The embodied mind: a psychosomatic unity

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Introduction

One of the major goals of the current neuroscientific research program is to naturalize consciousness and subjectivity, i.e. to explain them in neurobiological terms. Mental or subjective states seem to be localizable in the brain. The brain becomes the designer of the experienced world as well as the creator of the experiencing subject. In this view, consciousness is only the by-product of the brain's information processing, which creates an inner simulation or model of the real world. This neuroconstructivist view is summarized by the German neurophilosopher Thomas Metzinger:

> Conscious experience is like a tunnel (...) First, our brains generate a world-simulation, so perfect that we do not recognise it as an image in our minds. Then, they generate an inner image of ourselves as a whole (...) We are not in direct contact with outside reality or with ourselves (...) We live our conscious lives in the Ego Tunnel (Metzinger, 2009).

So are we in fact locked in the tunnel of a virtual model of the world, produced by the brain – similar to the inhabitants of Plato's cave who know nothing of the real world? Indeed neuroscience as it is mostly presented and popularized today seems to suggest that. However, this centralism of the brain largely ignores the interrelations and cycles in which the brain is embedded – just as if one would try to explain the heart's function without the blood circulation, or the lungs without the breathing cycle. In contrast, I will argue for an extended or ecological view of the mind and the brain. According to this view, the mind is not in the brain. As a function of the living organism as a whole, it is not located in any one place but it is rather distributed among the brain, the body, and the environment. The brain is a central organ of the conscious living being, but it is only an organ, not the seat of the mind; it is a mediator, not a creator of conscious experience. In other words: Human subjectivity is embodied, not "embrained". In what follows, I will develop this view in several steps.

The mind-body divide and dual aspect theory

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 1st-person perspective, the other only accessible from without, or from a 3rd-person perspective. Thus, the basis of the mind shrinks to the brain, and the body becomes a mere transducer of stimuli. What neuroscience fundamentally lacks is a concept of the living organism. It regards consciousness not as a function of the living organism but directly connects mind states with brain processes in a short-circuit,

as it were. What is missing here has been clearly recognized already by philosopher Ludwig Feuerbachin the 19th century:

> It is neither the soul that thinks and senses, nor the brain; for the brain as such is a physiological abstraction, an organ cut out from the totality of the skull, the face, the body as a whole. The brain is only an organ of the mind as long as it is connected to a human head and body (Ludwig Feuerbach, 1846).

To this I would add: … a human body that is connected to its environment and to other embodied human beings. For as we will see, it is only in the course of embodied interactions with others in early childhood that the higher cognitive systems of the brain can mature and develop.

I formulate my main thesis accordingly: The individual mind is not confined within the head, but extends throughout the living body and includes the world beyond the skull, especially the social world of self and other; and this is also the world in which mind and brain are essentially formed. Assuming such an embodied and extended view of the mind, the brain loses its mythological powers and turns into a still fascinating, yet far more modest ***mediator*** of human experience and action.

In contrast to the still prevailing dualism of the physical and the mental I propose a concept in which the ***living being or the organism*** is the primary entity. The living being may now be regarded under two aspects: on the one hand, as a lived body or subject-body, on the other hand as a physical body including the brain; or in other words, in may be regarded as ***Leib*** and ***Körper***. The first aspect corresponds to the 1st- and 2nd-person perspective, to the body as a center of subjective and intersubjective experience, the other to the 3rd-person perspective – the body as a physical object of natural science. Instead of a gap between two radically different ontologies (the mental and the physical), we now have a duality of aspects within embodiment, with a common reference to the ***living being***. The question then is about the relation between our body as we live and experience it subjectively and our body as an organism in the world.

On a daily basis, a doctor undergoes this change in aspects, for instance, when greeting a patient and seeing his (friendly, anxious or similar) gaze, yet shortly afterwards taking hold of the ophthalmoscope to examine the patient's eyes as physical organs: at this point, looking at them from too close a distance, the gaze has vanished. The doctor may even get still closer and investigate the retina – just like a neuroscientist may explore all the microstructures and microprocesses of the physical body. Nowhere will consciousness, mind or life show themselves – for they are ***macro-phenomena*** that are only accessible in co-existence, from the 2nd-person perspective.

