The earliest sense of self and others: Merleau-Ponty and recent developmental studies

SHAUN GALLAGHER & ANDREW N. MELTZOFF

ABSTRACT *Recent studies in developmental psychology have found evidence to suggest that there exists an innate system that accounts for the possibilities of early infant imitation and the existence of phantom limbs in cases of congenital absence of limbs. These results challenge traditional assumptions about the status and development of the body schema and body image, and about the nature of the translation process between perceptual experience and motor ability. Merleau-Ponty, who was greatly influenced by his study of developmental psychology, and whose phenomenology of perception was closely tied to the concept of the body schema, accepted these traditional assumptions. They also informed his philosophical conclusions concerning the experience of self and others. We re-examine issues involved in understanding self and others in light of the more recent research in developmental psychology. More specifically our re-examination challenges a number of Merleau-Ponty's conclusions and suggests, in contrast, that the newborn infant is capable of a rudimentary differentiation between self and non-self.*

Recent empirical studies in developmental psychology have not only revolutionized that field by challenging and revising a variety of traditional assumptions, they have also raised questions with important implications for a philosophical understanding of the experiences of self and other persons. In this paper we discuss two related research areas that have undergone significant, and even radical changes since the early 1960s. These two areas involve the existence of phantom limbs in cases of congenital absence of limbs (aplasia), and the imitation of body movements in infants. In contrast to traditional assumptions, the evidence from recent studies suggests that there exists an innate system that accounts for the possibilities of early infant imitation and the existence of aplasic phantom limbs. These results challenge traditional assumptions about the status and development of the body schema and body image, and about the nature of the translation process between perceptual experience and motor ability.

On all accounts, both traditional and the more recent, the organized and meaningful perception of self and of others depends upon a proprioceptive system

Dr Shaun Gallagher, Professor of Philosophy, Canisius College, Buffalo, NY 14208–1098, USA. Email: gallagher@canisius.edu. Professor Andrew N. Meltzoff, Department of Psychology, University of Washington, Seattle, WA98195, USA. Email: meltzoff@u.washington.edu

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of a developed body schema organized to allow for an intermodal translation between external and internal senses. Does the body schema's innate status have any consequences for how we experience ourselves and others, or how we accomplish intermodal translation?

These issues stand on their own as significant ones for both psychology and philosophy, and we want to explore them for their own importance. But these are also issues that were very much the concern of Merleau-Ponty. Perhaps more than any other philosopher, Merleau-Ponty has been known as a philosopher of the body. He made use of the concept of body schema (*schema corporel*) in discussions that ranged across a number of cognitive and existential issues (Merleau-Ponty, 1962). In this respect his philosophy was greatly influenced by his study of developmental psychology and by the psychologists and psychological research he cited, including the work of Piaget, Wallon, Guillaume, and Lhermitte. In specific reference to Merleau-Ponty we want to show that in a number of ways his conceptions of infancy and development were imprecise.

In contrast to Merleau-Ponty's view, it is not the case that various aspects of development are blocked by a neurological immaturity that prevents the elaboration of a body schema. Furthermore, infants are capable of external perception and of imitating the gestures of others much earlier than Merleau-Ponty thought. The recent studies of newborn imitation suggest that an experiential connection between self and others exists right from birth, and that this connection is not, as Merleau-Ponty believed, a confused and undifferentiated experience. In effect, infants are able to do several things that Merleau-Ponty, relying on developmental studies of his own day, assumed they would not be able to do. This fact motivates us to reconsider his conclusions about the relations between self-experience and the experience of other persons.

1. A scientific dispute concerning aplasic phantom limbs

In 1961, the year of Merleau-Ponty's death, a scientific debate about the status of phantom limbs began. The focus of the debate concerned whether phantoms exist in cases of the congenital absence of a limb (aplasia) and early (prior to age six) amputations. The psychological and neurological literature stretching from the early 20th century to the early 1960s indicated that in cases of aplasia and in most cases of early amputation no phantom develops. This, indeed, was the established scientific doctrine and it was the view held in the overwhelming majority of studies up until the early 1960s (e.g. Bailey & Moersch, 1941; Bonnier, 1905; Browder & Gallagher, 1948; Gerstmann, 1927; Head, 1920; Kolb, 1954; Lhermitte, 1939; Pick, 1915; Simmel, 1966, 1962; and White & Sweet, 1955).

Simmel (1961) reaffirmed this tradition, offering evidence that supported the contention that phantoms for congenitally-missing limbs do not exist. Making the traditional assumption that the phantom limb is exclusively a phenomenon of the body schema, Simmel also made clear what is at stake in this observation, namely, the view that the body schema results from or is built up in experienced (proprioceptive, kinesthetic, and tactile) sensations. On the hypothesis that the body schema is

not present at birth, "if a person lacks an extremity since birth, he has never received such sensations from the missing limb, and he should therefore not have a phantom" (Simmel, 1958). The studies conducted by Simmel indicated that this is precisely the case. There is no phantom in aplasia because the limb in question is never experienced, and thus is never incorporated into the body schema.

This view of the phantom was also expressed by Merleau-Ponty in connection with his acceptance of the received doctrine that the body schema is a product of development. Although he conceives of the body schema as an anterior condition of possibility, a dynamic force of integration that cannot be reduced to the sum "of associations established during experience", still, in terms of development, the operations of the body schema are " 'learnt' from the time of global reactions of the whole body to tactile stimuli in the baby..." (1962, pp. 101, 122n). The body schema functions *as if* it were an "innate complex" (p. 84), that is, as strongly and pervasively as if it were innate, but, as an acquired habit with a developmental history, it is not innate. It follows that the existence of a phantom limb is based on a history of sensory inputs, and the continuation of sensory inputs at the stump. Sensory impulses "establish and maintain its place, prevent it from being abolished, and cause it still to count in the organism". They are the *sine qua non* by which we "build up the phantom" (1962, p. 86).

Consistent with his view of the body schema, Merleau-Ponty, following Wallon, believed that experience "begins by being introceptive", and that the newborn is without external perceptual ability (1964, p. 121). What William James famously calls the "blooming, buzzing confusion", and what Merleau-Ponty calls the "chaos in which I am submerged" (1964, p. 118), is not straightened out until between the third and sixth month when a collaboration takes place between the introceptive and extroceptive domains—a collaboration that is not there at the beginning of life (1962, p. 121). One reason for the lack of any organized extroceptive perception is the absence of a "minimal bodily equilibrium".

