

Birch, J. E. (2010). The inner game of sport: is everything in the brain? *Sport, Ethics and Philosophy*, 4, 284-305.

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”Between ourselves, it is not at all necessary to get rid of “the soul” at the same time, and thus to renounce one of the most ancient and venerable hypotheses – as happens frequently to clumsy naturalists who can hardly touch on “the soul” without immediately losing it” (Nietzsche 1966, BGE 12)

The Inner Game of Sport: is everything in the brain?

The neurosciences are the new loud.¹ Not only can the electric activity in the brain be recorded by electroencephalography (EEG), but single cell recording techniques can actually show which individual neuron fires in a certain movement or visual stimuli. And the temporal and spatial resolution of functional magnetic resonance imaging (fMRI) vastly outperforms positron emission tomography (PET), so we can see what parts of the brain are used for certain tasks.² These techniques are likely to improve rapidly.

We all know that movements in sport are not generated by muscle and respiratory systems alone. The brain is involved in everything: you cannot see the ball without events in the occipital lobe, nor find your balance if the cerebellum is damaged. Neither can you choose between a pass and a shot without summations in axon hillocks, or extend your arm without events in the motor cortex. It seems that neuroscience should really be the sport science *par excellence*. Maybe the brain is a much better indicator of athletic ability than Vo2 max or 1 RM?³ It certainly seems self-evident that the brain must be studied to get a more complete understanding of sport and physical activity. The neurosciences might give us solid empirical answers to questions like those raised by Breivik (2008) on the nature of movement.⁴

At the moment imaging techniques like fMRI are limited in use because the person being scanned must lie still. But in some near future, we could probably analyze what goes on in the brain while playing basketball. What we want to know then, is how the mind of the athlete is related to the body and the world. The neuroscientific revolution has also made sure that philosophy of mind is, if not the new loud in philosophy, certainly louder than it has been

for centuries. It is considered plausible to study not only the brain and behaviour, but mind and subjective experience. And to do this in hard, scientific research language. How do these new scientific discoveries and theories relate to philosophy of sport and mind? It is the aim of this article to relate philosophy of mind, the neurosciences and a kind of philosophy of sport science. I believe this to be important because if you are going to ask and hopefully answer philosophical questions from a “new” scientific perspective, we should have some insight into what philosophical water we are treading. This also concerns sport science because the neurosciences may teach us a valuable lesson about a great many things: first and foremost that the mind is intertwined with the movement of the body. That will be argued for in this article. It will also be argued that consciousness (see below) is the mark of the mental, and as such must not be left out in the cold by studies of movement, brain and mind in sport. (Human Kinetic’s ad magazine for the first ever volume of biological sport psychology (Acevado and Ekkekakis, 2006) claims on page 45: “Cutting-edge research bridges the mind-body gap”. And Acevado and Ekkekakis (2006, ch 1) hails there is integration between mind and body at last. Williamson (2006, 29) seems to believe that understanding brain function is the same thing as understanding the mind. Finally the mind is being studied in sport by the empirical biological sciences then. Or maybe it is only the brain that’s being studied?

In this article I will first analyze three articles on fMRI and sport. What new insight can the neurosciences offer to studies of the mind in sport? If neuroscientists want to say something about the mind of the athlete, they’ll need a base neuroscientific theory of mind. If not, it will remain just neuronal talk. One of the world’s leading neuroscientists, Gerald Edelman (1987; 1992; 2006), presents such a theory. So the second part of this article will analyze the theory of Edelman and how the abovementioned empirical studies fit such a theory. The link between the empirical work on sport and Edelman might seem at bit hazy,

since the empirical work does not site such a theory. To make the leap from brain activity to mental activity, one needs a deck from where to jump. Without such a theory, relations between brain and mind remain speculative at best. The mission is to take a look at what such a theory *might* look like. The neuroscientific theory of Edelman is especially interesting to philosophers of sport because it puts more emphasis concerning the second half of the mind-body relationship. The theory makes claims beyond the scope of molecular and neuronal activity and moves to how the brain develops consciousness through the body and the world. Can we hope then, for a theory that goes from neuronal activity in the brain to higher cognitive aspects involved in sport? If so, the sport sciences must lend an ear to the new data arriving every week in neuroscientific journals and books. Like Graham McFee (2007) says, at least we should hear their options before we wave them off. In the third and final part, this article argues that the neurosciences give us a better understanding of mechanisms underlying many aspects involved in sport. The big question is: is everything there is to sport in the brain? Would we know everything about sport if we could see and record every brain event during actual performance? Throughout this article I will use the distinction from analytic philosophy between psychological- and phenomenal consciousness (see e.g. Chalmers 1996, ch. 1).⁵ Although not clear cut categories; psychological consciousness is what the mind *does* (awake, aware, alert, intentional, rational). Phenomenal consciousness is how the mind *feels*, the ‘what’s it like’ character (see Nagel 2006). It has been argued elsewhere that it is phenomenal consciousness that is the mark of the mental and what separates a conscious creature from something non-conscious.⁶ This will not be discussed here, but be a platform for this article. This article will argue that the mind is equivalent to both psychological- *and* phenomenal consciousness. The article concludes that phenomenal consciousness is an important part of practising sport, but that phenomenal consciousness is not reducible to neuronal activity or organization. If so, neither fMRI studies on sport, nor theories like

Edelman's can provide complete accounts of the athlete's mind, even if all brain events may be seen during actual performance. Without a complete account, an explanatory gap will remain unabridged also by neuroscientific methods or techniques.⁷

Sport and the neurosciences

It is an empirical question if the neurosciences make an impact on studies of mind in sport.⁸ I will give but three examples: "The Mind's eye: Functional MR Imaging Evaluation of Golf Motor Imagery" (Ross et al. 2003), "The mind of expert motor performance is cool and focused" (Milton et al. 2007) and "Why did Casey strike out?" (Milton, Solodkin and Small 2008). In these articles, fMRI is used to study the mind of the performing athlete. That is interesting indeed. These studies are worth examining a bit further.

