are sedimented in the form of organic habits, dispositions and interactive schemes that eventually constitute the

[4] In a more recent experiment, Mringanka Sur and his group were able to induce a major cortical reorganization in newborn ferrets (Melchner *et al.*, 2000; see also Noë, 2009, p. 54f.). They cut through one of their optical nerves whose stump then grew together with the part of the diencephalon which otherwise forwards impulses of the *acoustic* nerve to the cortex. Now visual stimuli reached a brain region which normally processes acoustic signals. Surprisingly, the brain adapted to the new sensory stimuli, and *the acoustic centre turned into a visual centre*. Even neurons characteristic of visual areas developed anew, so that the ferrets were able to see with the eye concerned (even though not as good as normally). What tasks a cortex region finally takes on is thus dependent on the sensory input and its specific, motion-related patterns. Similar cortical reorganizations can be observed after brain lesions or injuries.

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individual's personality. We may speak of an 'embodied socialization', because the specific human faculties can only develop in the course of mutual interaction and cooperation, through which they are imprinted on the organic growth processes of the brain.

The Brain as an Organ of Transformation and Resonance

To summarize, I have briefly described three cycles of embodiment:

- *cycles of organismic self-regulation*, including a basic bodily sense of self;
- *cycles of sensorimotor coupling* between organism and environment, resulting in an 'ecological self';
- *cycles of intersubjective interaction*, underlying the 'social self'.

The human brain is crucial for all three modes of embodiment. Yet it does not create, but mediates and regulates the cycles, and it is in turn shaped and structured by them throughout the lifespan. Now if the human mind emerges from these circular modes of interaction, and if it is accordingly embodied in the living organism as a whole, then the myth of the brain as a creator of the mind should be abandoned. On the contrary, it is the mind — understood as the process through which a human being relates to, and interacts with, the world in a meaningful way — that shapes and 'uses' the brain. From birth on, the spatial, temporal, logical and symbolical structures of the interaction processes are extracted and transformed into neural microstructures that facilitate corresponding future interactions. This interchange of process and structure enables the individual to use his acquired dispositions and skills (perceptual, motor, affective, cognitive, etc.) for interacting with the world on increasingly complex levels. The brain serves as a matrix *and* mediator of interaction at the same time.

This also corresponds to the original evolutionary role of the brain. Already primitive organisms without a central nervous system interact with the environment by sensing stimuli or nutrient gradients (afferences) and accordingly adapting their movements and reactions (efferences). In the course of evolution, the central nervous system was inserted into the already existing cycles of afferent and efferent processes as a transforming and diversifying organ. By linking different afferences to suitable efferences, it amplified the organism's scope of options. With growing development of the brain, its coordinating functions increased, in particular by the establishment of complex feedback and feedforward loops. However, this did not change its

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principal character as an organ that primarily mediates the organism-environment interactions.

Now, the decisive progress brought about by the evolution of the mind was not just an improved reaction to stimuli, but *gestalt formation*, i.e. the grasping of complex units, perceptual objects and situations as a whole. A situation is the situatedness of a living being towards its environment, and to grasp a situation means to grasp oneself in relation to it. This is mainly brought about (1) by one's *embodied being-in-the-world*, implying proprioceptive, kinaesthetic and sensorimotor experiences; (2) by an integrated evaluation of the meaning and the options of a given situation, which is experienced as *emotion*; (3) in later and particularly human stages, by symbolic representations of the world, i.e. by *language and concepts*. The mind is directed towards wholes or units, such as 'cats' or 'trees', 'lived body', 'feeling', 'self', or concepts. This allows the organism to experience the environment as well as itself in relation to it, and thus to act and react on it in a meaningful way.

