THEORIA ET HISTORIA SCIENTIARUM, VOL. VII, N° 1
Ed. Nicolas Copernicus University 2003

Monica Meijsing

Phantoms and Movements, Or, Are We Really Just Our Brains?

What kind of entity is it that we,-human beings, really are? This question is explicitly ontological. I will not here be concerned with the epistemological question of how we can be sure of what we are.'

The classical Cartesian position in philosophy of mind states that we are essentially just our (non-material) minds. Against this position Gareth Evans (1982) has argued that we are just as much spatially extended, corporeal beings as mental beings. In his argument a crucial role is played by proprioception: it is proprioception that establishes us as, in contemporary parlance, embodied beings, embedded in the world. I call this argument the *argument from proprioception.* I will argue that mainstream philosophy of mind, though avowedly anti-Cartesian, is still standing very much in the Cartesian tradition. It is anti-Cartesian in that it is materialistic, and rejects the notion of a separate *mind.* But what is left as "the engine of reason, the seat of the soul" (Churchland, 1995) is *not* the material body, but the material brain. According to eliminativist philosophers Dennett and Churchland, but just as much, though less conspicuously, according to their adversaries McGinn, Nagel and Searle, we are really just disembodied brains. The "disembrained" body is left literally dangling, a wholly dispensable puppet on an arbitrarily long string. We might as well not have a body at all, for most purposes. The brain alone can do all that is required to make us human beings.

I will examine what is presupposed in this position of the all-powerful brain. I will argue that, though it might have been possible that we were essentially just brains if we had been completely passive beings, a brain on its own could

[1] Actually, it is the *sceptical* question I want to avoid. The ontological problem cannot be dealt with without going into some epistemological issues.

not have any intentions. In order to have all the sensations and intentions and thoughts that we have, we must have actually moved, actually been active. So we are not essentially just our brains; we are essentially active, self-moving bodies. Call this the *argument from movement.* I will discuss some empirical evidence that is relevant to this claim. Thus I will argue that the Evansian argument from proprioception is insufficient. It relies solely on (passive) proprioception whereas (active) self-movement is more important.

But then I will show that the phenomenon of phantom sensations poses a serious threat to the position that we are living bodies, and not brains. There actually is a wide variety of phantom phenomena. In most cases these are sensations of pain or proprioceptive sensations of posture or even movement. These cases underscore the insufficiency of the argument from proprioception: here are real people (as opposed to merely thought-experimental subjects) who have proprioceptive sensations of body parts that aren't there. One might argue that at least the missing body part once existed; that the phantom phenomena were the result of an amputation. And indeed most phantom patients are amputees. But there are also reports of phantom phenomena in congenital limb-deficient persons, and some of these persons can even move their phantom limb at will. So here are real people who have never had some limb, and in consequence have never actually moved it, yet who not only experience this limb in question, but who can intend to move it and consequently experience the intended movement. These cases undermine not only the argument from proprioception, but also the argument from movement, which states that actual movement is necessary for us in order to have the sensations and intentions and thoughts that we have, and that indeed these patients have.

My conclusion will be that, although most of the empirical evidence is in support of the argument from movement, some phantom cases are not. I will suggest that this might be due to the very fact that phantoms aren't real. Central brain processes may seem sufficient when there are only phantoms to control, but when it comes to real limbs they cannot function without the help of external or peripheral feedback from real movement. Nevertheless, in some phantom cases central processes seem to be sufficient at least for intentions to move and for the concomittant sensations. So it seems that no account of what we really are can accommodate all of the evidence. There is still much work to be done to develop a satisfactory conceptualisation of what we really are.

Minds without bodies: Descartes' argument

According to Descartes, we are really just our minds: "... to speak accurately I am not more than a thing which thinks, that is to say a mind or soul" (Descartes

1967/1641, Vol. 1. p. 151). From his *cogito ergo sum* it follows naturally that this thing that thinks and therefore exists is essentially a *thinking* thing. That it is *not more* than a thinking thing requires some further justification. At first Descartes simply states that:

> I considered myself as having a face, arms, and all that system of bones and flesh as seen in a corpse which I designated by the name of body. In addition to this I considered that I was nourished, that I walked, that I felt, and that I thought, and I referred all these actions to the soul (Ibid. p. 151).[2]

But then his method of systematic doubt begins to strip away: first the body, then animation, sensation and perception:

> ... if it is so that I have no body it is also true that I can neither walk nor take nourishment... one cannot feel without a body, and besides I have thought I perceived many things during sleep that I recognised in my waking moments as not having been experienced at all (Ibid., p. 151).

And finally sensation and perception are identified as modes of thinking:

> Let it be so; still it is at least quite certain that *it seems to me that* I see light, that I hear noise, and that I feel heat. That cannot be false; properly speaking it is what is in me called feeling; and used in this precise sense that is no other thing than thinking (Ibid., p. 153).

So now feeling is again an attribute of the mind, but in the "precise sense" of *seeming to feel,* or rather, *thinking that one feels.* The reason why all these rather heterogeneous functions *can* be identified as essentially the same is that these are all the goings-on that we are immediately acquainted with: "thought is a word that covers everything that exists in us in such a way that we are immediately conscious of it" (Descartes 1967/1641, Vol. 2. p. 52). With this assimiliation, sensation and perception are moved inwards, as it were; out of the body, into the mind. And though "one cannot feel without a body", one can perfectly well *think* that one feels without a body. The *res cogitans,* the thinking thing, is all that we are. We are really not more than that. The body, that spatially extended thing, *res extensa,* is not essentially a part of us.

It follows from this conclusion that the ascription of physical properties to ourselves is fallible. All we can ascribe to ourselves without error are thoughts and feelings - which, in their "precise sense," are also thoughts.

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[2] Note that already here the body is not really living, it is "as seen in a corpse".

The argument from proprioception: why we are bodily subjects of consciousness

In present-day philosophy of mind, it is thought that self-ascriptions of (at least some) mental or psychological properties are immune to error. Not in the Cartesian sense that they are absolutely incorrigible.[3] It is rather that a certain special sort of error is not possible, the so-called 'error through misidentification relative to the first person pronoun'.[4] It doesn't make sense to say, when worrying about my daughter: "Someone is worrying about my daughter's health right now, but is it I who am worrying?"

Gareth Evans has used this notion of immunity to error through misidentification in an anti-Cartesian argument, claiming that also the self-ascription of some physical properties is immune to such error:

> None of the following utterances appears to make sense when the first component expresses knowledge gained in the appropriate way: 'Someone's legs are crossed, but is it my legs that are crossed?'; 'Someone is hot and sticky, but is it I who is hot and sticky?'; 'Someone is being pushed but is it I who am being pushed?'. There just does not appear to be a gap between the subject's having information (or appearing to have information), in the appropriate way, that the property of being F is instantiated, and his having information (or appearing to have information) that *he* is F; for him to have, or appear to have, the information that the property is instantiated just is for it to appear to him that *he* is F (Evans, 1982, pp. 220-221).