"The Mind's Eye" (Ross et al. 2003) is a study of which brain areas are activated when visualizing the golf swing. A first person perspective is included: the subjects' mental rehearsal of their golf-swing – as well as a third person perspective: the active brain areas indicating the neural events causing, correlating, or being identical with the mental imaging. It is, so to say, a reductive explanation of mental events in sport: reducing the mental event of imagery to neural events in the brain. And as such, it is also philosophically interesting, because the article suggests that this kind of reduction is possible and valuable. Six subjects with handicaps from 13 to 0 were tested in a "rest" scan: scanning the brain while the subjects mentally imagined sitting at a beach. This was compared to brain scans of the visualization of the golf swing. The study showed that the number of brain areas involved, and their degree of activation, diminished with lower handicap. And they conclude this has implications for (golf) learning theory, because compensatory increased brain activation due to failed automaticity may be resistant to conventional teaching methods (Ross et al. 2003, 1043). The study also

showed that fMRI scans can feasibly be used to test effectiveness of visualization techniques for athletes. That is not bad at all. I will comment on what I believe is problematic in the study below. But first, I want to go deeper into the related works of Milton et al. (2007), and Milton, Solodkin and Small (2008).

“The mind of expert motor performance is cool and focused” (Milton et al. 2007), is philosophically interesting because it makes daring claims. In the abstract, the author “suggests that the disparity between the quality of the performance of novice and expert golfers lies at the level of the organization of neural networks during motor planning” (Milton et al. 2007, 804). If that is so, neuroscience really should be *the* sport science. This study compared pre-shot routine for 6 LPGA players against 7 amateurs with less than 2 years experience. Using fMRI, the golfers were analyzed when viewing a non-golf scene (for control), and then when mentally going through a pre-shot routine for a 100 yard swing. As in Ross et al’s study (2003), the experts had fewer brain regions activated and also less activation in the central regions. This means less energy needed for execution and implies more efficiently organized motor programs. Only the novices activated lower-laying regions; the limbic areas and basal ganglia. This might be due to more fear and anxiety (normally associated with the amygdale in the limbic system), but the authors have another explanation. They suggest that novices have more trouble filtering out irrelevant information. Because beginners are not on the same level of automation, they must make conscious choices demanding more time and reducing accuracy (in actual performance). If the authors are correct in their analysis, they hope fMRI studies might stress the importance of sorting out relevant information and perhaps even develop more efficient teaching protocols (Milton et al. 2007, 811).

In “Why did Casey strike out?” (Milton, Solodkin and Small 2008), we can read the fascinating story of what is going on in baseball batters’ brains. The article reminds us that baseball cannot be fully analyzed by biomechanical physics. We also need an account of what goes on in the neural networks involved in motor programs (Milton, Solodkin and Small 2008, pp. 43-44). The article’s subtitle catches the drift: “The neuroscience of hitting”. The authors argue that a baseball batter could never calculate the speed, angle, spin on the ball and come up with the right motor-response, simply because the brain cannot possibly calculate these factors in the time available (Milton, Solodkin and Small 2008, pp. 44-47). This is a good example of practical implications from neuroscientific studies to sport science: the information-processing/functionalist model should not be the model theories are based upon.⁹ I will return to this topic in the discussions on Edelman’s theory, and in the section *Reduction and the explanatory gap in the neurosciences*. On the positive side, neuroscience can give us a clue to what actually goes on inside the head of the athlete. In the case of baseball, Milton, Solodkin and Small argue that it is a) the interpretation of the pitcher’s movement and b) the filtering of information that is important to finally preparing the motor programs for the movements of the swing (2008, pp. 49-52). To do this appropriately, the mirror neuron system comes to the rescue: when person A *see* another person B *perform* hand/arm-movements, the same neuronal events occur in the motor cortex of A and B. So, we are in some way able to “see” inside the brain of another person and predict the behavioural output: B’s movements are mirrored in A’s brain.¹⁰ In this sense, we do not process information in some kind of calculation. Rather, it is done automatically (or “mirroredly”) in the brain. When movements are mirrored, we know intuitively what is going to happen – without conscious or processed thought.

We can sum the two articles on golf making comparisons between novices and experts thus: novice golfers have higher brain activation than experts in almost all activated areas, and

the novices activate more areas as well. These studies illuminate how the neurosciences are beginning to put their mark on sport science.

From brain to mind - ?

There are several things that are problematic in the two fMRI studies on golf: the few subjects (6 and 13), that the data on activation areas and strength are at best diverse, or that blood oxygen level dependent (BOLD) which fMRI shows, does not actually show neuronal events *directly* - only the amount of oxygen used by brain areas. Neither can fMRI show the type of neuronal activity, so it cannot be determined whether the activity is excitatory or inhibitory. Another empirical problem is the time course: neural events occur in milliseconds – BOLD can only be measured a couple of seconds later. And why should we assume that a phenomenal state in visualizing golf would consume more oxygen than a comparable phenomenal state? We might also want to object with Paul Davis (2007), that other qualities such as courage is not under the consideration in these studies, so we are just getting a very narrow answer to what expertise amounts to. Although important, these worries are not my major targets.

First, I would rather attack the supposition which the studies rely upon, namely “that mental rehearsal is somehow analogous to the motor planning that occurs with natural movements” (Ross et al., 1041). That is indeed a key assumption. But how can we know that? If we cannot, at best we have seen the brain activation in imagery and mental pre-shot routine. At worst, we have only seen the brain activation in imagery and mental pre-shot routine in a laboratory, which might be quite different from the actual mental performances. If that is the case, all we have learned is that fMRI or its future replacement *might* be useful *if* it can be applied in real situations.

Second, is it feasible to think that the difference in performance lies at the level of neurons? On the one hand, it is not very surprising that brain activation differs both in subjects overall and in correlation with expertise. But on the other, it certainly does not explain why one is an expert and the other not. If that was the case, we could imagine that one could learn all there is to golf by exercising inside the MR machine to find the most efficient neural network and organization. But I think we have very good reasons to believe that this would not do the trick. If we are to take Edelman's theory discussed below at face value (and I think researchers like Milton, Ross and others should) it seems our brains must have bodily contact with the world to develop the enormous amount of synaptic connections that make up efficient neural networks and pathways. In a way, sport is a good counter argument to an identity theory of mind¹¹: if visualizing and actual performance actually *was* identical on a neuronal level (which it is not since visualizing also contains the inhibition of bodily movement), then visualizing movements would do the same trick as performing them.¹² As we all know: it doesn't.¹³ To debate whether embodiment is conceptually necessary for skill possession or not, is not where this article is going. The point is to see what sport science can gain from the neurosciences and maybe what not.