> Up to that moment [extroceptive] perception is impossible.... The operation of a postural schema—that is, a global consciousness of my body's position in space, with the corrective reflexes that impose themselves at each moment, the global consciousness of the spatiality of my body—all this is necessary for [extroceptive] perception (Wallon). (1964, p. 122)

The reason for the lack of a body schema, according to Merleau-Ponty, is neurological—a certain lack of physiological development. Myelinization is said to occur between the third and sixth months and is later in some limbs than in others (feet vs hand; left hand vs right hand). The development of the body schema happens only following these physiological conditions and thus only in a fragmentary way at first. It is then gradually integrated and, in a reciprocal system with external perception and sensory inputs, "becomes precise, restructured, and mature little by little" (1964, pp. 123).

A challenge to this general agreement about the development of the body schema and the impossibility of aplasic phantom limbs started to take shape in 1961. Weinstein and Sersen (1961) cited evidence that directly challenged the received

doctrine. They found, in a study of 30 cases of aplasia, that 17% experienced a phantom limb. Even this small percentage, they reasoned, would be enough to indicate "that phantoms need not result from prior stimulation of a part.... The fact that phantoms can exist for limbs which themselves never existed indicates that some native factor must be responsible, at least in part, for the existence of the phantoms" (Weinstein & Sersen, 1961, p. 910). In more precise terms, the evidence raises the possibility that the basic framework of a body schema is innate. Subsequent studies (Melzack, 1989; Poeck, 1963, 1964; Scatena, 1990; Vetter & Weinstein, 1967; Weinstein *et al.*, 1964) supported the thesis of an innate body schema based on a built-in neural framework or substrate; a schema from the very beginning, but one that is also open to modification by multimodal sensory experiences throughout the lifetime of the organism.

2. The body schema and the body image

(a) A conceptual distinction

The concept of an innate body schema clearly challenges the traditional view that the body schema is an acquired postural model. However, is the concept of an innate body schema validated by the studies that show the existence of an aplasic phantom limb? This depends on how one defines *body schema* and the extent to which it can be clearly distinguished from the concept of *body image*. As a provisional characterization (to be elaborated in more detail below), we can make the distinction in the following way. A body schema is a system of motor capacities that function without the necessity of perceptual monitoring. Body image, in contrast, consists of a system of perceptions, attitudes, and beliefs pertaining to one's own body. In light of the historical use and misuse of these concepts, however, we need to analyse the distinction between body schema and body image in more detail.

There is a long tradition of ambiguous terminological usage and conceptual misusage in the psychological literature on body image and/or body schema. A good deal of the current confusion between the two concepts can be traced back to Schilder (1923, 1935/1950), who had employed Head's (1920) term "body schema" to signify a conscious image or representation of the body. Head's concept of body schema, however, did not involve an image or perception of the body. Nonetheless, Schilder, and others who followed, used the terms interchangeably (for summary and critical review, see Gallagher, 1986; Poeck & Orgass, 1971). Schilder's definition amply shows this conflation of terms:

> The image of the human body means the picture of our own body which we form in our mind, that is to say the way the body appears to ourselves.... We call it a schema of our body or bodily schema, or, following Head...postural model of the body. The body schema is the tri-dimensional image everybody has about himself. We may call it 'body-image'. (1935/1950, p. 11)

Without clearly distinguishing between these two concepts, Schilder character-

izes a phantom limb as an "animated image" and "the expression of the body schema" (p. 13). Unfortunately, this ambiguity continues to manifest itself in the current discussion of aplasic phantom limbs. As a result, it is often difficult to tell whether claims about phantom limbs should be understood as claims made about the body schema, understood in terms of motor capability, or about the body image, understood as a perceptual experience of the body. Yet, as we shall see, this conceptual distinction is an important one to make. As a simple matter of logic, if, for instance, a claim is made about the body schema then the evidence cited to substantiate that claim should pertain to the body schema rather than the body image. It is not unusual, however, to find violations of this logic in the psychological research.

In fact, the distinction between body image and body schema is not an easy one to make because on the behavioral or existential level the two systems interact and are highly co-ordinated in the context of intentional behavior. A conceptual distinction is nonetheless useful precisely in order to understand the complex dynamics of bodily movement and experience. It will be apparent in the following discussion that the distinction we are employing cuts across a number of other distinctions, such as conscious/non-conscious, explicit/tacit, and willed/automatic. The body image/body schema distinction is not reducible to any one of these, and no other distinction seems to carve up the intellectual space in quite the right way, or at least in the way we want, except for this one. We believe this distinction can do some useful work despite the ambiguity involved in the historical use of these concepts.

The conceptual distinction between body image and body schema is related to the difference between having a perception of (or belief about) something and having a capacity to move (or an ability to do something). We can characterize the body image as involving perceptions, mental representations, beliefs, and attitudes where the intentional object of such perceptions, beliefs, etc. (that which they are directed towards or that which they are about) is one's own body. The body schema, in contrast, involves certain motor capacities, abilities, and habits that enable movement and the maintenance of posture. It continues to operate, and in many cases operates best, when the intentional object of perception is something other than one's own body. So the difference between body image and body schema is like the difference between a perception (or analysis or monitoring) of movement and the actual accomplishment of movement. Obviously a perception of one's own movement can be complexly interrelated to the accomplishment of one's own movement, although not all movement requires a body percept.

It is possible to find some evidence of a double dissociation between body image and body schema. For example, one can find evidence of an intact body schema in the absence of a complete body image in cases of hemi-neglect. Denny-Brown and his colleagues report that a patient suffering from a persistent defect in perception related to the left side of the body fails to notice her left side; excludes it from her body percept. She fails to dress the left side of her body or comb the hair on the left side of her head. Yet there is no motor weakness on that side. Her gait is normal, although if her slipper comes off while walking she fails to notice. Her left hand is held in a natural posture most of the time, and is used quite normally in movements

that require the use of both hands, for example, buttoning a garment or tying a knot. For instance, she uses her left hand and thus the motor ability of the neglected side, to dress the right side of her body (Denny-Brown *et al.*, 1952).

Dissociation of the opposite kind can be found in rare cases of deafferentiation. A deafferented subject who has lost tactile and proprioceptive input from the neck down can control his movement only by cognitive intervention and visual guidance of his limbs. In effect he employs his body image (primarily a visual perception of his body) in a unique way to make up for the impairment of his body schema (see Gallagher & Cole, 1995). These two examples, then, provide logical and empirical reasons for thinking that there is a useful distinction between body schema and body image.

The body image, consisting of a complex set of mental representations of the body, involves a form of explicit and self-referential intentionality. Studies involving body image (e.g. Cash & Brown, 1987; Gardner & Moncrieff, 1988; Powers *et al.*, 1987) frequently distinguish among three intentional elements:

(a) the subject's *perceptual* experience of his/her own body;
(b) the subject's *conceptual* understanding (including mythical and/or scientific knowledge) of the body in general; and
(c) the subject's *emotional* attitude toward his/her own body.