Nevertheless, both attitudes are directed to the same entity, that is, to the living being or the living person. The lived or subjective body as the location of sensations and affections (fatigue, pain, hunger etc.), the body as the medium of the enactment of life or of contact with others – none of these emerges as a construct in the brain, mysteriously projected into external space. Rather, this lived body is the organism itself under the aspect of its holistic aliveness that is manifested both subjectively as well as intersubjectively.

Correspondingly, the last two or three decades have seen the rise of a new paradigm in cognitive science, the so-called "Embodied and Enactive Cognitive Science". According to this paradigm, the mind is not in the brain; rather, it is embodied and enacted through the ongoing interaction of an organism with its environment. The brain is for the mind what the lungs are for respiration: they only function in a systemic unity with the environment – and in a sense, the mind is like the air which we inhale. This may also be called an ecological view of the mind and the brain, and in what follows I will take a closer look at this approach.

Cycles of embodiment

To begin with, there are mainly three permanent and intertwined modes of embodiment which form the basis of the human mind:

1) cycles of organismic self-regulation,
2) cycles of sensorimotor coupling between organism and environment
3) cycles of intersubjective interaction.

1) Organismic self-regulation

Let us start with the cycles of organismic self-regulation. The integrity of the entire organism depends on such regulatory cycles involving brain and body at multiple levels. But organismic regulation also has conscious and affective dimension. Affective neuroscience, represented in particular by Damasio and Panksepp, has emphasized the dependence of a background consciousness on the homeodynamic regulation of the whole body, mediated and integrated by brainstem and diencephalic structures such as the thalamus, and by the cingular and insular cortices. Background consciousness means a feeling of being alive, a basic self-affection or a core consciousness of our bodily selfhood that lends a sense of mineness ot all our experiences. Every conscious state is rooted in the homeodynamic regulation between brain and body, and, in a sense, integrates the present state of the organism as a whole. Thus, processes of life and processes of mind are inseparably linked.

Similarly, all affects as the core of our subjective experience are bound to the constant interaction of brain and body. Moods and emotions are always states of the

organism as a whole, involving nearly all its subsystems: brain, autonomous nervous system, endocrine and immune system, heart, circulation, respiration and expressive muscular system. Each feeling is inseparably linked with physiological alterations in the body's landscape. Only when these alterations are signalled to somatosensory areas of the brain, feelings in the full sense may arise.

This already makes it clear that the unity of brain and organism on the vegetative level also encompasses the higher brain functions. All conscious activities such as perceiving, thinking and acting are not based only on neural computations in the neocortex, but also on the continuous vital and affective regulatory processes involving the whole organism. Thus, the brain centeredness of cognitive neuroscience is ultimately based on a Cartesian separation of mind and body that does not stand a systemic analysis 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, leading to embodied cognition and action. In the traditional view, a cognitive being's world is a pregiven external realm, represented by the brain. From an enactive point of view, however, organisms do not passively receive information from their environment which they then translate into internal representations; rather, they actively participate in the generation of meaning. Thus, cognition implies an intrinsic connection of perception and bodily action. What the organism senses is a function of how it moves, and how it moves is a function of what it senses.

This is nicely illustrated by a classical experiment of Held and Hein (1963): They investigated two groups of newborn kitten 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 pregiven external container, but rather a 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 put forward by Varela and Thompson (1991) takes this generally: A cognitive being's world is not a pregiven external realm, represented internally by the brain, but a relational domain created by that being's interaction with the environment.

To illustrate this, let us look at perception from a representationalist approach: There is an object "out there", here a pair of pliers, 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 enactive approach, put forward by O'Regan and Noe (2001), regards the object as being constituted through sensorimotor Gestalt cycles: perceptual experience is not an inner state of the brain but a 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 dependencies are even more obvious. Moreover, objects are perceived as affording possible actions, as objects "ready-to-hand", as is obvious in the case of the pliers. 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 for us in the course of a living interaction, by the interconnection of perceptual and motor experiences. In these interactions, the brain works as a mediating or relational organ; it provides the ***open loops*** that are only closed to full functional cycles by complementary or fitting counterparts of the environment. This is supported by the discovery of so-called canonical neurons in the premotor cortex that are activated both when dealing with tools and when only looking at them (Grafton et al. 1997, Gallese u. Umiltà 2002). Instead of inner maps or models we are equipped with neuronal networks that underlie the complementary skills of perceptually interacting with objects. 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 active organism. Perception "evokes" these patterns which are derived from earlier sensorimotor experiences, or in other words: To know a thing is to know how to deal with it.