Third, how does one go from an efficient neural network to a focused neural network (Milton et al. 2007, 805)? Efficiency is shown by making the same (or better) performance by use of less energy. BOLD data suggest that something like Edelman's' Neural Darwinism (see next section) develops synaptic connectivity which are necessary for efficient networks in the brain. So we might say that neural networks are efficient in completing a task. But are the expert's neural networks focused? If you simply answer yes, then you are leaning towards an identity reduction; neuronal events *are* the mental state of the performer. If you think that to be focused is just the filtering of information (like late or early selection), and this causes some brain activation to decrease, then you hold an information-processing theory.¹⁴ I will

argue below that neither position is favourable in mind- and sport analysis. But what is it to be focused anyway? Isn't it a certain way to be in a situation, a 'What's it like', or a state of phenomenal consciousness? It does not even have to be efficient, but it has a certain qualitative feeling about it. What might be called a lack of qualitative noise (efficient) is not necessarily the same as qualitative clarity (focus). The articles under discussion describe this as automation, but I would claim that most states of automation are not the prime candidate for focus. Being absorbed by the situation, what I would call focus, is a quite different phenomenal state. Also, it seems strange that Milton et al's article argues that activation of the limbic system and basal ganglia is correlated with conscious thought and not automation (Milton et al. 2007, 810). The standard analysis is that conscious thought (meaning conceptual or a thought *about* something) is correlated with neo-cortex. The limbic system and basal ganglia, on the other hand, are normally involved in the automaticity of the CNS. In evolutionary terms, neo-cortex is necessary for human conscious thought. The article claims that the experts have more activation in the middle frontal cortex, and this explains a larger degree of automation. But it might be the other way around. This is not the place for what it means to be an expert, but it is appropriate to remind ourselves of Dreyfus' thoughts on expertise (Dreyfus and Dreyfus 1986): the expert does not act automatically, but intuitively.¹⁵ On this interpretation of expertise, the expert must come up with novel movement because each situation is different. The expert does not act automatically, but in a fluent, coping and skilful way. Automatic behaviour is signified by the intermediate skilled person, showing the same solutions for slightly different situations.

Finally, Milton, Solodkin and Small think that it is unproblematic to go from pre-shot golf routines to the actual pre-swing baseball routine (2008, 50).¹⁶ In "Why did Casey strike out?", it is argued that a baseball swinger has a pre-swing routine similar to golfers, so if fMRI studies on expert golfers show high activation in occipital cortex and cingulate motor

area, low in the rest, then it should be the same in baseball. How so? The golfer's preshot routine is on a static ball, with no weather (ruled out in Milton et al's study (2007, 805)) and no opponent. What Milton, Solodkin and Small classify as the baseball batter's pre-swing routine has mainly to do with the opponent: the windup, the shoulders, previous pitches and so on (2008, pp. 47-48). The pre-routine of the baseball batter, I find to be a perfect example of non-automation because the expert batter must adjust to each situation. I also believe that each golf shot is novel and not a kind of automation (though of course, some muscular contractions are). But what Milton et al have studied is not novelty. That is, their method shows what an expert would do *if* (s)he was in a situation of complete knowledge. The golfers/batters cannot possibly visualize a situation where they must adjust in the moment – creating novelty. They already know what is going to happen, because the opponent is themselves. In real sport though, it is always a new situation. It certainly is in the meeting between pitcher and batter. Edelman and Tononi (2000, 142) describes exactly this situation:

”When the tasks are novel, brain activation related to a task is widely distributed; when the task has become automatic, activation is more localized and may shift to a different set of areas...(W)hen tasks are automatized and require less or no conscious control, the spread of signals that influence the performance of a task involves a more restricted and dedicated set of circuits that become “functionally insulated”. This produces a gain in speed and precision, but a loss in context-sensitivity, accessibility, and flexibility”

Clearly Edelman suggests that it is not the expert performance which needs less and narrow brain activation; it is the simple, automatized task. Edelman claims that in a novel situation, what I have claimed typifies top-level sports, brain activation is different, meaning not automatized.¹⁷ We appreciate that neuroscience can give a fuller understanding of the brain-body relations in sport. But when Milton, Solodkin and Small claim that “what appear to distinguish a good athlete from a poor athlete in these sports are the activities that occur within the six-inch space between the batter's ears”, (2008, 49) we must insist that sport performance is no more reducible to neuronal events alone than to biomechanical physics.

The three studies above claim to view into the mind of the athlete. But do they? The only thing they look at is brain activation. So is mind identical to brain? Or does the brain cause mind? To get from brain events to mental events, we need some kind of theory. Preferably a neuronal theory, since neurons provides the data under discussion. What, then, do the leading neuroscientists tell us about mind and brain? And do these theories change or strengthen our views of brain, body and mind in sport? Edelman's theory below is one example of the new neuroscientific views on the mind-body problem and how the brain and body relate and develop through interaction with the world. As such it has impact on the philosophy of sport. But in addressing philosophical issues, a theory also encounters philosophical problems. Are they accountable for in neuroscience? As philosophers of sport, we should point out that the part of mind called phenomenal consciousness plays a major role in sport (I will argue for this later). Therefore, consciousness should be studied in a serious way. Can the neurosciences be this way? At least they claim to study consciousness both seriously and scientifically.

Consciousness and Edelman's "neural Darwinism"

So what's all this neuroscience about, really? Nothing but another reductive biochemical explanation of psychological phenomena? Well, yes – and, no. The most interesting thing about (some of) neuroscience is the attempt to include the phenomenology of subjective experience into hard scientific language. On the other hand, neuroscience is, to speak with John Bickle (2003), "ruthless reduction". That is, neuroscience is at large bottom-up reductions in terms of neural activity and synaptic transmission. How neurons communicate and cause things to happen, is not the issue in this article. The issue here is how theorists take

this knowledge and make further claims, especially philosophical ones about body, brain and consciousness.

Former Nobel Prize winner, Gerald Edelman, has high hopes on behalf of science (1992, xii): “We are at the beginning of the neuroscientific revolution. At the end, we shall know how the mind works, what governs our nature, and how we know the world.” Edelman wants to build a bridge between the humanities and the natural sciences and his bridge to close the gap is one of neuroscience. To do this, even subjective experience must be explained in neuroscientific terms. Of course, that will also close the explanatory gap. Philosophers of sport may then hypothetically ask: if we actually could see every brain event during performance, is that all there is to know? In *Bright Air, Brilliant Fire* (1992), Edelman puts forth his theory of “neural Darwinism”. He also attacks cognitive science and (computer) functionalism. This has important implications for sport science.