If we now try to describe the role of the brain for the mind on this basis, we may conceive it as an organ of *transformation* which integrates the configurations of single elements ('stimuli') of a given situation into wholes: the patterns of synchronized neuronal excitations correspond to the holistic structures or *gestalt* units emerging in subjective experience. However, these neuronal patterns are not inner representations of the outer world; rather, they should be conceived as *resonating* with the structures of the given environment, thus closing the corresponding interactive loops. We may illustrate this by a picture puzzle where the process of *gestalt* formation is a bit delayed (Figure 3):

Figure 3: Gestalt formation

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While we are scanning the picture with quick eye movements, its black-and-white structures interact with pre-existing patterns of neural excitations (= attractors) in the primary and associative areas of the visual cortex. Similar patterns are activated in quick succession in search for disambiguation or congruence. This 'tuning-in' of neural system and environment is achieved by repeated cycles of top-down and bottom-up processing. Once a suitable pattern of neural excitation has emerged — that means, a pattern or attractor that sufficiently resonates with the structures of the picture — we suddenly recognize the Dalmatian dog. In this way, the configuration of single spots or elements is transformed into a coherent whole, corresponding to our perception of the dog. According to our present state of knowledge, the pattern is stabilized by synchronized oscillations (20–30 Hz) of the participating neural assemblies which are thus resonating with each other as well as with the configuration of environmental stimuli (Singer *et al.*, 1995; 1997). Of course, these processes have still to be explored in further detail.

Why couldn't these patterns of neural excitation be called a 'representation' of the dog? Well, firstly the representatial relation — something *stands for* some other thing — requires someone who establishes this relation and *for whom* it exists. Tracks in the snow as such do not represent the animal that has left them; they are just mouldings in the surface unless someone recognizes them *as* tracks. Speaking of neural representations therefore runs into homunculous problems: who in the brain should recognize the excitation patterns as patterns of a dog? One might argue that neural patterns are not only *causally* connected to earlier input (as the tracks are) but also *functionally* connected to adequate behaviour (e.g. recognizing and calling one's dog). They could then be called representations because they fulfil a function *for* the living system. However, the perception of the dog is only accomplished through the ongoing interactions of neural activations, eye movements and environment forming a closed loop. There is no component within this cycle that represents another one, in the sense that it stands for it while it is absent. The term representation suggests that the brain activities could, at least in principle, be separated from the cycle, as if they were reconstructing inside what is outside. But in the perception-action cycle as described above there is no inside and outside any more. Instead, perception is enacted by the brain-body-environment system as a whole.

The inseparability of brain-body-environment interactions is crucial for the concept of the extended and enactive mind. If separable representations could serve as a sufficient supervenience basis for the

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mind, there would also be circumscribed neural correlates of consciousness, and body and world would merely play a causal, not a *constitutive* role for the emergence of consciousness. However, such delimited neural correlates of experience have never been demonstrated, and thought experiments of brains-in-a-vat producing consciousness without being connected to a living organism have been convincingly refuted (Thompson, 2007, pp. 239ff.; Cosmelli and Thompson, 2011). As shown above, already the background feeling of being alive is bound to the ongoing and reciprocal interaction of brain and body which is maintained even in states of dreaming or in locked-in syndromes (Kyselo, in press). Thus, the living body plays a constitutive role for awareness at the most basic level, and this is not compatible with traditional representationalism.[5]

What about the memory of the dog then? Shouldn't the neural patterns corresponding to this memory be called 'representations' that 'stand for' the dog and are activated once we recall, imagine or see it? But here the question arises: representations *of what exactly*? No memory is reactivated in the same way again, for there are no replicas or snapshots (or traces of snapshots) in the brain — any recollection is actually a reconstruction within a new context. We have never seen exactly this token of a Dalmatian dog before. There could be representational *types*, of course. But then the notion of representation loses all the circumscribed and distinct properties that made it so attractive to neuroscientists. For there would have to be not only inclusive hierarchies of representations (for animals, dogs, Dalmatian dogs, etc.), but also adaptations, distortions and mixtures of representations (imagining for example a Dalmatian lion), and so on, all recruiting partly different, partly overlapping neural assemblies in varying interactions. If we take the dynamic and creative character of imagination and recollection into account, wouldn't it seem more adequate to dispense with the notion of representation for these phenomena altogether?[6]

Of course, the transformation or gestalt formation described above is based on prior experience. Whenever the brain is repeatedly exposed to similar objects (such as Dalmatian dogs) or situations, it is induced to extract regularly correlated features or prototypes of these experiences. This is accomplished, according to Hebb's rule, through increased couplings and synaptic weightings of the neurons involved

[5] For a limited use of the concept of representation in the sense of dynamical, context-sensitive and action-oriented representations to be used for online problem solving, see Wheeler (2010).