Having the information 'in the appropriate way' means having gained it from proprioception. The self, the subject that makes these judgements, is at the same time the object of these self-ascriptions. It is not only a thinking thing, but the very thing that can have its legs crossed, or can be hot and sticky; not only a *res cogitans,* but at the same time a *res extensa,* an object extended in space. The self, to which the word T' refers, is not a Cartesian ego but a bodily subject of both mental and physical properties.

The content of proprioception is intrinsically spatial:[5] it is not, for instance, a pure, non-spatial sensation of pain that is somehow *inferred* to originate in the foot, it is a *pain-in-the-foot.* The spatial location is part of the feeling from the

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[3] According to Descartes they were: "Thought is a word that covers everything that exists in us in such a way that we are immediately conscious of it" (ibid., Vol. II, p. 52).

[4] See Shoemaker, 1968; Wittgenstein, 1958.

[5] See Brewer, 1995; Bermudez, 1998.

outset, and we have an immediate inclination to act towards that particular location. As Brewer says:

> ... the psychological subject is a spatially extended object. The ascribed [sensational] property is a property of the spatially extended body, but it is also essentially a property of the subject of consciousness itself. (Brewer, 1995, p. 303).

Let us call this anti-Cartesian argument the *argument from proprioception*-. through proprioception we are just as immediately acquainted with (some of) our physical properties as with (some of) our mental properties. We are spatially extended, *bodily* subjects of consciousness and not just minds. Cartesian dualism is replaced by a double aspect theory.

This argument from proprioception is phenomenologically much more convincing than the Cartesian position that *all* physical properties are somehow *not* immediately ours. But note that it is not truly an answer to the thoroughly sceptical part of the Cartesian reasoning. If the *precise sense* of feeling is thinking, we do not really have proprioception at all; we only think we have. In proprioception *it may seem to us* that we have some physical property. Proprioception is a mode of thinking because we are immediately acquainted with *it*, not with our physical properties.[6] One might object that, again phenomenologically, proprioception is not like thinking at all (not discursive, for instance). It is (often) a direct, unitary experience *of a physical property.* It is not an immediate consciousness *of proprioception.* But the Cartesian sceptic can retort: you can be mistaken as to what kind of experience it is. It is at this point that the sceptic becomes really unanswerable - and boring. So in the following I will ignore this sceptical kind of reasoning.

Brains without bodies: present-day materialist philosophy of mind

Cartesian dualism is outdated. Materialism is the reigning orthodoxy in present-day philosophy of mind. But though Cartesian *dualism* is rejected, many other aspects of a Cartesian concept of mind are still present, though often not in an explicit fonn *(See* Meijsing, 2001). Mainstream philosophy of mind can perhaps best be described as a truncated version of Cartesianism. Being beholden to a scientific worldview it has to do away with any kind of "mind stuff".[7] All that

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[6] I would like to thank Gerlof Verwey for drawing my intention to this point.

[7] See e.g. Dennett: "I declare my starting point to be the objective, materialistic, third-person world of the physical sciences" (1987, p. 5); or Bumyeat "... our task of starting from the existence of matter as physics and chemistry describe it and working up to the explanation of the secondary qualities on the one side and animal perceptual capacities on the other (1992, p. 22).

can exist is matter and matter is seen as mechanical. Thus the whole of nature is seen as a mechanism, including living organisms, including even us. And the task of philosophy of mind is to show how such a mechanical man could have, or seem to have, mental properties, could have feelings and thoughts.

The answer to that question is sought in the brain. The mechanical organism is split into a mechanical body and a mechanical brain, and the body is seen, for most purposes, as dispensable. All mental properties, and even wholesale behaviour, are ascribed to the brain, not to the organism as a whole.[8] So in a future, completed psychology or philosophy not only the mind will have disappeared, in some sense the body will have disappeared as well. Of course no one claims that the body does not exist. But it is hardly, if ever, mentioned, and it is deemed to play no role of any significance in the functioning of the human being. The brain is all that remains.[9]

Most of the spate of literature on consciousness of the last decade concentrates on the brain. Dennett claims to have explained consciousness:

> More precisely, I will explain the various phenomena that compose what we call consciousness, showing how they are all physical effects of the brain's activities (Dennett, 1991, p. 16).

Note that, right at the beginning of his enterprise, Dennett makes a shift from "consciousness" to "what we call consciousness," the latter being "more precise." Later on in the book, in his conversation with Otto, there is a similar shift:

> There is no such phenomenon as really seeming - over and above the phenomenon of judging in one way or another that something is the case ... But what about the *actual* phenomenology? There is no such thing (Ibid., p. 364-365).

This is strongly reminiscent of Descartes' substituting thinking for feeling, the former being the *precise sense* of feeling. In both cases feeling, experience, the actual phenomenology, is abolished.

Churchland sees the brain as *The Engine of Reason, the Seat of the Soul* (1995). Searle claims that "[mjental phenomena are caused by neurophysiological processes in the brain and are themselves features of the brain" (Searle, 1992, p. 1). Nagel, in his famous bat article, is more careful. He merely states that

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[8] Cf. Sheets-Johnstone's remark on "[t]he nonsensical, even comic, consequences of thinking [that it is brains that evolve in evolution] well exemplified by the biologist who affirmed that "Nonhuman primates have brains capable of cooperative hunting" (R.S.O. Harding, 1975), as if when summoned by hunger, it is brains that roll forth in concert to do battle on the savannah" (1992, p. 248).

[9] Cf. Sheets-Johnstone 1999, 404-406.

"mental states are states of the body; mental states are physical states" (Nagel, 1974, p. 446). But for all his emphasis on the *experience* of the organism, he *also* talks about "a Martian investigating my brain might be observing physical processes which were my mental processes" (Ibid., p. 444). And McGinn (1991) urges us to give up searching for the property P that accounts naturalistically for consciousness, never doubting that property P is a property of the brain.

All these philosophers hold different positions. Indeed, the discussions in mainstream philosophy of mind are mainly *between* these positions. But they all share the common presupposition that all mental states or processes or properties are states or processes or properties of the brain. They hardly ever mention the body, or when they do, like Nagel, they mean the brain. The rest of the body is completely insignificant. Though thoroughly material beings, we are still disembodied.

Why we are not brains in a vat; Dennett's argument and the argument from movement

Daniel Dennett is the clearest example of this ignoring of the body. In his story "Where am I" (1978) the brain is separated from the body and kept in a life-supporting fluid - the famous brain in a vat. The body is literally a puppet on a string, a string that can be arbitrarily stretched to any length. And when the string finally snaps, an arbitrarily different puppet can be attached to the brain, or even no puppet at all. Where we are is ultimately where the brain is. But, more importantly, *who* and *what* we are is just the brain. No more. In the absence of a body, perceptions and experiences can be fed directly into the brain by the scientists that tend its life-support system.