Edelman’s theory of “neural Darwinism” (and Changeux’s neuronal epigenesis¹⁸ (2004)) tries to explain how the central nervous system goes hand in hand with genetics and non-determinism. This has interesting perspectives for training and development in sport. We might say that Edelman’s theory could provide a neurophysiological framework to Searle’s background capacities discussed by Moe (2007). Edelman’s theory claims that our DNA codes for our biological-anatomical makeup while the brain is almost a neural *tabula rasa*. This is due to the enormous amount of neurons in the foetal and infant brain. During life these neurons are destroyed and pruned, and synapses diminish. Groups of neurons make up neural networks which if stimulated are then strengthened by greater synaptic connectivity. To be effective, neural networks must be stimulated in a good way. This view of what constitutes an effective neural network looks similar to Milton et al’s.

Learning then, is to eliminate. That is, we are genetically disposed to anything, but since neural patterns are developed momentarily, and if not – die, we lose capability.¹⁹ So, according to Edelman’s neurotheory, we could all do any kind of sport, probably even at excellent level. But since the capacity of the brain and stimulations are limited, only some skills are developed. Like Ross and Milton, Edelman gives us a neuronal answer to why some are better than others in sport: they have more effective neural networks, greater synaptic connectivity, and better regulation of neurotransmission. Edelman deepens our knowledge because he also gives us answers to how this happens: the ruthless neural selectionism from the interplay between the individual and the environment. Since neuronal and synaptic growth is most modular after birth and neurons die quickly, this interplay is most effective in the child’s early development. The morphology of neurons also tells us a lot about the difficulty or ease of learning new skills for adults: if similar neural networks exist due to earlier stimuli, things are easier. We can compare this with the impossibility of Japanese adults trying to learn the “ra” sound (see Changeux 1997, 244). This isn’t news to people engaged in sport, but the neurosciences give us a better explanation of *why* it is so. That is after all what science is about.

Another interesting aspect of Edelman’s theory is the importance he puts on embodiment. The brain is embodied, of course, but the relationship is so tight that he actually paraphrases Merleau-Ponty’s old saying “you *are* your body” (Edelman 2006, 24). Edelman also stresses the embeddedness of the body in the world through sensory inputs and effects. Again, from the *empirical* stance of the neurosciences, there can be no creature/creation acting like humans without embodiment and embeddedness. It is through the body’s interaction with the world that neural networks and synaptic connections are selected and strengthened. That is a consequence of “neural Darwinism” (and Changeux’s epigenesis). This is significant to philosophers of sport because it reminds everyone of the importance, not

only of the body, but its movements in the world. Without the movements of the body, neuronal growth and efficiency is heavily impaired, it is a necessary condition for human development. The neurosciences actually put the body back in pole position. This should be a relief to us, and in this respect we should embrace the neurosciences.

One of Edelman's main concerns is to state the importance of grounding any study of mind in the biological brain. Consciousness cannot come from any kind of matter; the matter must be biological and neuronal. Biological and neuronal matter has its own life story, from conception through life. This journey is a fundamental and necessary component for consciousness. This "evolutionary morphology" is not to be found in non-biological matter, and so computers and other machines cannot have consciousness (Edelman 1992, 29).

Edelman denies functionalism's multiple realization argument and any kind of computer analogies and cognitive science built upon this kind of theory (Edelman 1992, 13). This is of great importance, because if he is right, we must abandon most of our literature on skill learning and motor skill development based upon information processing theories.²⁰

Edelman's view *could* be thought of as a base theory for Milton, Solodkin and Small's scepticism regarding information processing accounts in sport studies.²¹ Edelman's concern, though, is still on the brain's *organization*. For consciousness to be realized in the brain, the brain must not only be built by proper biological matter, the brain must also be organized in the proper way (Edelman 1992, 16). Edelman sees the brain's complex organization and body-world involvement as one of two reasons not to fall into "silly reductionism" or embrace an identity theory of mind. The other reason not to hold a simple reductionist view is the individual's life story and morphology. This is what makes us able to categorize qualia (the qualitative features of experience) and establish subjectivity.²² To Edelman, qualia are just sense impressions. Edelman's theory of neural Darwinism provides an explanation of what consciousness *does*: it is a power evolved by natural selection to make fine grained

discriminations between sensory perceptions. But to answer ‘What’s it like’, how consciousness *feels*, is a question concerning the individual’s life story and as such not a scientific encounter (Edelman 1992, pp. 135-136, 151).²³ We might say Edelman has shed light on psychological consciousness, even an answer towards *why* we have consciousness. Why there is subjectivity is explained in brute brain science, but phenomenal states of subjectivity is ruled out as epistemically uninteresting. So unfortunately we are not enlightened on the phenomenal part of consciousness and still left with an explanatory gap. For sport this means that the neurosciences may enrich our knowledge on the possession, but not the acquisition of skills. For sport science, the latter is probably most interesting.

In his later work *Second Nature* (2006), Edelman is more optimistic. He assures us that we “can study consciousness even in the face of subjectivity” (Edelman 2006, 9). How the neurosciences could possibly bridge the gap between the athlete’s subjective experience of sport performance (the phenomenal part of consciousness) and the objective third person perspective of the natural sciences (and neuronal language), is what this article questions. Edelman includes phenomenal consciousness in his theory, stating that we could be able to create a device with internal phenomenal states which could be measured neurally (Edelman 2006, 10). Now that would be something. It is what would be needed for people like Milton, Ross and others to go from studying brain activity to make claims about the mind of the athlete. Again Edelman tells us the neuroscientific story of how this could be done to explain not only intentionality, but also phenomenal consciousness (Edelman 2006, 14). Through his work on robots designed on brain models, he and his collaborators have managed to build robots with discriminatory power and some ability to learn. So, if qualia are discrimination and robots can discriminate, we can learn something about human consciousness from these robots. This certainly sounds like information processing theory and computer analogies.