Although (b) and (c) are not always a matter of conscious awareness, they are maintained as a set of beliefs or attitudes, and in that sense form part of an intentional system. In the following discussion we focus on (a), the body percept [1].

In contrast to the body image, the body schema is not a perception, a belief, or an attitude. Rather it is a system of motor functions that operates below the level of self-referential intentionality, although it can enter into and support intentional activity. It involves a set of tacit performances, preconscious, subpersonal processes that play a dynamic role in governing posture and movement. In most instances, movement and the maintenance of posture are accomplished by the close to automatic performances of a body schema, and for this reason the normal adult subject neither needs nor has a constant body percept. In this sense the body tends to efface itself in most normal activities that are geared into some external goal. To the extent that one does become aware of one's own body in terms of monitoring or directing perceptual attention to limb position, movement, or posture, then such an awareness helps to constitute the perceptual aspect of a body image.

Of course, motor action is not completely automatic; it is often part of a voluntary, intentional project. When I jump to catch a ball in the context of a game, or when I walk across the room to greet someone, my actions may be explicitly willed, but my attention, and even my complete awareness in such cases, is centered on the ball or on the other person, and not on the precise accomplishment of locomotion. In such cases the body moves smoothly and in a co-ordinated fashion due to the functioning of the body schema, and not due to an image (a perception) that I have of it. The body schema thus contributes to and supports intentional action.

It is also the case that a body image or percept may sometimes help me to

control my movement. The visual, tactile, and proprioceptive awareness that I have of my body may help me to learn a new dance step, improve my tennis game, or imitate the novel movements of others. In learning a new dance step, for example, I may consciously monitor and correct my movement. My movement along a narrow ledge above a deep precipice may involve a large amount of willed control based on the perception of my limbs. In such cases, the contribution made to the control of movement by my perceptual awareness of my body will always find its complement in capacities that are defined by the operations of a body schema and that continue to function to maintain balance and enable movement. Such operations are always in excess of what one can be aware of (see Gallagher, 1995). Thus, the body schema is not the same as a perception of the body; it is never equivalent to a body image.

Although Merleau-Ponty does not make an explicit conceptual distinction between body image and body schema, he is much more careful and consistent than the psychological literature is on this point. He argues that, on an existential level, there is a continuous development between the schema and the image, that they are elements of one system, and that on the level of the lived experience of the body there is an "indistinction" between these elements. Still, on the conceptual, analytical level he is careful not to confuse them [2]. For example, it is quite clear that Merleau-Ponty, citing the postural schema described by Head (1920), names and identifies the body schema (rather than the body image) as the anterior condition of the possibility for perception. He calls the body schema a dynamic form, a being-in-the-world, of which we have a "tacit understanding". When he does say that the body schema involves a consciousness of the body, he quickly qualifies this by claiming that it is not a "positional consciousness, a representation, *Vor-stellung*". In this sense, he suggests, the body schema might best be expressed as a set of laws rather than a set of images (1962, pp. 99–101, 104; 1964, p. 133).

In the context of developmental psychology Merleau-Ponty traces the initial emergence of the body schema, and then the subsequent development of body image, a conscious awareness in which the "child takes notice of his own body", to a stage in which it becomes a conscious objectification of the body. He places great emphasis on the mirror or specular image as a way of building the body image (1964, pp. 121–125). In the context of discussing the phantom limb, Merleau-Ponty consistently maintains that the phantom is "a modality of the body schema" (1962, p. 101 n.2), and that it can be reduced neither to a physiological substrate nor to a representation or image (see 1962, pp. 80–85).

(b) Phantom limb: image or schema?

In contrast to Merleau-Ponty, the previously-cited experimentalists who have worked on the issue of aplasic phantom limbs, whether they defend the notion of an acquired schema or an innate schema, are not as careful in their use of these concepts. Simmel (1958, 1962, 1968), for example, who is one of the few psychologists to recognize an explicit distinction between Head's notion of body schema and Schilder's notion of body image, still confuses the two. Although she claims that

the phantom is part of the body schema, and arises because of the latter's resistance to alteration, the evidence cited in her study actually suggests that the phantom may be part of a body image—what Katz (1993, p. 151) terms the 'phantom limb percept'. Thus, Simmel's data, based on interviews in which subjects were explicitly asked to describe their phantom, show that the phantom is an "experiential representation" that patients consciously "feel" (as itchy or painful, for example), and that it has a cognitive status, dependent on intellectual maturity. Thus, Simmel defines the phantom as part of the body schema, but describes and studies it as part of the body image.

That the phantom may have the status of an image is even clearer in other studies. The procedures used by Weinstein and Sersen (1961), asking the child to indicate the length of his limbs, for example, require the child to focus attention on the limb; such procedures thereby test for a phantom limb percept. The descriptions supplied in their case studies of aplasic phantoms, for example, descriptions of the appearance of the phantom—long, short, wrinkled, etc.—also indicate an image-based phenomenon rather than a schematic process. Poeck (1964) and his patients, in a similar fashion, describe "the conscious presence of a phantom" which appears or disappears under certain circumstances. Scatena (1990) refers to phantom phenomena as "perceptual events". Melzack (1989, 1990), who rejects the explanation of the phantom in terms of the body schema, describes it as involving perceptual awareness.

We thus need to entertain the hypothesis that the aplasic phantom is a phenomenon of the body image. If this hypothesis is correct, is there any evidence that the aplasic phantom is also part of a body schema? Two considerations reinforce the idea that aplasic phantoms do *not* have the status of a body schema.

First, one needs to consider what kind of evidence would count as evidence that the phantom is part of the body schema. One clear kind of evidence that a non-aplasic phantom limb is part of the body schema (and not solely part of the body image) is described by Merleau-Ponty: in some cases of phantom limb after amputation "the subject appears to be unaware of the mutilation and relies on his phantom limb as he would on a real one, since he tries to walk with his phantom leg and is not discouraged even by a fall" (1962, p. 81). Simmel (1966) refers to these cases as often-reported "incidents of 'forgetting' ". Poeck (1964) reports this type of incident in a 50-year old woman who lost her right thumb when she was 5 years old: "Every time she handles an object with her right hand, she tries to grasp it as if the missing member were still present. Even today, it is only when her grip fails that she becomes consciously aware of her defect" (p. 272). The phenomenon of forgetting suggests that the missing limb continues for a time to function schematically in a normal way in motor behavior. Such normal functioning, however, does not depend on a vivid representation or percept of the missing limb. Rather, forgetting is possible precisely because motor behavior does not ordinarily require that my limbs be the object of perceptual attention [3]. So, in incidents of forgetting, missing (phantom) parts of the body remain operative within a motor schema. Most significantly, however, although incidents of forgetting are frequently reported

following amputation, no incidents of forgetting have been reported in subjects with aplasic phantoms.