The first chapter of *Consciousness Explained* (1992) starts with a similar case:

> Suppose evil scientists removed your brain from your body while you slept, and set it up in a life-support system in a vat. Suppose they then set out to trick you into believing that you were not just a brain in a vat, but still up and about, engaging in a normally embodied round of activities in the real world (Dennett, 1991, p. 3).

All goes well as long as the scientists only feed the brain some sensations: of music, of warmth as of sunshine on the skin over the ventral side and graininess as of sand on the dorsal side. And the brain thinks: "Here I am, lying on my back on the beach, paralyzed and blind, listening to some rather nice music ..." (Ibid., p. 5). But as soon as they let the brain

> Wiggle [its] right index finger in the sand ... they are faced with a problem that will quickly get out of hand, for just how the sand will feel depends on just how you

> decide to move your finger. The problem of calculating the proper feedback, generating or composing it, and then presenting it to you in real time is going to be computationally intractable on even the fastest computer ... the evil scientists will be swamped by *combinatorial explosion* ...One conclusion we can draw from this is that we are not brains in vats ... in case you were worried (Ibid., pp. 5 and 7).

It is interesting to see on what grounds Dennett concludes that we are not brains in vats. It is because the fastest computers cannot calculate the feedback in real time. It is a *technical* problem. But note that a host of other, more *principled* problems aren't even addressed. The problem is stated as "how the *sand* will feel depends on just how you decide to move your finger" (Ibid., 5; my italics). There is no mention of the problem of how *the finger itself is* experienced following the decision to move it. Indeed there is no mention at all of how the *body* is experienced as lying in the sand, only how the sand and the sun are experienced. Not only is the actual body removed in this thought experiment; it is completely ignored in the description of the brain's experience. In the experiment there is only the virtual external reality - music, sun, sand - on the one hand and the brain on the other with nothing in between, not even a virtual body.[10] The whole notion of *proprioception* is never mentioned. For instance, the feeling of lying on your back in the sand doesn't consist solely in a grainy feeling on your dorsal side. That wouldn't account for the feeling of *lying.* Proprioception is needed, not only to specify the actual disposition of your limbs, but more generally the experience of orientation and gravity.

A second problem that is not addressed is the problem of how this brain can even think the simple self-reflexive thought, "Here I am, lying on my back on the beach ..." Presumably this is the *brain's* spontaneous thought; it does not belong to the stimulation of the scientists to feed it some sensations. But where do the very concepts come from, not only the concept of a beach, but of "lying on my back" and of "I"? Surely a naked brain has never had the opportunity to come by them. It has even been argued that all of our basic concepts - of agency, causality, space, self - are grounded in the primitive experience of our own body." Most philosophers opt for externalism these days: "meanings just ain't in the *head"* (Putnam, 1975, p. 227).[12] A brain on its own cannot have meaningful internal states.

[10] It thus looks like an extreme form of the "Input-Output Picture", which "confuses the subpersonal-ievel distinction between causal input and causal output with the personal-level distinction between perception and action." (Hurley, 1998, p. 3). Hurley defends "instead the view that the contents of perceptual experience and intentional action depend on a structure of causal flows that constitutes a complex dynamic feedback system" (ibid., p. 3).

[11] Cf. Stem, 1985; Johnson, 1987; Bermudez, 1998; Lakoff and Johnson, 1999.

[12] See Hurley, 1998 for an extended discussion on externalism, internalism and contextualism.

A final point that is taken for granted, but that is actually quite problematic, is that the brain could *decide* to move its (?) fingers. Call the intention to move your finger a basic intention (Hurley, 1998, p. 256). Basic intentions are intentions that you cannot act on by acting on another intention.

> You may intentionally (frighten off the burglar by turning the light on). And you may intentionally (flip the switch by moving your finger). But at some points your intentions run out: you do not intentionally (move your finger by moving a neuron), under normal conditions (Ibid., p. 357).

Now we can ask: how could this brain know *what* it was trying to do? How would it know what the content of its basic intention was? The more global intention to act might be clear, but the basic intention, the executive part of the plan, would be left completely open. It would be as if a general, intending to win the war, issued the order to use plan B, but wouldn't have the faintest idea what plan B amounted to.

The question is this: can we try to do something if we had never had any external feedback that we had succeeded in doing it? Take, for instance, biofeedback. You get the instruction to relax your frontal muscle, the large vertical muscle in the middle of your forehead. So your global intention is to do just that, but still you haven't the faintest idea what it is you are supposed to do. You may pull some faces or try to look as blank as possible, but even then you have no idea whether you have succeeded in what you were instructed to do. You know, from proprioception, that you have pulled those faces or looked blank. But you still don't know whether you have relaxed that particular muscle. Yet it is under voluntary control, because when the tone of that muscle is recorded with an electrode, and rendered visible as a signal on a screen, you can very quickly learn to reduce it, simply by reducing the amplitude of the signal. So now, with the help of this external feedback, you know what you were supposed to do. Linking the external feedback with the proprioceptive feedback you know: this is what I must do. It may be quite difficult to keep the exact nature of "this" in mind in the absence of the external feedback, but with training it gets easier.

Once you have felt, proprioceptively, what it is you are supposed to do, or rather, what it was you did when you succeeded, you know what your basic intention is. This fact is being used in physiotherapy, where the therapist moves the limb of a paralytic patient in order to give her the feel of the movement she is supposed to make. Our detailed intentions to move, our basic intentions, are, without external or peripheral feedback of success, not only futile, they are empty. The problem is not so much that we do not succeed; we do not know what we are trying to do. As the philosopher Carlos Moya puts it:

> ... trying to move follows the natural ability to move, and not vice versa. Someone who is paralytic from birth cannot try to move. He simply does not know how to try, because he lacks the ability to move (Moya, 1990, p. 27).[13]

If the foregoing is correct, it would imply that, if you had no real fingers, you simply couldn't try to move a finger that you never had, because you have never experienced an external criterion of success. Not only is it the case that conceptual meaning ain't in the head, basic intentions ain't in the head either. Real movements precede basic intentions.

So Dennett is right in saying that we are not brains in a vat. But he is right for the wrong reasons. It isn't just that the proper feedback is too difficult to calculate once the brain intends to move. The problem is that the passive brain cannot even feel itself lying on its (?) back without proprioception, it cannot think to itself without having (had) a moving body, it cannot intend to move without actually having moved. The very integrity of the thought experiment collapses when you examine it more closely.

Note that Dennett might argue that his ignoring proprioception was simply an oversight; that his scientists simply have to feed the brain these sensations as well. He would of course be hard put to claim that this would "be within the limits of technical virtuosity in the near future" (Dennett, 1991, p. 4). But technical problems apart, proprioception is not the principal obstacle to the view that we are just our brains. That is *movement.* Movement lies at the very origin of our existence, both phylogenetically and ontogenetically. It precedes both thinking and intending. Call this the *argument from movement',* we cannot have thoughts or intentions without being moving bodies. Because of this one might speak of *The Primacy of Movement.*

> It might be said that our present-day love affair with brain neurophysiology is leading us astray. It blinds us to the fact that in the most fundamental sense, we are living bodies and that where goeth living bodies, so also goeth minds, not in the sense of a twosome, but a onesome (Sheets-Johnstone, 1999, p. 406).