Edelman denies that it is, because his robots are built on how the brain (not a computer) works. But his view is a perfect example of functionalism's multiple realization argument: mentality can be built in different ways by different matter.²⁴ Edelman takes phenomenal consciousness to be the subject's qualia, in his theory meaning some distinguishable sensory input (Edelman 2006, pp. 2-14). Consciousness then, is a value system, which selects some inputs from others, and selects an output from others.²⁵ This picture doesn't look very different from Milton et al's: the mind of the expert gathers perceptions and acts accordingly. In neuronal terms, this is the summation of inhibitory and excitatory inputs in the axon hillock, nothing more. Phenomenal consciousness is to categorize what qualia are reduced to: sensory inputs, and then select responses (Edelman 2006, pp. 36-40). Of course, if this is all there is to consciousness, we are probably capable of creating a "conscious" device and study its processes. Most computers do some sort of selectional process, just like the "brain based" robot Edelman describes (2006, ch. 12). But what happened to the 'What's it like' feeling of phenomenal consciousness? That's what we are looking for in consciousness studies in philosophy, and that is what is meant by qualia in philosophy. We want to know not only what consciousness *does* (categorize and select according to Edelman, the psychological part), but how and why things *feel* the way they do (the phenomenal part). If we want to know the mind of the athlete, then we must know what it feels like to be in the state of selecting a certain response.

Reduction and the explanatory gap in the neurosciences

Philosophy of science normally operates with three kinds of reduction: bridge laws, functional- or identity reduction (see Kim 2005, ch. 4; Levine 2001, pp. 94-96).²⁶ A full blown theory of consciousness will need more than neural correlates. So, the neurotheory above must be some kind of reduction of mental events to neural events.²⁷ Edelman argues

that the brain's complex organization separates the neurosciences from simple reduction. Empirical evidence from the neurosciences themselves also goes against simple reduction: evidence shows that even identical twins have different brains and that brains process the same assignments differently at different age levels (Edelman 1992, 25). This is because the brain is made to develop in accordance with new inputs, so the brain's plasticity makes it difficult to make universal claims. This means; reducing one activity to neural events in one person does not equal the neural events in another person doing the same activity - maybe not even amongst the persons themselves from time to time. Edelman himself argues against identity reduction (Edelman 1992, 170, 198). That is interesting because the new wave of identity theories is based on the hope of full reduction from the neurosciences.²⁸ It also means that projects like Milton's, reducing expert performance to organization of neural networks, is questionable because two different athletes will not have identical networks and neural events doing the same movements. A consequence might be that brain imaging would only help the particular athlete, not give general recommendations.

What about functional reductions? Functionalism defines mental states by their causal relations to each other and to inputs from the external world and behavioural outputs. It thus appears to resemble neuroscience: stimuli coming into, say, the retina, are being sent through *nervus opticus* to the thalamus, then to the visual cortex and finally some perception/representation is instantiated. Edelman's theory seems to have some aspects of reduction through both identity (there is nothing mental above or beyond neuronal events) and functionality (for instance emphasize on organization and creating a "conscious" robot).

What is puzzling is that Edelman is clearly a big opponent of cognitive science, computer analogies and information processing theories – in a word: functionalism. At least he rejects a computational functionalism. In this case he resembles Milton, Solodkin and

Small's denial of the brain's *computation* of a ball's velocity, angle and spin. Edelman's argument is simple and powerful: the brain is neither built nor works like a computer: neurons do not carry information (Edelman 1992, 27). If the neurosciences are going cognitive, they should not be built on some vague and outmoded version of functionalism. How do we reduce consciousness then? Edelman's strategy is almost an eliminative materialism; explaining qualia away. How something feels to me, is something it would take a life story to deduce (it is a result of an individual's morphology) – so we should not ask for a scientific explanation or reduction (Edelman 1992, 136; 2006, pp. 139-140). But, since Edelman claims qualia are discriminatory information from the world to the subject, he has given qualia a) an evolutionary history; without qualia we could not distinguish how sweet feels from bitter, and b) causal power; they make a difference in the world – we act upon the discriminatory information. But if qualia have causal powers, they should be reducible because we (and certainly Edelman) believe that only physical events can be causally potent. And if qualia have this power through how it feels, this subjective experience must also be reducible. Edelman though, claims that qualia are some kind of epiphenomenon and as such are not reducible (2006, 145). The problem is that if they are epiphenomenon they cannot have causal potency. But, that is exactly what Edelman has given qualia, since they provide us with information about how the world is and feels (2006, pp. 139-141). Edelman's position faces the argument of Jaegwon Kim: non-reductionism of consciousness leads to epiphenomenalism and no causal power (see Kim 2005).

Any neurotheory of mind will face these two problems: i) the irreducibility of consciousness, ii) mental causation. The first leaves us with an explanatory gap and Edelman believes there is no such thing. The latter problem is certainly not what a neuroscientist would want. It is not the problem sport scientists would want either. At least if you think

consciousness does make a difference in the world of sport. It would be an awkward position to go all the way to argue how the body shapes the brain through interactions with the world and then end up with no causal connection between brain and consciousness. Edelman's position here is confusing since he argues both that only a brain developed by neuronal selection through a bodily lived life can create consciousness, *and* that a robot built *like* a brain (but not by biological matter) can have consciousness. It is not clear how these two statements are to be reconciled. A major problem is that any kind of functionalism seems incapable of explaining phenomenal consciousness since it is the behavioural output that matters, not how it feels to behave that way.²⁹ That might also mean that a neuroscience based on functional reduction is not the place to look if you want to study both psychological and phenomenal consciousness in athletes.

In short: if Edelman claims that qualia cannot be reduced to neural events, they must either be non-physical events or epiphenomenon. He sticks with the latter. But then qualia cannot have causal powers. He must either give up his account of what qualia do, or go for full reduction. In the reduction attempt though, he falls into some kind of bio-robot functionalism – and the same position he least of all wants to be associated with: information processing theory.

Edelman's theory discussed in this article wants to have a cake and eat it too. It wants a biological functionalistic identity theory. That might be ok in some waters, but when treading philosophical ones, it is not. For one thing, the individual differences and plastic properties of the brain should amount to an insight about consciousness: it is unaccountable for by an identity-like scientific theory. So Milton; expertise is not just in the head. Neither can a functionalistic theory explain phenomenal consciousness. So there is still an explanatory gap both in consciousness studies and in sport sciences. This gap will not be closed even if

imaging techniques improve so drastically we actually could see brain and neural events in persons actually playing a game. Edelman believes his approach to studies of consciousness is not reductionistic - I have tried to show that it is. He also believes that there isn't an explanatory gap, and if there is – it isn't science's mission to close it. I have argued that when dealing with consciousness, this is also wrong.