Does the fact that aplasics never exhibit the forgetting phenomenon imply that the aplasic phantom does not operate as part of a body schema? Although it seems clear that aplasic patients do experience certain perceptual aspects of phantom limbs, it remains uncertain whether schema-related experience with an actual limb at some point of one's life is a necessary condition for such errors as "forgetting one doesn't have it" to occur. The fact that aplasics do not report the forgetting phenomenon raises the possibility that the aplasic phantom is not part of the body schema although it is part of the body image. These issues remain unresolved in the literature on aplasic phantoms.

Second, in the majority of cases of aplasic phantoms the onset of the phantom takes place relatively late. In cases where specific ages are provided to indicate the onset of the aplasic phantom, the age of onset ranges from 4 years to 30 years, with the majority of subjects experiencing the onset of the phantom between the ages of 5 and 8 years (see Poeck, 1964; Saadah & Melzack, 1994; Weinstein & Sersen, 1961, and Weinstein *et al.*, 1964). For example, Poeck (1964) reports that an 11-year-old girl born with congenital absence of forearms and hands first experienced phantoms at the age of 6 years. Sohn (1914) reports that a patient born with her left forearm and hand missing began to feel a painful phantom with her first menstruation at the age of 14 years. In a study of 18 cases of aplasia with phantoms reported, five developed phantoms at the age of 7 years or older, with one of them developing it only at age 12 years (Weinstein *et al.*, 1964). Saadah and Melzack (1994) report the onset of phantoms, following minor surgery or injury to the congenitally absent limb site, at ages 6, 16, 26, and 30 years respectively in four subjects with congenital limb deficiencies [4].

The evidence cited suggests that the aplasic phantom is a phantom *image* that develops relatively late. On this evidence the inference that the body *schema* is innate is not logically justified. Of course, this does not require us to conclude that the body schema is *not* innate. Indeed, the data on aplasic phantoms are not inconsistent with the idea that both a body schema and perceptual elements of a body image exist at birth. It is quite possible that, as in some cases with phantoms after amputation, aplasic phantoms gradually disappear as the schema and image adjust and develop. Since this would happen relatively early in the case of aplasic phantoms, it is not unlikely that most subjects do not recall a phantom when interviewed later. This, and not the traditional doctrine that denies the body schema and body image at birth, may be the basis for the data reported in the pre-1961 studies—that subjects do not report a phantom in cases of aplasia [5]. It is also known, however, that phantoms sometimes appear temporarily, and for various reasons, due to stress, anxiety, or physical stimulation (Katz, 1993). This is compatible with the idea that, although there may be an innate basis for aplasic phantoms, it is still possible to have reports of aplasic phantoms developing or, more precisely perhaps, re-emerging only at later ages.

In summary, the early studies of aplasics concluded not only that aplasic phantoms do not exist, but that they are actually impossible because no body

schema exists at birth. The more recent data on aplasics indicate that aplasic phantoms do exist, and it is sometimes inferred on this basis that this is evidence for an innate body schema. None of the studies, however, clearly differentiates between body image and body schema, and the evidence cited indicates that the aplasic phantom may have the status of body image rather than body schema. What does this tell us about the innate status of the body schema or body image? The most conservative position is that no firm conclusions can be reached on the basis of the data supplied by this research. However, there is other, rather more direct evidence from developmental studies that both a body schema and some primitive elements of a body image are innate. An examination of the evidence concerning imitation in newborns will help to clarify this issue.

3. Imitation in newborns: innate body schema and primitive body image

Better evidence that both a body schema and certain primitive perceptual elements of a body image are innate can be found in studies involved in a second scientific conflict—a conflict concerning the concept of "invisible imitation". The traditional view is represented by Piaget (1962). He defines invisible imitation as the child's imitation of the other's movements using parts of the child's body that are invisible to the child, for example, the imitation of facial movements. How is invisible imitation possible? It requires the operation of the body schema. Thus, according to Piaget (and Guillaume (1943), as well as most other classical theories of development), invisible imitation is not possible prior to 8–12 months of age:

> The intellectual mechanisms of the [child under 8 months] will not allow him to imitate movements he sees made by others when the corresponding movements of his own body are known to him only tactually or kinesthetically, and not visually (as, for instance, putting out his tongue)...Thus since the child cannot see his own face, there will be no imitation of movements of the face at this stage...For imitation of such movements to be possible, there must be co-ordination of visual schemas with tactilo-kinesthetic schemas... (Piaget, 1962, pp. 19, 45)

In other words, the child must have a body (tactilo-kinesthetic) schema to which she can relate the visible movement or gesture of the other person. This view is clearly consistent with the assumption that the body schema is acquired, from which it follows that imitation dependent on the body schema would not be possible until its acquisition at 8 to 12 months of age.

Merleau-Ponty had no reason to doubt the empirical work of Piaget and Guillaume on this point. He indicated that to imitate:

> it would be necessary for me to translate my visual image of the other's [gesture] into a motor language. The child would have to set his facial muscles in motion in such a way as to reproduce [the visible gesture of the other]...If my body is to appropriate the conducts given to me visually and make them its own, it must itself be given to me not as a mass of utterly

> private sensations but instead by what has been called a "postural" or "corporeal schema". (1964, pp. 116–117)

In other words, for the same reason that the traditional view denies the notion of an aplasic phantom limb, that is, because of the absence of a developed body schema, the traditional view also denies the possibility of invisible imitation in early infancy.

In stark contrast to this traditional view, studies on imitation in infants conducted by Meltzoff and Moore show that invisible imitation does occur in newborns (1977, 1983, 1989, 1992, 1994). Their experiments show that newborn infants less than an hour old can imitate facial gestures [6]. A review of several experiments will help to clarify the results and their relevance to the issue of the innate status of the body schema and primitive elements of body image.

> *Experiment 1* (Meltzoff & Moore, 1983): Subjects were 40 normal and alert newborn infants ranging in age from less than 1 hour to 71 hours. The experimenter presented each infant with a mouth-opening gesture over a period of 4 minutes, alternating in 20-second intervals between the mouth opening and a passive facial appearance. The same procedure was then followed using tongue protrusion as the target gesture. In terms of both the frequency and duration of the infants' response gestures, there was a clear and statistically significant result demonstrating that normal and alert newborn infants systematically imitate adult gestures of mouth opening and tongue protrusion.

The youngest infant in the study, who showed a strong imitation effect, was just 42 minutes old at the time of the test. It is difficult to conceive of any stronger evidence for nativism than this. As for exactly what one can infer is innate and how to characterize this nativism, this shall be considered shortly.