[6] For an extensive critique of the representationalist concept of memory, see Bennett and Hacker (2003, pp. 154–71); Edelman and Tononi (2000, pp. 93ff.).

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(Edelman and Tononi, 2000, pp. 113ff.). But there is no need to resort to the static notion of representations to denote these neuronal dispositions. A concept based on 'attractors' and 'resonance' seems much better suited to account for the dynamic and flexible interconnection of brain, body and environment systems. To take another example: as children we learnt to read words letter by letter (e.g. 'a-p-p-l-e'), which induced our brains to form corresponding neural patterns, attractors or 'open loops'. Once established, they now enable us to immediately grasp the meaning of the word 'apple', without being aware of the single letters. The loop is closed by the resonance of the specialized neural networks with the configuration of black lines, even when these are given in different fonts, enlarged, distorted, etc. The neural system is not made for mirroring or reconstructing the environment in the head, but for attuning to, and reaching as much coherence with, the environment as possible. The same applies for motor action: if I want to write the word 'apple' in a letter, the underlying patterns of neural activity are transformed into corresponding motor patterns, resulting in the action of my hand, with continuous proprioceptive and sensory feedback from my writing. Again, a closed sensorimotor loop has formed, including the brain and nervous system, the hand, the pencil and the letter.

In sum, the brain serves to transform configurations of single sensory or motor elements into higher level units or patterns of neural activation which correspond to the perception-action cycles on the subjective level. Through this, the brain becomes an organ of mediation between the microscopic world of physical processes on the one hand, and the macroscopic world of the living organism and its experiences on the other hand. By integrating elementary processes into higher-order patterns, it enables the living being to relate to the world through perceiving and acting. However, this is not a one-way (bottom-up) relationship: the formation of patterns of neural activity may only be explained top-down, namely through the macroscopic structures or *gestalt* units which characterize the interaction of the living being with its environment. We may describe this as a circular relationship or *circular causality* which combines both top-down and bottom-up influences between higher and lower levels.[7]

Following this line, we cannot regard subjective experience as a mere epiphenomenon of underlying neuronal ('real') processes. On the contrary, it plays an essential role in the interaction of organism and environment. For it is only through conscious experience that the

[7] See Fuchs (in press) for a more detailed description of circular causality.

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organism is able to enter into a relation with the environment on the higher level of meaning, of integrated perceptive and cognitive units or *gestalten*; and these meaningful units in turn influence the plasticity, the structuring and functioning of the brain. A 'biographical biology', as we may call it, implies the continuous formation and reshaping of the brain through subjective experience. There is an ordering or structuring influence that the mind exerts on the properties of the brain: it consists in forming, maintaining and interconnecting meaningful units of experience which stabilize corresponding neuronal activity patterns and thus are also able to trigger actions and reactions of the organism as a whole.

Thus, we arrive at a duality of aspects not only in description, but also in explanation. Let us take an example: what is the cause of blushing? From a physiological point of view, that means, regarding the object body, one would name the increased blood flow caused by a dilation of the skin vessels, which for its part is triggered by a specific activation of the limbic system, corresponding to a transitory imbalance of trophotropic and ergotropic processes in the diencephalon, etc. However, with all this we remain strictly within the causal concatenation of physiological processes, thus within a layer where we find neither feelings nor motives, no meaningful relations that could give rise, for example, to shame or anger. There are only sequences and patterns of activity in the brain and the nerves. To be sure, neuronal processes enable the experience of feelings. But enabling does not mean causation, for conversely it is also true that only meaningful biographical experiences have made the neuronal processes possible in their specific form.