Consciousness in sport

So far I have argued two things. First, the neurosciences can teach us a great many things about how the brain/body/person integrates sensory inputs and behaviour, perhaps even rational behaviour. Second, that the neurosciences cannot, contrary to some claims, close the explanatory gap between phenomenal consciousness and reductive accounts of humans. So what? Well, I believe there are some very serious *whats* here. The first question we have to ask ourselves: is there phenomenal consciousness in sport? Second, if there is, is it important in our sporting practice and science? It is time to argue for a view that says “yes”.

I think it is easy to agree that in practising sport we execute the psychological part of consciousness. It certainly seems that athletes are awake (not sleeping), alert (ready to act) and aware (of opponents/objects). It also seems that sport is intentional (in a goal directed way). We have intentions about bodily movement, desires to do them and beliefs about how. The main point in this article remains the same: awareness and intentionality in humans do not happen in the dark. There is a ‘What’s it like’ feeling when practising sport. This is the phenomenal consciousness of the athlete. What about it?

The story that qualia freaks want to tell is that we have a feeling related to our decisions and experiences. According to Damasio's neurotheory (see Damasio 1994; 1999;

2003); without this feeling, decisions tend to be irrational. Maybe we could also say with Damasio that when we do sport, we do not compute, we *feel*. It might be the case that expert golfers have a different kind of phenomenology when they visualize or do their pre-shot routine than beginners. We can certainly subscribe to the different feel of mastering something than not. Phenomenal consciousness is perhaps the difference of being in a situation. The intention of beginners and experts is probably the same when visualizing. Maybe it is the way we just *are* in a situation that makes the difference. Put this way, our phenomenal consciousness makes a difference in how we respond on the field. It has causal potency. It does not mean that psychological consciousness does not make a difference. We should have this perspective on sport: when we practise sport - are intentional, attentive, aware – we do not do it in the dark. On the contrary, we have a very strong ‘What’s it like’ feeling in these moments. I do not even feel obliged to argue that we do.³⁰ Rather, I do believe that it also a major reason to do sports. Why else would we? Action without phenomenal consciousness is the picture sport sciences, bearing upon other reductive sciences, paint though. Neuro- and muscular physiology goes on without any consciousness involved. Still, hardly anyone believes that the mental is not important in sport. Sport psychology is full of literature on mental training, awareness and attention in sport. But there’s surprisingly little about phenomenal consciousness.³¹ The same is true of skill learning and motor skill development. They are presented in a reductive, often functionalist programme which leaves phenomenal consciousness out of the picture, as if the way we feel doesn’t matter. Like Edelman, I believe that we must take biology seriously and not build theories on computer models. Sport is an activity for biological creatures, and if our brain is not built or works like a computer we should abolish such ideas. The importance of evolutionary morphology must be emphasized; we could not learn anything without interplay with the environment. But again, phenomenal consciousness has a story to tell. And the story

is that there is still an explanatory gap in the natural sciences, because phenomenal consciousness makes a difference and so must be taken into account. Philosophers of sport must remind reductive sciences that the gap must be admitted and resolved, not explained away. Especially when fMRI pictures showing brain activity are claimed to be mind and skill.

How the neurosciences change everything and nothing for sport ³²

Studies of sport seem remarkably far from dealing with consciousness. My claim has been that either consciousness is left out altogether, or it is treated in a reductive physicalist way, close to an identity or functionalist theory. If this is true, there is an explanatory gap both in the neurosciences and in sport sciences. I have tried to show that there is. I have also tried to show that we can be taught a great deal from the neurosciences. For instance, cognitive science has had a long reign in explaining, let's say, how memory and learning are involved when establishing athletic skills. On the basis of neurobiological evidence, Edelman denies representational memory, the sort of account often held in cognitive science. Edelman claims that memory is no more a representation of the outside world than an antibody is a representation of a virus. ³³ A better understanding of mechanisms behind memory and learning are surely important to sport science, and if the neurosciences can increase our understanding of them - excellent. But we have to remember that what a person does in the laboratory is probably not the same as in real sport. So to make suggestions as to what athletes actually do is difficult. But where else do studies like Ross, Milton and Edelman's contribute to our understanding?

Ross and Milton's studies show that standard or simple situations should call for low and limited brain activation. This enables the athlete to have more capacity when difficult and novel situations arise. This is certainly true for stamina and strength factors, and they might

have shown it to be reasonable for the brain as well. They have also shown that activation in the occipital lobe is high in experts. This might mean that the brain's importance lies in what meets the eye: information, knowledge, preparation comes through the retina. This again means that training regimes should focus even more on visual information gathering, for example on how many factors can be dealt with simultaneously in visual attention. If their suggestive thoughts on mirror neurons are close to the target, it might mean that training should always be done with human opponents and not some kind of simulation or machines.

³⁴ Except for high occipital activation it is the cingulated and supplementary motor systems that do the experts' job. Milton et al argue that this is a sign of the experts: they have higher activation in a narrow area (lateral premotor cortex and superior parietal lobe) – meaning only those areas necessary to execute the movement. For the rest, less is more. That is something to think about for us with a higher handicap than our shoe size: the golf swing is a *small* movement, it does not take a lot to hit that little ball. How do we then, transfer this into useful knowledge?

- 1) Give up on information-processing theories, the brain does not work like that. The idea that the human brain is an information-processing unit is not supported by neuroanatomy, neurobiology, the neurotheories of Edelman, Changeux (see footnote 19) and Damasio (see footnote 23), nor the empirical work discussed in this article.
- 2) Because the interaction between body and world creates neural networks that are necessary for (efficient) movements, we should stress repetition and reduce theory for children as well as adults. This is a consequence of Edelman and Changeux's theories. Synaptic connectivity in neural networks are first and foremost selected and formed by senso-motoric actions.

- 3) Neural networks and synaptic connectivity are most plastic and selective in infancy and childhood. Edelman's Neural Darwinism and Changeux's epigenesis explain how synaptic connectivity is established and pruned when used, and die if not. Since neural growth and diminishing is greatest in our very first years, the golden age of skill learning is probably much earlier than 8-12 years of age, so there should be more focus on motor development and coordination at an earlier stage – for example in kindergartens. This does not call for early specialization; on the contrary, it is necessary to build a wide platform of different movement solutions.
- 4) Mirror neurons might show us how important good modelling is, but also *why* it is so important. Milton's claims based upon Rizzolatti's discovery of mirror neurons suggest the following: if there is strong congruence on a neuronal level between performer and observer (neurons being mirrored), then an expert doing the modelling will be better for both action recognition and imitation.
- 5) More stress should be put on the visual system, especially familiarization with varied, speedy motions of several objects and persons. This follows both from the role mirror neurons is said to play in action recognition discussed by Milton, but also from the empirical evidence found by both Ross and Milton: experts have higher activation than novices in the brain's visual cortex.