> *Experiment 2* (Meltzoff & Moore, 1989): Subjects were 40 normal and alert newborn infants, all of them less than 72 hours old (the youngest at 13.37 hours). Each infant was shown tongue protrusions and head movements (full rotations of the head clockwise in the frontal plane) in experimental conditions similar to Experiment 1. As in Experiment 1, infants systematically matched the adult display shown to them. There were a significantly greater number of infant tongue protrusions when they were shown the tongue-protrusion gesture than when shown the head movement, and vice versa. The data was broken down to discriminate between head movement that simply tracked the displayed head movement, i.e. counter-clockwise movement of the infant's head which tracked the experimenter's clockwise movement ("perceptual tethering"), and imitation of the adult that could not be based solely on such visual tracking (infant's clockwise head movement). Not only was imitation of the clockwise movement demonstrated, but the authors also examined imitation during intervals in which the adult stopped gesturing. The analyses showed that infants initiated imitation during the adult passive-face periods when no movement was in the visual field. For example, infants produced more head movements in the passive-

face intervals following the head-movement displays than in the passive-face intervals following tongue-protrusion display. This demonstrates that genuine imitation and not just perceptual tethering occurred.

Meltzoff and Moore (1977) extended the range of gestures that young infants imitate to a wider set, showing that 12- to 21-day-old infants imitate three facial gestures (lip protrusion, mouth opening, and tongue protrusion) as well as sequential finger movement (opening and closing the hand by moving the fingers in a serial fashion).

Experiment 3 (Meltzoff & Moore, 1977): Subjects were 12 infants between the ages of 16 and 21 days. They were shown mouth-opening and tongue-protrusion gestures in experimental situations similar to Experiments 1 and 2. During the period of stimulus presentation, however, a pacifier was placed in the infant's mouth. Throughout stimulus presentation the infants continued to suck on the pacifier, making it impossible for them to engage in any sort of co-action with the experimenter. Not only were they prevented from imitating while the gesture was present, but they actually engaged in alternative motor activity, since reflexive sucking occurred in all the babies tested. It was noted that infants actively sucked on the pacifier and showed no tendency to open their mouths and let the pacifier drop out during the mouth opening display, or to push out the pacifier with their tongues during the tongue protrusion display. The pacifier was removed only after the adult completed his gestural display and had assumed a passive-face pose. Thus, imitative responses were delayed and only allowed when the gesture had vanished from the perceptual field; nonetheless, the data documented that infants imitated even under these conditions.

The findings of imitation under these experimental conditions rule out "reflexes" or ethological releasing mechanisms as potential mediators of this activity. First, reflexes and releasing mechanisms are highly specific—that is, narrowly circumscribed to limited stimuli. One cannot have a releasing mechanism for imitation in general. The range of behaviors displayed by infants would require one to postulate distinct releasing mechanisms for each kind of behavior: tongue protrusion, mouth openings, lip protrusion, head movement, finger movement, as well as smile, frown, etc. Second, the delaying effect of the pacifier suggests that the imitative behavior involves memory and representation. A delayed reaction of this sort is incompatible with a releasing mechanism or reflexive response. Finally, as Experiment 4 shows, infants improve or correct the imitative response over time. They get better at the gesture after a few practices. Again, this is incompatible with a simple reflex or releasing mechanism.

Experiment 4 (Meltzoff & Moore, 1994): Subjects were 40 normal and alert 6-week-old infants. An adult displayed either a passive face or one of three target gestures: mouth opening, tongue protrusion at midline, or a novel gesture of tongue protrusion to the side. Tests with the same infants were conducted over 3 days and divided into five time periods: three involving

immediate imitation, and two "memory periods" involving imitation at a delay of 24 hours. As in previous experiments, immediate imitation was clearly demonstrated. The novel aspect of this experiment is that it also showed imitation after a delay of 24 hours. During the memory periods infants saw the identical person they had seen the day before, but he now had a passive face (instead of demonstrating the gesture). If the earlier display gesture had been tongue protrusion, the infant, 24 hours later, would produce significantly more tongue protrusions during the memory period. The second important finding of the study was that infants improved their gestural performance over time. Their first attempts at imitation do not necessarily replicate a gesture with a high degree of accuracy. When tongue protrusion is displayed, infants quickly activate the tongue; but they improve their motor accuracy over successive efforts.

If we follow the logic expressed by Merleau-Ponty and the traditional view, namely, that imitation requires a developed body schema, then the studies on newborn imitation suggest that there is a primitive body schema from the very beginning—an innate body schema sufficiently developed to account for the possibility of invisible imitation [7]. Furthermore, although newborns do not have a visual perception of their own faces, or other conceptual and emotional aspects of a developed body image, the possibility is raised by this research that the infant does have the most primitive perceptual element required for the formation of a body image—proprioceptive awareness.

Proprioception can be understood as serving a twofold function. First, proprioception consists of nonconscious, physiological information that updates the body with respect to its posture and movement. In this sense it plays an essential role in the body-schema system. This same proprioceptive information can also be the basis of a body-awareness. Because of proprioceptive awareness, I can tell you where my legs are even with my eyes closed. Proprioceptive awareness is a felt experience of bodily position that helps to constitute the perceptual aspect of the body image [8].

The studies on infant imitation suggest that the infant has both a primitive body schema (a system that works automatically to make possible the co-ordination of posture and movement) and a primitive body image—a proprioceptive awareness, e.g. of its face, that can be represented and matched to a remembered visual input. In contrast to normal adult motility, the infant faced with novel motor and gestural activities uses the proprioceptive experience of its own unseen movements to copy what it sees in the face of the adult and, even more revealingly for theory, to monitor, correct, and improve imitative performance. Conclusions like these are entailed by the experimental data which show, not just that infants imitate, but that they correct their imitations, that they are able to imitate novel gestures (tongue protrusion to the side), and that they can imitate from memory.

How do these mechanisms work? Meltzoff and Moore have proposed a model that involves a "supramodal perceptual system" that enables the infant to recognize a structural equivalence between itself and the other person. For the infant to be able to imitate a displayed facial gesture, it must be able to translate a visual display

into its own motor behavior. In a supramodal system, proprioception and vision are already in communication with each other [9].