This applies for motor action as well. My actions are embodied, that means, they 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. 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 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.

3) Cycles of intersubjective interaction: Embodied intersubjectivity

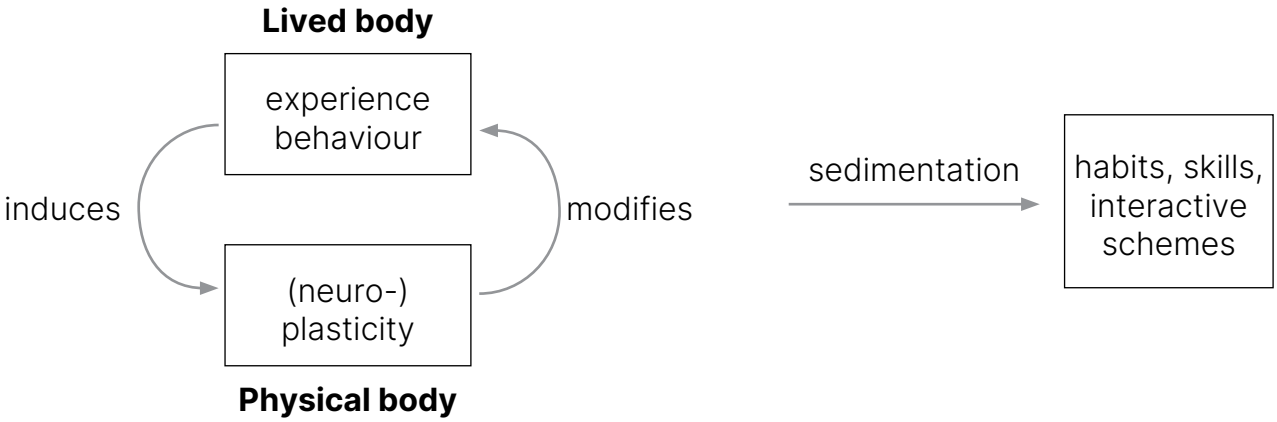
Cognition and action, as we have seen, are both activities of the embodied subject. However, the development of the specific human subjectivity requires not only the interaction of brain and body, and body and environment, but above all the interaction with others. It means primarily embodied intersubjectivity, or to use a term by Merleau-Ponty, "intercorporeality". Thus, recent research has shown that the capacity of imitation in human infants is essential for understanding others. From birth on, infants possess an interpersonal body schema for spontaneous facial imitation and emotional resonance. They experience the other's body as similar to their own, and thus, they also transpose the seen facial expressions and gestures of others into their own feelings. These schemas underlie the development of more sophisticated empathic abilities in the course of early interactions. Embodiment and interaffectivity thus form the basis of social understanding through an interactive practice of meaningful and expressive bodies.

Let us take a look at the brain side of this development. Research on 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. 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 – e.g. the perceived expression of pain, disgust or fear activates corresponding brain areas linked to one's own emotional experience (Gallese et al. 2004).

However, brain mechanisms such as the mirror neuron system can hardly be taken as a sufficient basis for mutual understanding. Rather, the infant has to learn herself that others are "like me" in the course of mutual exchange and interaction. The neuronal mirror system has to be "trained" through sensorimotor experience in order to adequately react to social situations. Hence, a merely cross-sectional view misses the biographical character of social brain systems. They only develop and function within in a common space of embodied and meaningful interactions.

Due to the singular neuroplasticity of the human brain, the history of the interactions continuously influences the infant's dispositions and skills Each bodily experience or behaviour induces changes in the highly plastic neuronal matrix of the brain – changes in synaptic structure of neural networks and in the connectivity strength between brain regions, mediated by epigenetic alterations of cellular functions, and resulting in more

adaptive dispositions and patterns of neural activity. Conversely, however, from this sedimentation of experience, in turn, a modified experience and behaviour arises. So we have a downward and an upward direction of causality, but now in a historical dimension.



In other words, there is a continuous circularity between ***experiential process*** and ***organic structure,*** or in other words, ***between lived and physical body.*** Over time, experiences are sedimented in what may be termed ***body memory***, namely the totality of dispositions, habits, skills and interactive schemes that are characteristic of an individual.