Articles like Ross and Milton's give us a better understanding of how the brain functions, how it integrates stimuli, coordinates organs and limbs, develops and initiates movements. The neurosciences give us the opportunity to study and understand the neuronal events necessary for physical activity. This can be used in many concerns, from blocking the athlete's awareness of pain and thereby reducing fatigue associated behaviour (see Craig 2006), or how exercise affect emotions (see Panteleimon and Acevado 2006), to an

explanation of why psychosomatic illnesses might be altered through physical exercise (see Meeusen 2006). In this respect the neurosciences change everything on how we understand the lower level workings of the brain. But when it comes to the complexity of phenomena like sport itself or the athlete's subjective experience of sport, all this doesn't change a thing. I have argued that one of the reasons why this is so is that the neurosciences assume some form of functionalism, computationalism or identity theory, all notoriously infamous for not explaining phenomenal consciousness. Focusing on computational and/or neural mechanisms will not capture phenomenal consciousness, simply because those levels of description were never meant to.³⁵ That is why brain imaging is not mind-imaging.

Gap junctions in the postsynaptic neuron

A final comment must be given on the key assumption shared by neuroscientists, namely that human cognition in general and consciousness in particular is describable by neuronal structure and organization.³⁶ This is actually quite puzzling. It seems that the neurosciences undermine their own project of defining human cognition and abilities through neurons by insisting on how they must develop through the whole body's relationship with the external world. If neuronal development is so heavily dependent on the body's interaction with the world, how then can everything reside in the brain alone? One might argue that the neurosciences may study the possession of conscious life and skills, but maybe not the acquisition since that depends on lots of external factors. But, the science itself explains the modularity and change of internal neural networks and synaptic connectivity. That means studying skills in the head might leave us with just coarse grained explanations and predictions. On the one hand, the neurosciences demonstratively show us the importance of the body. On the other, they dismiss the role of the body and world when it comes to consciousness, concentrating only on neurons. Since the neurosciences naturally deal with

neurons, that is fine. But when dealing with consciousness, it is not. If phenomenal consciousness is a part of sport, and I have argued that it is, the neurosciences cannot give a complete account of sport performance either. If so, seeing all brain events during performance will leave us with questionmarks. Still the importance of the brain must not be underestimated by sport scientists. Describing sport cannot be done by muscular or skeletal analysis alone. No surprise there. The surprise comes from the study of tiny neurons: the tremendous role of the body in shaping not only neuronal networks in motor cortex and cerebellum, but our mental life as well. The body then, shapes both the mind and the brain.³⁷

In some ways, neuroscience really is the new loud. And I do believe that some discoveries concerning how the brain enables perception, memory, movement and mental imagery are relevant to sport science. These discoveries are not only relevant; they should even renew some theories of sport science. But when it comes to consciousness and subjective experience, I would rather speak in the tongue of hip hop group Public Enemy's Flavor Flav: don't believe the hype.

Notes

¹ I will use the term "neurosciences" in plural because the research is being done in a cluster of intertwining fields: neurobiology, neurophysiology, neuropsychology, molecular biology and genetics. The neurosciences are new in a historic sense; and loud when it comes to impact

² EEG provides a continuous recording of overall brain activity through electrodes placed on the scalp, which measures large, active populations of neurons producing electric potentials. Single cell recording measures change in the response rate of an isolated cell. This is achieved through inserting a thin electrode into the brain. Both PET and fMRI measure changes in metabolism or blood flow in the active brain. Normally, a PET scanner determines the brain's local need for oxygen by injecting water with radioactive oxygen into a subject. With fMRI, imaging is focused on the magnetic properties of haemoglobin. The fMRI detectors measure the ratio of oxygenated to deoxygenated haemoglobin – called the blood oxygenation level dependent effect (BOLD). For a more extensive treatment of the methods of (cognitive) neuroscience, see Gazzaniga (2002, ch. 4).

³ 1 repetition-maximum indicates maximum strength; V o₂ max (maximal oxygen uptake) indicates aerobic capacity.

⁴ Breivik tries to integrate fundamental questions about the body's dealing with the environment, bodily intentionality, the positioning of the body in the vertical (and horizontal) field, and proprioceptive awareness. These questions relate to the neurosciences, e.g. to the neurophysiological system of proprioception.

⁵ For a more thorough treatment of consciousness and the explanatory gap in sport, see Birch (2009).

⁶ See Birch (2009), Chalmers (1996), Levine (2001) and Nagel (2006).

⁷ The expression “explanatory gap” is usually associated with Joseph Levine (2001, ch. 3). It describes the problem of reducing subjective experience (the phenomenal consciousness of a first person perspective) to objective language of science (a third person perspective) without losing something along the way.

⁸ Keil et al (2000) argues for the impact of neuroscience and particularly Edelman’s views for sport psychology.

⁹ A related critique from the philosophy of sport comes from Moe (2005).

¹⁰ The discovery of mirror neurons (see Rizzolatti and Sinigaglia 2008) may have tremendous impact on sport science, but is not the issue in this article.

¹¹ For a short treatment of identity theories, see Rosenthal (1994).

¹² Even Jeannerod (1999) has accepted that imagery and activity are not identical brain events. Although not the topic here, visualizing and neuroscience should certainly be a hot topic for sport scientists. Among interesting findings, see e.g. Lacourse et al. (2005) and Rodriguez et al. (2008).

¹³ See Birch (2009) for a critique of identity between brain states and skills.

¹⁴ To review the myriad of different views and theories in the field is far beyond the scope of this article. I believe it suffices to make a distinction between identity theory and functionalism. Short and simple, it might be said that all information processing theories are functionalistic at bottom, but not all functionalists hold an information processing theory. James Gibson (1979) might be said to be an example of the latter.

¹⁵ For a more radical view on automaticity and consciousness, see Bargh and Chartrand (1999).

¹⁶ Milton, Solodkin and Small also claim that we can take the golf results to account for other kinds of fast-ball sports (2008, 49).

¹⁷ Of course, it is likely experts still have more restricted activation than novices in novel situations. The claim is that it is not always preferable to have as little and narrow activation as possible.