Phantom limbs and the argument from proprioception

The experiment of a brain in a vat is a *thought* experiment, and because of that it will always remain somewhat inconclusive. The brain-in-a-vatter can always say: "apart from the *technical* problems, the evil scientist can also feed the *memory*

[13] Cf. also Hurley, 1998, 272 ff.; Sheets-Johnstone, 1999.

and *experience* of actual movement to the brain, can feed it everything it needs in order to form concepts" - where "everything" would presumably mean the whole ontogenetic or even phylogenetic history of the brain in question. It is just *because* the technical and empirical problems are *ignored*, that such thought experiments are ever thought to be convincing.

So let us now look at some actual empirical data. It is here that the argument from proprioception is immediately seen to fail. For consider the phenomenon of phantom limbs. Though physical self-ascriptions are immune to error through misidentification, phantom limb studies bring out that the very spatiality of their content is not immune to error. After losing a limb or other body part, subjects often report that it feels as if the missing part is still present. This phenomenon was first described in 1551 by the French physician Ambroise Pare, and termed 'phantom limb' by the American war-surgeon S. Weir Mitchell in 1871 (Lott, 1986, p. 244n3).

Phantom limbs have traditionally been associated with pain, but apart from painful phantom limbs there are also non-painful phantom limbs (Melzack and Wall, 1998). Non-painful phantom limbs are felt as tingling or numb, as heavy, as hot or cold or as swollen or tight. But sometimes they are simply felt as being there, having a certain position or posture or as even moving.

There are many individual differences in the experience of phantom limbs, and also within individuals there is a variety of phenomena. Phantoms are very seldom experienced as just continuously there. This is unlike normal limbs, of which you also are not continuously aware, but which are nevertheless always "there." Katz gives a list of excerpts from interviews with amputees, showing "how dynamic and fluid the phantom limb experience can be, consisting of frequently changing perceptual experiences that depend upon current sensory input, the emotional state and past experience of the individual amputee" (Katz, 2000, p. 46).

The limb in question does not have to be actually missing: recent studies show that a temporary de-afferentation by local anaesthesia regularly produces non-painful phantom sensations (Dirksen et al., 2000).

Many of the subjects with phantom limbs can move them at will, for instance in trying to take hold of something. Ramachandran and Blakeslee mention a case of someone who reached with his phantom arm for a cup. When the cup was pulled away, he cried out in pain, because his phantom fingers had just taken hold of the cup handle (Ramachandran and Blakeslee, 1998, p. 64).

Descartes already knew about phantom limbs and used the phenomenon in his argument for the self as *res cogitans.* He says:

> [I]n an infinitude of other cases I found error in judgements founded on the external senses. And not only in those founded on the external senses, but even in those

> founded on the internal as well; for is there anything more intimate or more internal than pain? And yet I have learned from some persons whose arms or legs have been cut off, that they sometimes seemed to feel pain in the part which had been amputated, which made me think that I could not be quite certain that it was a certain member which pained me, even although I felt pain in it (Descartes 1967/1641, Vol. 1., p. 189).

The content of proprioception is intrinsically spatial, but as this very spatiality can be wrong, there is no guarantee for the spatiality of the self to which this content is ascribed. So it seems as if we cannot use proprioception in an argument against Descartes after all. There is *empirical* evidence that undermines the argument.

Descartes gives a neurophysiological explanation of the case of a girl with a phantom arm:

> She had various pains, sometimes in one of the fingers of the hand which was cut off, and sometimes in another. This could clearly only happen because the nerves which previously had been carried all the way from the brain to the hand, and afterwards terminated in the ann near the elbow, were there affected in the same way as it was their function to be stimulated for the purpose of impressing on the mind residing in the brain the sensation of pain in this and that finger (Descartes 1967/1641, Vol. 1,, pp. 293-294).

This is known as the bell-rope account. When a certain bell rings on the bell-board in the butler's pantry, it is a sign that someone rang in the library. But that same bell will ring when the connecting rope is pulled anywhere on its way from the library to the pantry. So a prankster could fool the butler into thinking that he is wanted in the library, by pulling the rope somewhere else.

This account of phantom phenomena is still very influential today.[14] It is also exactly the kind of theory that leaves room for the idea that we are really just our brains. If it is the function of the afferent nerves to cause the brain to impress on the mind the sensation of pain in the finger, *no matter where that nerve terminates on the peripheral end*, that nerve itself can be arbitrarily short. And if there is "a certain movement [of the brain] which nature has established in order to cause the mind to be affected by a sensation of pain represented as

[14] See Ramachandran & Hirstein, 1998, who call it the textbook account of phantom phenomena; see also Katz, 2000. Descartes didn't make the distinction between efferent and afferent nerves; he thought that there was only one kind of nerve. In fact there are two: afferent nerves lead from the periphery *to* the brain and efferent nerves lead *out of the* brain to the periphery. It is clearly the afferent nerves (and not the efferent nerves, which come from the brain) that are stimulated. Modern theories often mention the stimulating of neuroma in the stump of the amputated limb as the cause of phantom phenomena.

existing in the [finger]" (Descartes 1967/1641, Vol. 1., p. 197), then this movement alone is enough for the experience of pain in the finger. This idea of specific movements of the brain can be seen as the forerunner of the notion of a cortical map of the body. If the afferent nerves are stimulated at the point where they enter the brain, or if the cortical map is directly stimulated, the brain will just go on thinking it has a pain in the finger. That is, we might not be bodily entities (in the old-Cartesian sense), or we might not be more than just brains (in the neo-Cartesian sense). Proprioception might not be a property of the body, but only of the brain.

The sense of ownership of phantom limbs

Of course phantom patients *know* perfectly well that they do not have real limbs. But what if they had been blind as well? Now they have the visual information that the limb isn't there, but what if that visual feedback were missing - or manipulated?

There is a scientist - though by no means an evil one - who has tried to manipulate the visual feedback of phantom limb patients, and the results are amazing. V.S. Ramachandran has put patients with one real arm and one phantom arm in front of a specially constructed mirror. Thus he gave them the visual feedback that they had two real arms. When given the instruction to move both arms symmetrically, they *saw* two arms move symmetrically: the real arm and the mirror image of the real arm. But they also *felt* both their arms move symmetrically: the real arm and the phantom arm. The visual feedback overruled their normal feeling that the phantom arm didn't move, couldn't move. But as soon as they closed their eyes, the felt movement stopped (Ramachandran and Blakeslee, 1998, pp. 68-71).