An impressive example of top-down causality is found in an experiment of the neuroscientist Mriganka Sur. They were able to induce a major cortical reorganisation in newborn ferrets, which are blind at first (Melchner et al. 2000). Now Sur and his group cut through one of their optical nerves, connected it with the auditory pathways to the cortex and afterwards let the ferrets move around. Now visual stimuli, in dependence on motor activity, reached a brain region which normally processes acoustic signals. Surprisingly, the brain adapted to the sensorimotor patterns produced by the superordinate organism-environment interaction. Gradually, ***the auditory center turned into a visual center***, so that the ferrets were finally able to see with the eye normally.

Due to the singular neuroplasticity of the human brain, the history of the interactions continuously influences the infant's dispositions and skills. The human brain is fundamentally adapted to develop within a social context. It is not inserted into the world as a prefabricated apparatus, but rather is structured epigenetically by the continuous interaction of an organism and its environment, like a key and its lock 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.

In a recent experiment, Mriganka Sur and his group were able to induce a major cortical reorganisation 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 ***acustic*** nerve to the cortex. Now visual stimuli reached a brain region which normally processes acustic signals. Surprisingly, the brain adapted to the new sensory stimuli, and ***the acustic center turned into a visual center.*** Even neurons characteristic of visual areas developed anew, so that the ferrets were able to see with the eye concerned.

"Form follows function": Interacting with the environment induces the development of the neuronal conditions necessary for ever smoother interaction. Of course, similar cortical reorganisations can also be observed after brain lesions or injuries where patients can re-learn major skills just by continuous practice. ***Interactions thus create the corresponding brain structures*** which in turn modify and enable future interactions. This circularity was already recognized long before the age of neuroscience by the German philosopher Ludwig Feuerbach:

> Only through thinking is the brain formed as an organ of thought and adapted to thinking; it is modified and determined through the habit of thinking this or that, one way or another (...) But only through the fully shaped organ of thought thinking itself becomes erudite, skilled, secure (...) What was effect, becomes cause, and vice versa (Ludwig Feuerbach, 1838).

Of course, we have to consider this not as an individual development – thinking is essentially dependent on language acquisition, which in turn is scaffolded by situations of intercorporeality, shared attention and joint practice. The social environment thus becomes the crucial 'ecologial niche' for the infant's brain to develop the appropriate neural structures. In the course of this development, customs, habits and cultural techniques are acquired by imitation, interaction and cooperative learning. The embodied mind is thus intersubjectively formed from birth on.

We may also speak of an "embodied socialisation", for specific human faculties can only develop through mutual co-operation and are thus imprinted on the organic growth processes of the brain. Culture in this encompassing sense is not only a cognitive system of signs and meanings, but rather implies that all formation processes of the individual and her faculties are engrained into her brain structures. By this, the human brain becomes an essentially social and biographical organ.

Summary

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

– cycles of organismic self-regulation, including a basic affective sense of self

– cycles of sensorimotor coupling between organism and environment, resulting in an "ecological self"
– cycles of intersubjective interaction, underlying the intersubjective self.

The human brain is crucial for all three modes of embodiment. But it does not create, but mediates and regulates the cycles, and it is in turn shaped and structured by them throughout the lifespan.

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. If neuronal processes function as "carriers" of mental processes, they can do so only as part of over-arching life processes that include the organism as a whole and its environment.

Circular causality of living systems

In my final part, I will look at the circular relation between these higher or macro-level processes of the organism-environment system and the micro-processes on the neural and molecular level. To this aim, I will use the concept of ***circular causality*** between higher and lower level processes, or between the whole and its parts. Thus, a living being may be regarded as a system that continuously reproduces the components of which it consists (organs, cells, etc.), while these components reciprocally sustain and regenerate the system as a whole. The whole is the condition of its parts, but is in turn realized by them. Such a structure, for instance, characterizes the relations between genes and the organism: the genetic structure of an individual cell nucleus controls the necessary production of specialized cellular organs and functions ("upward"- or part-to-whole-causality). Conversely, the configurations and functions of the entire organism determine which genes are even given relevance for the development, specialization and regulation of a certain individual cell ("downward"- or whole-to-part-causality).