The dual function of proprioception—proprioceptive information (PI) serving the body schema and proprioceptive awareness (PA) constituting part of the perceptual aspect of the body image (see note 8)—may help to explain how cross-modal communication between vision and proprioception is at the same time a communication between sensory and motor aspects of behavior. There are two interrelated processes involved here: (a) crossmodal communication between vision and PA; and (b) communication between the perceptual system (which includes vision and PA) and PI. On the physiological level PI and PA depend on the same proprioceptors, and in some cases the same central neural structures, which supply the information necessary for both the automatic governing of movement and the perceptual sensation of one's own movements (Phillips, 1985). Since PI and PA depend on the same physiological mechanisms it would not seem unreasonable to suggest an immediate two-way connection or interactive co-ordination between proprioceptive information, updating motor action at the level of the body schema, and proprioceptive awareness, as a perceptual element of the body image. And since PA and vision are intermodally linked, then there is also a link between vision and PI, or more generally between sensory/perceptual and motor activities. In the case of imitation the subject who is intentionally imitating depends on both PA and PI. What she sees gets translated into a proprioceptive awareness of her own relevant body parts; and PI allows her to move those parts so that her proprioceptive awareness matches up to what she sees. In effect, this supramodal *intra*-corporeal communication is the basis for an *inter*-corporeal communication and has profound implications for the child's relations with others.

4. The proprioceptive self and the experience of others

On this basis we can address the related issues of self-image and the perception of others—issues of importance, not only to Merleau-Ponty, but to many contemporary writers (e.g. Bermudez *et al.*, 1995; Johnson & Smith, 1990; Yeo, 1992). For Merleau-Ponty the problem of the perception of others is postponed in ontogenetic time until the child is at least 6 months of age (1964, pp. 122–125). For us, in light of the studies of newborn imitation, the problem is pushed back to age zero. Does this difference in time frame make any difference for the experience of self and others?

The central problem in this context was already stated by Merleau-Ponty. For invisible imitation to be possible "it would be necessary for me to *translate* my visual image of the other's [gesture] into a motor language" (1964, p. 116, emphasis added). The central problem is a translation problem, and the *sine qua non* of translation is that there be, metaphorically speaking, two languages—in this case a visual language and a motor/proprioceptive one. The difference in time frame (0 vs after 6 months) does make an important difference in the translation problem.

According to Merleau-Ponty,

> the different sensory domains (sight, touch, and the sense of movement in the joints) which are involved in the perception of my body do not present themselves to me as so many absolutely distinct regions. Even if, in the child's first and second years, the translation of one into the language of others is imprecise and incomplete, they all have in common a *certain style* of action.... Understood in this way, the experience I have of my own body could be transferred to another...giving rise to what Wallon calls a 'postural impregnation' of my own body by the conducts I witness. (1964, pp. 117–118)

Several things should be noted here. First, Merleau-Ponty thought that the translation process was an imprecise one even in very late infancy and early childhood. Second, Wallon and Merleau-Ponty thought that the "postural impregnation" only occurred relatively late in infant development (between 6 and 12 months). Furthermore, for Merleau-Ponty, the translation process between visual and proprioceptive senses is accomplished in my own body first (visual and tactile experiences of, for example, my own limbs, becoming co-ordinated with proprioceptive experience of them), and only then is "transferable" to my relations with others. In this sense, "the perception of one's own body is ahead of the recognition of the other" (1964, p. 121). This indicates something like a development "from the inside out", that is, from the body outward, so that only after a minimum bodily equilibrium is established can one start to perceive the world and others. On this view, the immaturity of body equilibrium prevents, blocks, or acts as a brake on perceptual and intersubjective development. This is also consistent with his view that in early infancy external perception is not possible, or if possible is chaotic and not correlated to introceptivity (1964, pp. 121–122).

Casting the issue in terms of a "supramodal code" instead of what Merleau-Ponty calls a "certain style", the studies of newborn imitation indicate that the translation is immediate. More precisely, and strictly speaking, no "translation" or transfer is necessary because it is already accomplished, and already intersubjective. A supramodal code already reaches across the child's relations with others. Infants already apprehend, with quickly-improving precision, the equivalencies between the visible body transformations of others and their own invisible body transformations which they experience proprioceptively. The concept of a supramodal code means that the visual and motor systems speak the same "language" right from birth. It is not, as the traditional view would have it, a matter of gradually developing a translation process between initially independent spaces—a visual space, a lived proprioceptive space—that function independently and are co-ordinated with growth and experience. Rather, information picked up by the separate sense organs are represented with relative precision within a common supramodal space (Meltzoff, 1990a, 1993; Meltzoff & Moore, 1995; Meltzoff & Gopnik, 1993).

From early infancy, then, the visual experience of the other person communicates in a code that is related to the self. This communication is organized on the basis of an innate system that does not necessarily give priority to body experience over and against the experience of the other. Thus there is a coupling between self

and other, and this coupling does not involve a confused experience (Meltzoff & Moore, 1995). On this view, it is not the case, as Merleau-Ponty claims, that at the beginning of life there is "an entire phase in which extroceptivity (i.e. vision, hearing, and all other perceptual relating to the external world), even if it begins to operate [and Merleau-Ponty denies that it operates this early], cannot in any case do so in collaboration with introceptivity" (1964, p. 121). Rather, there is perception and the possibility of collaboration from the very beginning, precisely because what Merleau-Ponty identifies as the condition of possibility for perception, namely, the body schema, is operational from the very beginning. The body schema, working systematically with proprioceptive awareness, operates as a proprioceptive self that is *always already* "coupled" with the other. What Husserl (1970) calls "intentional transgression" is operative from the very beginning.

With the notion of an innate supramodal system of body schema and proprioceptive experience, it is possible to propose a solution to a problem that Merleau-Ponty attempted to answer—a problem that is frequently identified with Husserl's account of intersubjectivity. Husserl's theory depends on the experiencing subject making an analogy (not a thought-out inference but an "analogizing apprehension") between herself and the other person on the basis of the similarity between the subject's own body and the body of the other. In effect, Husserl's theory depends upon a comparison or analogy between body images—the perceptual image I have of my body and the perceptual image I have of the other's body (Husserl, 1970, §§50–54). One objection to Husserl's theory is that I experience my body in a way that is very dissimilar to the way in which I perceive the other person's body. In contrast to the visual perception of the other's body, I visually experience my body with characteristic perspectival distortions—for example, I do not visually perceive my own face without the aid of mirrors. As long as we remain on the level of visual images, however, this problem does not get resolved and, at any rate, we note, this type of analogy would not be possible for the newborn, since the newborn, on anyone's theory, does not have a visual image of its own face on which to base the analogy.

Husserl's theory might be recast in the following way. The analogy would really have to be made from my own body, operating as a co-ordinated system (of body schema and proprioceptive experience), to the visual image of the other's body. But this formulation remains imprecise on two counts. First, the objection might still be voiced: we are still talking of two different types of experience—proprioception and visual perception. So, rather than speak of an analogy made between two bodies, one might speak, as Merleau-Ponty does, of a translation within the space of a certain style. But, on Merleau-Ponty's account, to the extent that the translation process is still viewed as something entirely learned in experience, the intentional transgression of the other would be delayed for 6 to 8 months or longer after birth. In contrast, the conception of an already-accomplished, innate, supramodal visual-motor/proprioceptive link suggests that the transgression is immediate and that *experientially*, and not just objectively, we are born into a world of others.