It is not quite clear whether these patients just felt their arm move, or whether they felt that they themselves moved it. If they relied only on the visual feedback, it would be no more than a *documentation* of the movement. Of course the same thing goes for people who rely on genuine proprioceptive feedback: here too the feedback amounts to a documentation of movement. Proprioceptive feedback accounts for a sense of ownership: I feel *my* arm move. Obviously, something more is needed for a sense of agency, for: "I feel that *I move* my arm".[15] *Afferent*

[15] Cf. Gallagher, 2000, who develops a model to account for the fact that in schizophrenia, the senses of ownership and of agency come apart. Schizophrenics sometimes suffer from thought insertion, where they experience their thoughts as their own in the sense of ownership, yet as alien because they do not consider themselves to be the agents of these thoughts, the instigators or origins.

signals do not suffice. Strangely enough, a causally efficacious *efferent* signal does not suffice either. Neuroscientist Wilder Penfield describes the reactions of his anaesthetised patients under brain stimulation:

> When I have caused a conscious patient to move his hand by applying an electrode to the motor cortex of one hemisphere, I have often asked him about it. Invariably his response was: "I didn't do that. You did". When I caused him to vocalize, he said: "I didn't make that sound. You pulled it out of me" (Penfield, 1975, p. 76).

Here both afferent (proprioceptive) and efferent signals are present. The patient feels his hand move, has a sense of ownership, but not of agency. Proprioception accounts for the sense of ownership of movement, but it is not yet quite clear what does account for the sense of agency.

One might claim that, when grounded in genuine proprioceptive feedback, the sense of ownership is immune to error - this in contrast with visual feedback, which can generate all kinds of error as to *whose* arm is moving. There is no question that it is *my* arm that moves in the genuine proprioception case. But the subjects in Ramachandran's experiments not only *thought* or *inferred* that their arm moved, they really *felt* it move. Moreover, there are also cases of experienced or felt movement of phantom limbs *without* visual feedback. On the contrary, visual feedback indicates in these cases that there is no limb, hence no movement. And in these cases there is no other peripheral feedback, as again there is no limb, hence no periphery. Can one even speak of proprioceptive feedback from a limb if the limb in question doesn't exist?

In these cases the sense of ownership does not seem to be grounded in proprioception, but must be accounted for by a more central process, a brain process. So not only is proprioception no guarantee for the spatiality of the body, it is also not necessary for a sense of ownership of a body. One can sometimes experience at least parts of the body, and experience them as one's own, without the existence of those body parts, hence without the existence of proprioception from those parts.

Phantom limbs and the argument from movement

At first sight phantom phenomena seem to point less unambiguously in the direction of the claim that we are just our brains when one considers their *history*. The nature and quality of phantom phenomena are often correlated with the situation of the limb in question at the time of amputation or loss. Phantoms are more vivid, and persist longer, after traumatic limb loss, or following amputation of a previously very painful limb, than after a planned surgical amputation of

a non-painfi.il limb (Katz and Melzack, 1990; Ramachandran and Hirstein, 1998).[16] Indeed the phantom limb often occupies a habitual posture, the one it had just prior to amputation.[17] Even much more detailed memories are retained in the phantom limb: patients sometimes continue to feel a wedding ring or a watchband on the phantom (Ramachandran and Hirstein, 1998). Ramachandran and Hirstein also describe the following case:

> ... one of our patients reported that, before amputation, the arthritic joint pains in her fingers would often flare up when the weather was damp and cold. Remarkably, whenever the air became humid the same pains would recur in her phantom fingers. Also, when her hand went into a clenching spasm in the evening, the thumb was usually ... 'sticking out' ...but on the occasions when it was flexed into the palm, the spasm was accompanied by the distinct feeling of her thumbnail digging into the pad of the fifth digit. The curious implication of this observation is that even fleeting sensory associations may be permanently recorded in the brain (Ibid., p. 1607).

In the light of these findings it looks as if phantom phenomena are a question of *memory traces',* after amputation there is no limb and accordingly no proprioception from that limb. But memory traces of the situation just prior to the amputation linger on, no longer contradicted or damped by fresh proprioceptive feedback. This would account for the fact that a phantom limb so often stays frozen in its habitual posture, haunted by its remembered pain.

That would mean that real proprioception from a real limb has to precede the experience of phantom limbs, otherwise there would not *he* any *memory traces.* So phantom limbs cannot support the view that we are really just our brains after all. The argument from proprioception doesn't do too badly. Now let us see how the argument from movement fares.

Phantom limbs aren't always immobile. Ramachandran's patients in the mirror experiment were tricked into experiencing movement. But many patients experience involuntary movements spontaneously. And indeed quite a few patients claim that they can move their phantom limbs at will. They experience sensations of reaching out to grab something or of moving their fingers voluntarily. They need neither visual feedback, nor any feedback from proprioception in the periphery - they have no periphery. The sensation of movement must therefore arise centrally, probably through what is called efference copying. When a motor command is sent from the motor cortex to the muscles in the periphery, a copy

[16] Katz (2000, p. 79) urges to use both spinal and general anaesthesia before amputation, in order to block both somatosensory and cognitive memories and thus to prevent or diminish post- amputational phantom pain, which can otherwise be extremely persistent.

[17] Or anaesthesia: see Dirksen, et al. 2000. See also Katz and Melzack, 1990.

of this command is sent to the cerebellum and to the parietal lobe of the cortex, telling the brain, as it were: "This is what the body is doing." Phenomenally, the effect of this may be that the intended movement is felt even in the absence of proprioceptive feedback. Even if there is no body to follow the motor command, the brain may still think that the body has done what it was commanded to do. It is as if an overconfident general was sure that his commands were obeyed as soon as they were given without checking on the field, because the commands were filed in his office. Efference copying is one way in which the body schema is updated. But normally there is also a peripheral check (proprioception) and often an external check (visual feedback) that the intended movements were indeed performed.'[8]

These patients have both a sense of ownership and a sense of agency of their movement. Both of these senses must be accounted for by central processes, as they currently do not have any peripheral or external feedback of movement, or indeed a real moving limb. So the sense of ownership has to arise centrally in these cases, as a result of efference copying. And the sense of agency *must* arise centrally, as a result of at least the original efferent command. However, according to the argument from movement, the *content* of the efferent command, or, more precisely, of the basic intention, can only have originated in real movement. These patients miss a limb now, but in the past they still had it and could move it. There must have been a history of real movement to account for the very possibility of basic intentions. This history can also account for the memory traces of the detailed interplay of efferent commands and sensory experiences: the patients not only *intend* to move their phantoms and *experience* them moving, they experience the very movement they intended.

In order to move voluntarily, or even have a basic intention to move, you need external or peripheral feedback of success. Real movement came first. It looks as though even these phantom phenomena do not support the view that we are just our brains. The basic intentions to move and the experiences of movement of these patients must have originated in real movement. The extreme importance of pre-amputation and peri-amputation history for phantom phenomena seems to point in that direction.

So despite the occurrence of phantom phenomena, we can still stick to the argument that real movement precedes basic intentions to move,[19] hence to the notion that we are *not* really just our brain, but living, moving *bodies.*

[18] See Ramachandran and Blakeslee, 1998, 66-67.