Vertical causality also characterizes the functions of the brain. To give an example: an emotional state such as a patient's anxiety can be treated pharmacologically, i.e. by directly influencing the transmitter metabolism in the brain ("upward"). On the other hand, this can also be achieved by a calming talk, i.e., on the higher level of social interaction, which changes the patient's perception of one's situation ("downward").

As such, intersubjectivity corresponds to an integral level of organism-environment interactions that feeds back into lower-level physiological processes.

"Downward" causality is often criticized and rejected, arguing that it either presupposes unknown physical forces that impact on the micro-level, thus contradicting the laws of physics. However, it is by no means necessary to restrict the notion of causality to effective causes ***(causa efficiens)*** according to billiard balls acting on each other. Macro-structures may well develop forming or organising effects with regard to the micro-elements in which they are realised, in accordance with Aristotle's ***causa formalis*** (Juarrero 1999, 125-8). This does not mean that new forces emerge which would contradict physical laws. Macro-structures rather are in a position, thanks to their form and configuration, to ***select*** specific properties and behaviours of their components and to ***block*** others.

A good example for this is the giant molecule ***hemoglobin***: Normally, iron exposed to oxygen and humidity oxidizes, it rusts, because it binds oxygen irreversibly. Now for the whole process of respiration, it is decisive that the iron is forced to do something that it would never do under normal circumstances, namely to incorporate oxygen reversibly. This purpose is served by haemoglobin, a macromolecule consisting of about 10.000 atoms, with the sole purpose to enable iron to release its oxygen again in the necessary areas of the organism. No physical "miracle" is required to accomplish this, but only a higher order structure which "enslaves" its own constitutive elements and involves them in specific patterns of behaviour.

Analogously, mental processes, as embodied and integral acts of a living organism, can well be effective in its physical behaviour. Of course, the mental or intentional aspect does not effect physiological processes as an external force, but rather exerts a top-down formative influence over them. If I, for instance, speak a sentence, the muscles of my tongue and larynx display organised patterns of movement. Their proximate or efficient cause is the release of acetylcholine ("acitlcholin" at the motor endplates of these muscles. Nevertheless it is equally correct to say that my tongue and larynx move in these ways ***because I am speaking these words*** and I am intentionally directed towards their content. This "because", however, no longer signifies an efficient, but a higher-order ***selecting and forming cause:*** the muscles are always ready for excitation, and now they are drawn into a selective, superordinate dynamics. Thus, the organising cause of the muscle actions is my speaking ***(downward)*** which in turn is realised by a complex, but constrained dynamics of physiological mechanisms ***(upward).***

However, the same applies to the neuronal activity in motor and other areas of my brain: They proceed in this precise way, because ***I am speaking*** these words, consciously spanning the intentional arc of the sentence over time, roughly anticipating the meaning of the sentence and the next words to come. In other words, my embodied intentions and

protentions are able to organise their physical implementation with the potential ***to even achieve a future state that does not yet exist***. As overarching enactments of life, conscious processes may thus be effective in the behaviour of a living being without "acting on brain processes" externally.

In order to avoid any connotation of such efficient cause, one could also speak of an ***"implicational causality"***: ***By way of*** thinking or speaking, I – as a living being – also realise certain organised processes in which ordered neuronal and muscular activities are implied – they cannot help, as it were, similar to water molecules being drawn into a whirl that nevertheless consists of them. The whirl as form or order ***implies*** their specific movements without acting upon them. Thus, the complete cause of my speaking is neither my tongue nor my brain, but I am this cause myself as a living being. In each conscious action – walking, speaking, writing, or thinking – the living being as a whole acts as the forming, selecting and organising cause. This may be seen as a reconceptualization of Aristotle's causa formalis in terms of modern dynamical systems theory.

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. 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.

And this also in correspondence to our own experience: We are not pure subjects who observe events from the margin of the world, but we are embodied subjects who experience events in the world. So the answer to the question: "Where is the subject, if not in the brain?" should be: As a conscious, experiencing and acting being I am not inside my brain; I am a living, embodied being, i.e. I am always there where my body with all its physiological functions is that make my experience and actions possible. But this also means that I am at the same time always transcending my physical body to live in the world and with others. I am the one who is standing here, who is talking now, whom you are seeing, and whose voice you are hearing.