Second, it is not precisely the image of the other's body in the sense of the other's objective appearance or the way the other body looks that forms the

extroceptive moment of this relation. On this point we must agree with Merleau-Ponty. The infant does not perceive the outward appearance of the other, but the *action* of the other. "Thus it is in [the other's] conduct, in the manner in which the other deals with the world, that I will be able to discover his consciousness". The other presents me with "themes of possible activity for my own body" (1964, p. 117). Communication with another person is dependent more on lived and perceived motility than on the actual appearance, shape, or image of the other's body. The infant does not perceive the other as an object so much as it "recognizes", at the behavioral level, that the expression of another is one the infant itself can make. (For further studies on infants recognizing people by their actions and not merely by their static perceptual features, see Meltzoff & Moore, 1994, 1995; for work on infants learning the affordances of objects through observing the conduct of others with those objects, see Meltzoff, 1988a, 1988b, 1990b.)

Studies of newborn imitation also suggest an important modification in the conception of early experience which Merleau-Ponty describes as the "pre-communication phase". According to this description, which Merleau-Ponty adopts from a wide variety of theorists who have espoused it, including Guillaume, Wallon, *Gestalt* psychologists, phenomenologists, and psychoanalysists, "there is not one individual over against another but rather an anonymous collectivity, an undifferentiated group life" (1964, p. 119). Wallon calls this "syncretic sociability". "Syncretism here is the indistinction between me and the other, a confusion at the core of a situation that is common to us both" (1964, p. 120). On this view there seems to be, in the infant's phenomenal experience, a complete lack of differentiation between itself and the other which only starts to get transformed when the infant begins to acquire a body schema, and which is totally overturned when the child acquires a body image (some time after 6 months and the mirror stage).

The studies of newborn imitation, however, not only demonstrate that imitation of actions (conducts, gestures) is possible from the very beginning, and that the supramodal system that makes this possible is innate; they also indicate that the original *in*differentiation is never complete. The first exclusively visual notion of self may be tied to the later mirror stage, or a later form of imitation (Campbell, 1995; Meltzoff, 1990a). However, self-recognition in the mirror is only one measure, one aspect of a broader concept of self. The phenomenon of newborn imitation suggests that much earlier there is a "primordial" or "embryonic" notion of self, what we might call a proprioceptive self—a sense of self that involves a sense of one's motor possibilities, body postures, and body powers, rather than one's visual features. The newborn infant's ability to imitate others, and its ability to correct its movement, which implies a recognition of the difference between its own gesture and the gesture of the other, indicates a rudimentary differentiation between self and non-self. This may be a bare framework of the self based on an innate body system, but it serves to introduce a disruptive moment into the supposed indifferentiation of the earliest hours [10]. Furthermore, it suggests that this earliest period is not a "*pre*-communication" phase, but is already an experience of pre-verbal communication in the language of gesture and action. And this, we note, would actually support some of Merleau-Ponty's other views about the relation between the infant and language.

5. Conclusions

The two areas of research examined here, the one concerning aplasic phantom limbs, the other concerning imitation in infants, are logically connected on the level of their fundamental assumptions about the status of the body schema and body image. Traditional views in both areas hold that the body schema has the status of a learned or acquired equilibrium, and that the body image is a learned representation. More recent research in these areas suggests that some primitive aspects of both body schema and body image are innate. The data on aplasic phantom limbs, however, despite claims made in the recent literature about the innate status of the body schema, remain inconclusive on this point. In this paper some clarification of this issue has been offered on two fronts.

First, by distinguishing on the conceptual level between body image and body schema we are able to make the issue more precise. To what extent does the phantom limb function as part of the body schema, and to what extent is it an aspect of the body image? The studies conducted on the possibility of aplasic phantoms clearly test for the existence of a perceptual aspect of the body image by focusing on questions about how subjects consciously experience the phantom. It is therefore questionable whether, on the basis of such studies, one could legitimately draw the conclusion that the aplasic phantom is part of a body schema.

Merleau-Ponty follows the traditional view that aplasic phantoms are not even possible because of the absence of a body schema in the newborn, a view challenged by the more recent research. We now know that there are indeed phantoms in aplasic patients and these phantoms arise or occur in the absence of experience with the limb. Notwithstanding his positions on aplasic phantoms and the body schema, Merleau-Ponty provides some guidance by suggesting a criterion for determining whether the phantom limb is an operative part of the body schema, namely the phenomenon of "forgetting". But since no instance of forgetting has been recorded in the data of the aplasic phantom studies, there are still no sure conclusions to be reached with respect to whether the aplasic phantom is part of the body schema. Similarly, although aplasic phantoms exist, the question of innateness has not been definitively settled by these studies.

Second, the studies on infant imitation provide clearer evidence for the innate status of both a primitive body schema and the primitive perceptual aspect of a body image, especially that aspect which depends on proprioceptive experience. These studies, then, have important implications both for the issue of aplasic phantoms and for philosophical issues about the nature of the self and relations with others.

(a) To the extent that the studies on infant imitation indicate the existence of innate and primitive aspects of body schema and body image, they make the suggestion that the aplasic phantom functions as part of such an innate system more feasible, even if, at this point, the details are still speculative. The data on aplasic phantoms are not inconsistent with the possibility that, similar to some cases of phantoms after amputation, aplasic phantoms gradually disappear as the schema and image adjust and develop. In the case of aplasic phantoms this would happen relatively early so that most subjects would not recall a phantom when interviewed

later. Non-aplasic phantoms are also known to reappear on occasion. Ramachandran and his colleagues have shown how some form of innate neural framework may explain the disappearance and reappearance of phantoms after amputation [11]. Aplasic phantoms may be established (or re-established) later in childhood by a process similar to that described by Ramachandran. Thus the possibility of an innate basis for the aplasic phantom is not inconsistent with the fact that some subjects do not experience a phantom (because it has disappeared very early perhaps) and the fact that some subjects experience the onset of an aplasic phantom relatively late.

(b) The conclusions drawn from the studies of infant imitation put into question certain assumptions made by Merleau-Ponty on the basis of his readings in the area of developmental psychology. We have shown that his conception of what infants are able to do, based on the traditional assumption that the body schema is acquired through experience, stands in need of revision. Infants are not only capable of external perception and of imitating the gestures of others much earlier than Merleau-Ponty thought, they are also able to imitate after a delay, imitate novel gestures, and monitor their own movements and correct them to match a visually-specified target. These abilities involve, in addition to an innate body schema, an innate capacity for proprioceptive experience, an important element of a primitive body image. An infant's gestures, in effect, become an object of attention for the infant and she is able to discriminate between her own gesture and the gesture of the other. The experiential connection between self and other is operative from birth, and is not, as Merleau-Ponty contends, a syncretic confusion. At the very least, for the newborn infant there is a rudimentary differentiation between self and non-self, so that one's earliest experiences include a sense of self and of others.