[19] And presumably the experience of movement as well.

Further evidence

It would have been nice to end my story here, on a satisfying, unambiguous conclusion. But things are more complicated. Phantom phenomena are not restricted to amputees.

Memory does play a crucial role in phantom phenomena. And indeed the older literature states that children bom without limbs do not experience phantom limbs. Prolonged sensory input from a limb was held to be necessary for the formation of the cortical representation of the limb, which is presumed to underlie the body schema and the experience of the phantom (Simmel, 1958). Also children with amputations before the age of five were thought not to experience phantoms (see Lott, 1986). But such complacency is no longer possible. Weinstein and Sersen (1961) mentioned cases of phantom limbs in subjects with congenitally absent limbs and more cases have been reported since.[20]

These findings have been ignored or criticised for some time because children were supposed to be highly suggestible and therefore unreliable subjects (e.g., Skoyles, 1990). But Saadah and Melzack (1994) present four cases of adults with congenital limb deficiencies. Three of them felt phantoms for the first time as adults. The authors conclude that:

> ... despite the neural changes that are known to occur after deafferentation, a portion of the neural representation of the body in the brain persists into adulthood - even in those who are congenitally limb-deficient - to permit a phantom limb to be experienced (Saadah and Melzack, 1994, p. 480).

To make matters even more complicated, some of these congenital limb-deficient patients can move their phantoms at will. Weinstein, Sersen and Vetter (1964) report that 7 of their 13 subjects with congenitally missing limbs were able to voluntarily move their phantom. One might suggest that in these cases there was only one limb missing and the experienced movement was a crossover effect of the experience of real movements of the corresponding real limb. However, Poeck (1964) describes the case of an 11-year old girl who was bom with congenital absence of *both* forearms and hands. She reported distinct phantom hands. She was able to move her fingers and, like other children her age, she used her fingers to solve arithmetic problems. Also Ramachandran and

[20] Weinstein, Sersen and Vetter, 1964; Saadah and Melzack, 1994; Ramachandran and Blakeslee, 1998; Wilkins et al,, 1998.

Hirstein (1998) mention a young woman with congenitally missing arms who could move her phantoms in waving and gesticulating. They suggest that:

> ... these vivid sensations arise from the monitoring of reafference signals derived from the motor commands sent to the phantom during gesticulation. What is remarkable, however, is that the neural circuitry generating these gesticulatory movements is 'hardwired' and has actually survived in tact-for 20 years in the absence of any direct visual or kinesthetic reinforcement from her own limbs (although watching other people's limbs might have played a role) (Ibid., p. 1606).

These cases form a direct threat to the argument from movement. Of course, one has to be somewhat wary of these reports. In the first place, the evidence is still very much anecdotal. It is only in a small proportion of congenital limb-deficient patients that phantom phenomena occur at all: Weinstein and Sersen (1961) mention and incidence of 19% of phantom phenomena in this group, Melzack et al. (1997) 12% and Wilkins et al. report phantoms in 7.4% of their congenital subjects. And of these small groups it is only an extremely small proportion that can move their phantom at will. There are perhaps no more than some ten cases documented.

And what exactly does it mean to say that a person can move a limb that she has never had in the first place? What kind of experience is this experience of movement? Surely the experience of a phantom is itself an illusion. Can the experience of the movement of the phantom be an illusion of an illusion - the phantom is "really" experienced but its movement is an illusory movement? Also there are large individual differences in the vividness of imagination. What exactly is the status of a moving phantom limb? Is it imaginary or somehow perceptual, is it experienced proprioceptively? Gallagher et al. mention in this connection the phenomenon of "forgetting":

> In some cases of phantom limb following amputation, subjects appear to be unaware that a limb is missing and, for example, try to walk on a missing leg.... The phenomenon of forgetting suggests that the missing limb continues to function as part of a motor schema. Significantly, however, although incidents of forgetting are frequently reported following amputation, no incidents of forgetting have been reported in subjects with aplasic [congenital] phantoms (Gallagher et al., 1998, p. 55).

However that may be, it will not do to ignore these cases or not to take them seriously. Gallagher et al. (1998) claim that, despite the inconclusiveness of much of the data on congenital phantoms, they must be explained by the existence of specific neural circuitry associated with innate motor schemas, such as schemas for hand-mouth coordination. Even if the experience of the phantom itself is accounted for by the efference copies (or reafference signals) of the motor commands, the motor commands themselves are 'hardwired' in the brain *without any prior real movement of real limbs.*

The notion of ready-made, 'hardwired' motor schemas or programs is losing popularity with the emergence of dynamic systems theory.[21] Motor commands are monitored 'online' and in real time, so to speak, in the continuous interplay between efference from the motor cortex, afference from the limbs themselves, and feedback from the wider environment. But, if there are any innate motor schemas, it is plausible that they are schemas for such very crucial and primitive movements as hand-mouth coordination. In these schemas hand and mouth are represented, regardless of the existence of real hands.

There is also evidence that gesticulation is a very primitive kind of movement, both ontogenetically and phylogenetically.[22] It seems that in some congenital limb-deficient patients there are still some innate motor schemas for gesticulation. However, when it comes to counting on one's fingers, are we really to believe that we have innate motor schemas for that? At least here it seems much more plausible that the little girl has seen other children use their fingers, and imagines using her own.

To sum up: it is undeniable that there are topological neural representations of the body in the brain - in fact more than one.[23] And, despite the criticisms from dynamic systems theory, there may very well be innate motor schemas in the brain. This in itself does not give support to the claim that we *are* just our brains, or that the brain can function on its own. But if those representations and motor schemas can function *in the absence* of real limbs and real movement, then that fact would support the claim that we are essentially just our brains. And though in most cases real limbs and real movements *are* necessary, even in cases of phantoms or of deafferentation, in some cases they are not necessary. There are real cases (as opposed to thought-experimental ones) where innate neural representations and motor schemas are functioning to produce basic intentions and experiences of movement, even when there never were real limbs or real movements. The argument from movement is now in real trouble.

But what does the functioning of innate representations and motor schemas really amount to? When there are no real limbs, they work well enough. Phantom limbs are intended to move and subsequently they are experienced to make exactly the intended movement. Basic intentions are in place without any real movements. But when there are real limbs, central processes cannot function so easily. In that case real movement *precedes* basic intentions, and not the other way around.

Infants look at their moving hands for hours on end. The hands seem to move of their own accord before the infants learn to actively move them.

[21] See e.g. Hasan and Stuart, 1988; Butterworth, 1993; Thelen and Smith, 1994.
[22] See e.g. Armstrong et al., 1995; McNeill, 1995, 2000.
[23] See Ramachandran and Blakeslee, 1998.

Gradually they learn the dynamic interplay of visual and proprioceptive feedback, and so their basic intentions to move take shape. In the words of Maxine Sheets-Johnstone:

> We were apprentices of our own bodies ... We learned our possibilities by moving and having moved - by catching ourselves in the kinetic act, so to speak. (Sheets- Johnstone, 1999, p. 225).