Now from the subjective point of view, regarding the lived body, we would not hesitate to say that blushing is the expression of the *shame* that the person experiences in an embarrassing situation. In blushing the embodiment of the subject becomes manifest; for shame is not an inner state but inseparable from its bodily expression, as well as from the situation to which it is intentionally directed. Shame is a meaningful reaction of the embodied subject or the person to his or her environment. The development of this emotional reaction within interpersonal situations of early childhood has also shaped the neuronal patterns underlying the present feeling. Thus, 'shame' encompasses the totality of physiological, motivational, subjective and intersubjective phenomena which, however, correspond to very different aspects or perspectives. Therefore we have to describe and explain shame in a dual way, i.e. from two complementary perspectives that are not transferable into each other: on the one hand as a

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complex concatenation of physiological mechanisms, on the other hand as a biographically understandable reaction to an interpersonal situation. However, there is no causation involved *between* 'the mental' and 'the physical', as if they were separated entities; rather, *the person* as a living being embodies and encompasses both aspects — the lived and the living body.

Conclusion

I have outlined what may be called an ecological view of mind and brain as both being embedded in the relation of organism and environment. In this view, there is no locus of the mind; rather, the mind is a distributed phenomenon. Conscious experience corresponds to the highest level of integration of brain processes, but it may not be restricted to them; it only arises in the overarching system of organism and environment, on the basis of an interplay of multiple components. These are the brain and the whole organism with its senses and actors as well as the corresponding and suitable counterparts in the environment. Thus, the brain as such does not contain any more of consciousness than e.g. the hands or the feet. It is only the living being or the person as a whole that is conscious, perceives and acts. This also corresponds to our own experience: we are not pure subjects who observe events from the margin of the world, but we are embodied, living beings who experience events in the world. There is nothing inside us which perceives, feels, or thinks — neither a Cartesian mind nor a bodiless brain. Consciousness is not an inner state, but an activity of a living being in its world.

The brain is certainly necessary for the emergence of consciousness, because all circular processes that I have outlined are converging in it. It could thus be compared to the main station of a railway system: if the station or major parts of it are destroyed, then the traffic will break down. But, to carry the comparison forward, the railway traffic is neither produced nor localized in the main station. On the contrary, it is the traffic that employs the rail system with its manifold branchings and of course its central coordination in the main station in order that the transport processes run as fluently as possible. Similarly, conscious activity is not localized within the brain; rather, it is the integral of the actual relations between brain, organism and environment.

We tend to overestimate the importance of the brain to the extent that we even ascribe our own thoughts, feelings or actions to it. But the brain is only one of our organs; it does not produce, but only

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mediates and modulates the cycles of embodied interaction. It functions as a system of open loops or attractors that are constantly complemented by the environment; but it cannot construct the world by itself. Indeed, there is no such thing as a brain by itself, unless it has been separated from the living organism through an autopsy.

This becomes fully obvious once we look at the co-development of mind and brain. The brain develops and continuously changes with the experiences we accumulate during our lives. As these experiences are always organized by spatial, temporal, logical and other cognitive structures, they shape the brain in such a way that it becomes a medium for the mind to function in the world. Every time a new disposition of coherent neural activity is formed through repeated experience or exercise, meaningful structures of that experience are imprinted onto the brain which now allows for smooth and unimpeded functioning. Process turns into structure, and *vice versa*. Thus the brain enables us to intentionally direct ourselves to the objects or goals we choose — for example, reading or writing a letter — without getting stuck in single details or interfering distractions. The brain is like a window to the mind: it is transparent for its functions *because it is structured by the mind itself*. Conversely, any dysfunction of the brain results in some kind of opacity — a certain window to the world is blurred or closed.

Of course this is not to say that mind is something external to life; rather, it is a manifestation of the life process itself. Correspondingly, it is through the process of life that the brain becomes an organ of the mind; for this process is inherently meaningful and 'mindful' from the beginning. How the intertwining of (neuro-)physiological and mental processes in the living organism is to be understood in more detail remains an open question for further research. However, instead of trying to localize mental functions in brain structures or searching for static neural representations of external objects, future research should rather investigate how each neural activity is inserted in the functional cycles of perception and action, and by this, in the relation of organism and environment. For only this relation provides the meaningful context into which neural processes have to be embedded in order to subserve mental life. Therefore only an embodied and ecological view of the brain may adequately capture its role as a mediating organ.

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