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Notes

[1] Denny-Brown and his colleagues rightly interpret the case of neglect cited above as a primary defect in the body percept that does not involve Head's notion of body schema. Noting the confusion of terms in Schilder, they use the term 'body image' to mean only (b) a conceptual understanding of the body, which they show to be intact in their patient (Denny-Brown *et al.*, 1952, p. 463). Thus she is able to properly identify parts of her body or other bodies when asked. On our definition, however, insofar as this patient suffers from a defect of (a) the body percept, it is a defect of body image.

[2] Merleau-Ponty's carefulness is completely obscured in the English translation (Merleau-Ponty, 1962) in which Colin Smith consistently translates *schema corporel* as 'body image'.

[3] This view contrasts with Melzack (1990) and Aglioti *et al.*, (1994) who suggest that the vividness of the phantom accounts for incidents of forgetting.

[4] The lateness of onset in cases of aplasic phantoms contrasts to cases of phantoms following amputation. In 4–5 year-olds, phantoms follow amputations almost immediately (see Weinstein *et al.*, 1964, cases 21, 22, & 30; and Poeck, 1964, cases 2 & 3). The earliest *report* of a phantom was made by a 3-year-old girl whose legs were amputated at age 1 year 6 months (Simmel, 1962, case 454). A possible explanation for the onset of phantoms in some of the aplasic cases may involve stress- or anxiety-related or emotionally motivated change in the body *image*, rather than a primary change in the body schema. Katz (1993) notes that in some cases of phantoms following amputations, stress, anxiety, and even perceptual processes may generate a phantom. It might also be suggested that in cases of aplasia, subjects project the phantom limb into their own body image on the basis of their constant perception of other humans who have the full complement of limbs because so much else about their bodies is perceived to be the same. This possibility of an extreme intermodal learning, the incorporation from others to self, is not unrelated to our later remarks about early imitation.

[5] It is also possible, in regard to the lateness of onset of aplasic phantoms documented in the post-1961 studies, that reports of aplasic phantom limbs may be limited by the subject's abilities to reflect and verbally report on such experience, something that children may not be able to do prior to 4 years. Ability to report may be complicated especially because there would be a contradictory representation of a limb being present and experienced at the same time that it is visually absent. This sort of conflict between perception and reality may well be a problem for children less than about 4 years old (an age at which much empirical research on "children's theory of mind" indicates there are substantial intellectual changes). This only adds to the uncertainty involved with these studies. We thank one of the anonymous reviewers for this journal for pointing this out.

[6] Over the past 15 years these results have been replicated and extended in a large number of studies. See Meltzoff and Moore (1994) for summary. Field *et al.* (1982), for instance, showed that 2-day-old infants can imitate the smiling, frowning, or surprised expressions of adult models.

[7] For our purposes here, we do not need to examine the complex sources of information that help to constitute the developed body schema system. Besides proprioceptive information, they include information from kinetic, muscular, articular, vestibular and equilibrial sources. Part of this system also includes the contribution of visual proprioception, the function of which, recent studies suggest, is innate (Butterworth, 1995; Butterworth & Hopkins, 1977; Butterworth & Pope, 1983). Butterworth also reports other findings showing that there is an early organization and co-ordination of information about the body. For example, Butterworth (1995) observes that "about 15% of the spontaneous arm movements of the awake, alert newborn infant result in the hand contacting the mouth.... The mouth "anticipates" the arrival of the hand which, incidentally, can find its way to the mouth by a variety of trajectories and without visual guidance".

[8] Proprioceptive awareness (PA) as a self-referential awareness, a felt awareness of my own body, forms part of the perceptual aspect of the body image. Proprioceptive information (PI), in contrast, is processed on the subpersonal, nonconscious physiological level that subtends and operates as the basis for PA. PI, however, is more than simply the cause of PA. It automatically controls posture and movement even when my consciousness is totally taken up with action or cognition that does not involve the explicit self-referential intentionality of a body percept. PA will allow me to tell you where my legs are even with my eyes closed. PI, however, even when PA is absent, allows me to engage in motor activity that is quite automatic, such as walking across the room.

Some theorists argue that PA is never absent—that there is a constant, perhaps marginal awareness of the body. Even if this is so, the physiological processing of PI always involves more than PA. If I jump to catch a ball, I'm not aware of the "calculations" or "calibrations" that take place in and between proprioceptors and neural structures to maintain balance among a number of muscle groups; nor am I necessarily aware of the actual muscle adjustments. The "calculations" and adjustments are carried out without the mediation of PA.

Although, in the normal adult, in some circumstances, proprioceptive experience may be used to monitor and assist motor activity, the majority of normal adult movements do not require anything like the explicit proprioceptive awareness involved in a body percept. Rather, posture and

movement are normally governed by the more automatic processes of the body schema (Gurfinkel & Levick, 1991). Close-to-automatic processes such as established motor programs can function even in the absence of proprioceptive information (Volpe *et al.*, 1979).

[9] In support of the idea of an innate supramodal perceptual system, other experiments conducted by Meltzoff and his colleagues show that there is also an early relation between vision and touch and between the sound of speech and the particular lip movements that cause them (Meltzoff, 1993). Meltzoff and Moore (1995) provide a detailed analysis of the nature and limits of infantile supramodality.

[10] What we call the proprioceptive self is quite consistent with what Neisser (1988, 1991) calls an ecological self based on both visual proprioception and a sense of movement and action. The account that we provide complements and supports Neisser's suggestions that there are connections between the ecological and interpersonal self and that there is not a complete undifferentiation between self and non-self in early infancy.

[11] Ramachandran and his colleagues (Ramachandran *et al.*, 1992; Yang *et al.*, 1994) investigating the plasticity of the somatosensory cortical representation of the body show that after amputation of a limb, neuronal functions correlated with other body parts expand into and appropriate the neuronal area that had been associated with the amputated part. The neuronal structure associated with the amputated part deteriorates but does not totally disappear. As a result, two things occur. First, to the extent that the innate neural framework responsible for the body percept is modified, the phantom gradually fades. Second, stimulation of the body parts associated with the neural structures that appropriate the deteriorated neuronal space can cause activity in the deteriorated neuronal structure and sensation in the corresponding (phantom) part. Stimulation of the face or stump area, for example, may cause the reappearance of a phantom arm or a specific sensation on a phantom arm. Ramachandran's work on phantoms after amputation could be extended theoretically to the case of aplasic phantoms. See, for example, Shatz (1990, 1992) for a summary of recent research on neuronal development and plasticity.

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