In normal infants moving the fingers separately, for instance, has to be *learned.* And to most people learning to play a musical instrument does not come easily: again the controlled movement of each finger separately has to be *learned.* We still learn new basic intentions as adults, but not without external help, external feedback. When we have to move real limbs, the brain alone is unable to do the job.

Once having mastered our basic intentions, we can usually rely on proprioception - we very seldom have to *look* anymore. But without proprioception we are utterly lost. I.W., a deafferented subject who has lost all proprioception from the neck downwards following an illness, has to use visual feedback in order to make voluntary movements. In the dark he is completely helpless, though not paralysed (Cole, 1995; Cole and Paillard, 1995).[24] The central process of efference copying is hardly of any use to him. Neither can he rely on motor schemas that were previously established - whether innate or learned. His brain cannot function without the help of peripheral feedback.

At first, just after his illness, he felt alienated from his own - moving! - body. He had to learn to move *himself* all over again (Gallagher and Cole, 1995). He had to repossess his own body, to regain his sense of ownership. His sense of ownership is completely dependent on his sense of agency, his sense that once more he himself is the origin and controller of his own movements. But he needs constant external feedback in order to know exactly what to do, what muscles to contract with what strength. His basic intentions must, by necessity, be much more detailed than those of ordinary people.[25]

Whereas normal people first need visual feedback, and afterwards still constant proprioceptive feedback, and deafferented people cannot do without

[24] See also Meijsing, 2000.

[25] I.W. realises the importance of making gestures in communication. He claims that he had to consciously relearn them. Yet it is remarkable that now he is able to make normal gestures while telling a story, even *without being able to see his hands*, though after a while he loses track of his hands and the gestures deteriorate, first topokinetically and then, as a result, morphokinetically (Cole et al. 1998; Cole, Gallagher and McNeill, in press). Apparently gestures, being much more a linguistic phenomenon than an instrumental movement, depend less on visual feedback than his other movements. I.W.'s linguistic abilities were in no way influenced by his illness.

visual feedback, some phantom patients can use their phantom limbs without any external or proprioceptive feedback. They can intend to move their limbs and subsequently experience the intended movement. Why do central processes suffice for these patients, whereas for normal people, and for patients like I.W. and G.L., they do not?

Perhaps the crucial difference is that the motor commands of phantom patients are not going anywhere, they're not going to real limbs.[26] In order to account for the phenomenon that some congenital limb deficient subjects can move their phantoms at will, we have to presuppose the existence of innate motor schemas. But they cannot be very powerful. When there are real limbs to control, these schemas have much to learn from feedback - in fact they need constant feedback of one kind or another. In the absence of any feedback whatsoever, when there are no real limbs, the efferent motor commands, and the efferent copy, aren't dampened in any way. They may give the patient the experience of moving a limb. Central processes are sufficient for *unreal* movement, but they are quite insufficient for *real* movement.

Conclusion

Present-day mainstream philosophy of mind is in a sense Cartesian, namely in the sense that it all but ignores the body. Instead of concentrating on the disembodied mind it concentrates on the brain. The brain is material, to be sure, but it is considered on its own, as a disembodied brain, rather than as a part of a living body. We, human beings, are considered as really no more than our brains.

I have tried to show that this is a wrong conceptualisation of ourselves. Both conceptual analysis and empirical evidence indicate that the brain simply cannot function if it isn't part of a living body.[27] Real limbs and especially real movements are necessary for the functioning of the brain, for our thoughts, feelings and intentions.

Unfortunately, not all of the empirical evidence points in the same direction. Some phantom phenomena in congenital limb-deficient patients drive us back towards the claim that we are essentially just our brains. Both neural representations of the body and innate motor schemas function in these patients although they never had the limbs in question, and never made the actual movements. It seems that, though in the majority of cases real limbs and real bodies are necessary, in some cases just the brain will do for proprioceptive

[26] I would like to thank Ton Derksen for making this suggestion.
[27] Cf. Damasio, 1994, 1999.

experience, basic intentions and the feeling of voluntary movement. To be sure, these neural representations and innate motor schemas are only sufficient for *phantom* experiences and *phantom* voluntary movements. When it comes to *real* experience and movement they are powerless on their own. But it does seem that in at least a few phantom cases, and perhaps only for a few primitive movements, they are sufficient for basic intentions on their own, in the absence of any real experience or movement.

For most cases, even for most phantom cases, the argument from movement is valid: real movement comes first. Only in a very few phantom cases the brain can have some basic intentions without prior real movement. And even if such innate basic intentions only seem to lead to voluntary movements *because* there are no real limbs to control, still the intentions themselves are there in the brain. The argument from movement is not completely valid. And this means that as yet we haven't got a conceptualisation of what we really are that accommodates all of the evidence. There is still work to be done.[28]

References

Armstrong, D. Stokoe, W. and Wilcox, S.E. 1995. *Gesture and the Nature of Language.* Cambridge: Cambridge University Press.

Bermudez, J.L. 1998. *The Paradox of Self-Consciousness.* Cambridge MA/London: MIT Press.

Brewer, B. 1995. Bodily awareness and the self. In *The Body and the Self.* J.L. Bermudez, A. Marcel and N. Eilan (eds). Cambridge MA/London: MIT Press, pp. 291-310.

Bumyeat, M. 1992. Is an Aristotelian philosophy of mind still credible? In *Essays on Aristotle's "De Anima".* M.C. Nussbaum and A. Oksenberg Rorty (eds). Oxford: Clarendon Press, pp. 15-26.

Butterworth, G. 1993. Dynamic approaches to infant perception and action: old and new theories about the origins of knowledge. In *A Dynamic Systems Approach to Development: Applications.* L.B. Smith and E. Thelen (eds). Cambridge MA/London: MIT Press, pp. 171-187.

Churchland, P.M. 1995. *The Engine of Reason, the Seat of the Soul.* Cambridge MA: MIT Press.

Cole, J. 1995. *Pride and a Daily Marathon.* Cambridge MA/London: MIT Press.

Cole, J., Gallagher, S., McNeill, D., Duncan, S., Furuyama, N. and McCullough, K-E. 1998. Gestures after total deafferentation of the bodily and spatial senses. In *Oralite et gestualite.* Santi et al. (eds.). Paris: L. Harmattan, pp. 65-69.

[28] I would like to thank Paul Eling for his suggestions for literature on phantoms in congenital limb-deficient subjects.

Cole, J., Gallagher, S. and McNeill, D. In press. Gesture following deafferentation: A phenomenologically informed experimental study. *Phenomenology and the Cognitive Sciences* 1.1 (2002).

Cole, J. and Paillard, J. 1995. Living without touch and peripheral information about body position and movement: Studies with deafferented subjects. In *The Body and the Self.* J.J. Bermudez, A. Marcel, and N. Eiian (eds). Cambridge MA/London: MIT Press, pp. 245-266.