¹⁸ Jean Pierre Changeux (1997; 2004) shares several of Edelman’s views. Consciousness is, according to Changeux, a regulatory system, and to examine consciousness is to examine “its different states and identify the mechanisms that guide the change from one state to another” (1997, 145). Changeux describes the regulatory system as an evaluative mechanism for the surveillance of linking mental objects. The brain and the central nervous system then, are also *sufficient* conditions: “From the interplay of these linked regulatory systems, consciousness is born” (1997, 158). These linked regulatory systems are neuronal groups in the reticular formation, “piloting” information to cortical areas, and receiving information as to what is being performed through re-entries in loops. To explain consciousness is to explain these regulatory systems through neurons and mechanisms between them.

Changeux also emphasizes subjectivity and qualia (2004, pp. xii-xiii). Changeux believes the key to understanding subjective experience is the biological matter and organization of the brain (2004, 9). Changeux opens for individual variation due to environmental adaption, epigenesis - neural Darwinism in Edelman’s words. Still, he claims that qualia are not necessarily inaccessible to scientific investigation. Even though experiencing qualia is different to every person, Changeux believes that a person’s experience of, say red, is constant and this implies constant neuronal states (2004, 74). If so, then subjective oral information can be correlated with brain states. It is a somewhat strange position to hold this identification of brain states and oral exclamation alongside the individual epigenesis. It seems that Changeux believes that questions of subjective experience can be answered if the underlying neural states of qualia can be identified. When this is done, there isn’t more to be said about subjective experience. This neural state is the subjective dimension of consciousness. This certainly sounds like a strong form of identity theory, and is in empirical controversy with the claims Changeux also makes: if each individual brain differs due to environmental inputs, the same type of physical event just cannot be the same type of mental event.

¹⁹ Changeux states the possibility that brain hemispheres are equal at conception, but then develop different structures and functions due to stimuli (1997, 241).

²⁰ Information processing theories use computer models as a base for their claims. In this respect they are functionalistic accounts, philosophically speaking. In functionalism it makes no difference if the computer’s (or brain’s) functions are generated through electrical, mechanical or chemical mechanisms. To review the enormous amount of such approaches goes far beyond the scope of this article, but some major contributions include Honeybourne (2006); Piek (1998, part II); Schmidt and Lee (1999); Williams and Hodges (2005, part I).

²¹ Edelman’s critique of information processing theories is much more fundamental. Milton et al simply acknowledge that the brain’s capacity is too limited to work in such a way.

²² For a brief discussion of qualia, see Block (1994). Birch (2009) discusses qualia in relation to sport.

²³ Anotonio Damasio (1994; 1999; 2003) claims that *feelings* must be understood if we want to understand consciousness. Damasio thus puts forth an account of consciousness as constituted by the neurophysiology of feelings.

Damasio’s theory says all creatures with a central nervous system have some kind of homeostasis, the regulative and life preserving mechanisms. To secure an effective homeostasis one needs a continuously updated picture of the creature’s status. Most of this is done automatically and non-consciously in the lower-laying

regions of the brain: the thalamus, hypothalamus and epithalamus. Damasio's account is in opposition to Milton et al's (2007) on this point. The evaluation of body status with some response, Damasio labels emotions. Feelings are the knowledge of these emotions (Damasio 2003, 92). The life preserving benefit is that feelings can overrun otherwise automatic responses and we get a more flexible, adaptable creature with choice. Damasio claims that the brain forms maps of what goes on in the body; this is the internal relation of brain-body. He calls this the somatic marker hypothesis (Damasio 1994, ch. 8). An emotion is a significant difference in such a map, such that some sort of response is necessary to preserve life in a fitting way. A feeling is the knowledge of such a change, and the choice of how to deal with it. Damasio gives us a neuroscientific theory to how a sense of self is developed and how this makes interaction with others possible (see also Whitehead 2007). Consciousness is the conscious feeling of a change in body states that arises to neo-cortex, and a complex and effective life preserving mechanism for novel and changing environment (Damasio 2003, pp. 207-208), just like those we experience in sport performance.

In philosophical terms I believe Damasio's theory is a kind of representational theory of mind. The standard claim is that consciousness is the higher-order representation of some lower-level state. I hope the link to Damasio theory where feelings are the higher-order knowledge of a lower level emotion is quite clear (see Damasio 2003, 87, 194). Damasio claims that a somatic marked emotion becomes conscious when accompanied by a thought. His theory is similar to Rosenthal's (2005) in this respect, but the somatic marker also resembles Lycan's (1997) "monitor-theory". A problem that faces representational theories, and Damasio's, is the question of what makes the higher-order state conscious: it is not enough to say it represents the lower-level. Damasio might have enlightened our views on what feelings *do*, but not how they *feel*. He has not enriched philosophy when it comes to the hard problem of phenomenal consciousness.

²⁴ The same view is shared by Edelman's long time collaborator Giulio Tononi (2001, 298).

²⁵ Edelman claims consciousness is the process of selectional reentrant of groups of neurons in cortical areas (see Edelman 2006, ch. 3-4).

²⁶ I will not deal with bridge law reduction. As Kim explains (2005, pp. 98-101), it is not appropriate in mind-body relations.

²⁷ Or to quote Pasko Rakic: "Although many have speculated whether the reductionist approaches of developmental neurobiology could ever be harmonized with the largely integrative approaches of cognitive neuroscience, it now appears as though that time is coming." (Gazzaniga 2004, 3)

²⁸ Block and Stalnaker (1999) and McLaughlin (2001) build their theories on Crick's 40 Hz hypothesis (see Crick 1994).

²⁹ For an excellent overview of objections to functionalism, see Levin (2004).

³⁰ For an argument, see Birch (2009).

³¹ There are exceptions, especially from phenomenological psychology. See e.g. Thompson (2007)

³² This subtitle is inspired by Greene and Cohen (2004).

³³ For a detailed discussion of Edelman's view on memory, see (Edelman and Tononi 2000, ch. 8-9).

³⁴ See Milton, Solodkin and Small (2008, pp. 53-54). It must be emphasized that congruent mirror neurons have only been found for hand movements, and to some degree, the mouth (see Gazzaniga 2002, 535).

³⁵ See Revonsuo (2000) for a more detailed critique of cognitive neuroscience.

³⁶ Again, perfectly stated by Rakic (see Gazzaniga 2004, 3).

³⁷ See Gallagher (2005).

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