Damasio, A.R. 1994. *Descartes' Error: Emotion, Reason, and the Human Brain.* New York: Putnam.

Damasio, A.R. 1999. *The Feeling of What Happens. Body, Emotion, and the Making of Consciousness.* San Diego CA: Harcourt.

Dennett, D.C. 1978. Where am I? In *Brainstorms. Philosophical Essays on Mind and Psychology.* D.C. Dennett. Hassocks: Harvester Press, pp. 310-323.

Dennett, D.C. 1987. *The Intentional Stance.* Cambridge MA: MIT Press.

Dennett, D.C. 1991. *Consciousness Explained.* Boston etc.: Little, Brown and Company.

Descartes, R. 1967 [1641], Meditation II, Meditation IV, Principles IV. In *The Philosophical Works of Descartes.* E.S. Haldane and G.R.T. Ross (trans). Cambridge: Cambridge University Press.

Dirksen, R,, te Giffel, S,, Slappendel, R,, Eling, P.A.T.M., Bugter, M.L.T., Geeraedts, L.M.G. and Weber, E.W.G. 2000. Fantoomsensaties tijdens plexus brachialis anesthesie. *Tijdschrift voor Anesthesiologie* 13: 4-9.

Evans, G. 1982. *The varieties of Reference.* Oxford: Clarendon Press.

Gallagher, S. 2000. Self-reference and schizophrenia: A cognitive model of immunity to error through misidentification. In *Exploring the Self.* D. Zahavi (ed). Amsterdam/ Phildelphia: John Benjamin's Publishing Company, pp. 203-239.

Gallagher, S. and Cole, J. 1995. Body image and body schema in a deafferented subject. *The Journal of Mind and Behavior* 16: 369-390.

Gallagher, S., Butterworth, G.E., Lew, A. and Cole, J. 1998. Hand-mouth coordination, congenital absence of limb, and evidence for innate body schemas. *Brain and Cognition* 38: 53-65.

Harding, R.S.O. 1975. Meat-eating and hunting baboons. In *Socioecology and Psychology of Primates.* R.H. Tuttle (ed). The Hague: Mouton, pp. 245-257.

Hasan, Z. and Stuart, D.G. 1988. Animal solutions to problems of movement control: The role of proprioceptors. *Annual Review of Neurosciences* 11: 199-223.

Hurley, S. 1998. *Consciousness in Action.* Cambridge MA/London: Harvard University Press.

Johnson, M. 1987. *The Body in the Mind: The Bodily Basis of Meaning, Imagination and Reason.* Chicago: University of Chicago Press.

Katz, J. 2000. Individual differences in the consciousness of phantom limbs. In *Individual Differences in Conscious Experience.* R.G. Kunzendorf and B. Wallace (eds). Amsterdam/Philadelphia: John Benjamin's Publishing Company.

Katz, J. and Melzack, R. 1990. Pain "memories" in phantom limbs: Review and clinical observations. *Pain* 43: 319-336.

Lakoff, G. and Johnson, M. 1999. *Philosophy in the Flesh: Embodied Mind and Its Challenge to Western Thought.* New York: Basic Books.

Lott, T.L. 1986. Descartes on phantom limbs. *Mind & Language* 1: 243-271.
McGinn, C. 1991. *The Problem of Consciousness.* Oxford: Basil Blackwell.
McNeill, D. 1995. *Hand and Mind: What Gestures Reveal about Thought.* Chicago: University of Chicago Press.
McNeill, D. (ed) 2000. *Language and Gesture. (Language, Culture and Cognition 2).* Cambridge: Cambridge University Press.
Meijsing, M. 2000. Self-consciousness and the body. *Journal of Consciousness Studies* 7: 34-52.
Meijsing, M. 2001. Still stuck with that terrible concept of mind. In *Moving Ahead: Philosophy of Mind and Realism.* T. Derksen (ed). Tilburg: Dutch University Press, pp. 13-28.
Melzack, R., Israel, R., Lacroix, R. and Schultz, G. 1997. Phantom limbs in people with congenital limb deficiency or amputation in early childhood. *Brain* 120: 1603-1620.
Melzack, R. and Wall, P.D. 1988. *The Challenge of Pain.* (2nd ed). New York: Basic Books.
Moya, C.J. 1990. *The Philosophy of Action.* Cambridge: Polity Press.
Nagel, T. 1974. What is it like to be a bat? *Philosophical Review* 83: 435—450.
Penfield, W. 1975. *The Mystery of the Mind: A Critical Study of Consciousness and the Human Brain.* Princeton: Princeton University Press.
Poeck, K. 1964. Phantoms following amputation in early childhood and in congenital absence of limbs. *Cortex* 1: 269-275.
Putnam, H. 1975. *Mind, Language and Reality. Philosophical papers Volume 2.* Cambridge: Cambridge University Press.
Ramachandran, V.S. and Blakeslee, S. 1998. *Phantoms in the Brain: Probing the Mysteries of the Human Mind.* New York: William morrow & Co.
Ramachandran, V.S. and Hirstein, W. 1998. The perception of phantom limbs. The D.O. Hebb Lecture. *Brain* 121: 1603-1630.
Saadah, E.S.M. and Melzack, R. 1994. Phantom limb experiences in congenital limb- deficient adults. *Cortex* 30, 479—485.
Searle, J. 1992. *The Rediscovery of the Mind.* Cambridge MA: MIT Press.
Sheets, Johnstone, M. 1992. Taking evolution seriously. *American Philosophical Quarterly* 29: 343-352.
Sheets-Johnstone, M. 1999. *The Primacy of Movement.* Amsterdam/Philadelphia: John Benjamin's Publishing Company.
Simmel, M.L. 1958. The conditions of occurrence of phantom limbs. *Proceedings of the American Philosophical Society* 102: 492-500.
Stem, D. 1985. *The Interpersonal World of the Infant: A View from Psychoanalysis and Developmental Psychology.* New York: Basic Books.
Shoemaker, S. 1968. Self-reference and self-awareness. *Journal of Philosophy* 65: 555-567.
Skoyles, J.R. 1990. Is there a genetic component to body schema? *Trends in Neuroscience* 13: 409.
Thelen, E. and Smith, L.B. 1994. *A Dynamic Systems Approach to the Development of Cognition and Action.* Cambridge MA/London: MIT Press.
Weinstein, S. and Sersen, E.A. 1961. Phantoms in cases of congenital absence of limbs. *Neurology* 11: 905-911.

Weinstein, S. Sersen, E.A. and Vetter, R.J. 1964. Phantoms and somatic sensation in cases of congenital aplasia. *Cortex* 1: 276-290.

Wilkins, K.L., McGrath, P.J., Finley, G.A. and Katz, J. 1998. Phantom limb sensations and phantom limb pain in child and adolescent amputees. *Pain* 78: 7-12.

Wittgenstein, L. 1958. *The Blue and Brown Books.* Oxford: Blackwell.