



The innate sense of the body develops to become a public affair by 2–3 years

Philippe Rochat

Department of Psychology, Emory University, Atlanta 30322, United States

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ABSTRACT

Infants from birth do express a sense of their own body as a differentiated entity among other entities in the world, an entity that is situated, physically bounded, organized, and agent in the environment. Quickly however, this implicit sense of self develops to become explicit, conceptual, and more importantly, public and social. This development would correlate with the maturation of specific prefrontal cortex regions. By 2 years of age, children begin to perceive and represent the embodied self through the evaluative, possibly coveting eyes of others. They become self-conscious. This developmental transition is further exemplified with the parallel emergence of an explicit sense of possession. By the second birthday, the “me” is extended to include the “mine”, giving children new embodied power to share, exchange, and give.

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In this article, I re-visit the sense of the body at the origins of development. There are 2 questions of interest: what do we know about young infants' sense of their own body? And how does the early sense of the body develop into childhood?

The first question pertains to the old issue of what is the starting state self-awareness of the infant. Are babies born in a blooming, buzzing, confusion (William James)? Lacking perceptual unity and coordination among the various sensory modalities (Jean Piaget)? Or even, in a starting state of un-differentiation with the world, described as some sort of “normal autism” or “primary narcissism” (Sigmund Freud)?

The second question deals with the issue of what changes in the development of self-awareness in the course of the first years, in particular the awareness of a body that matures quickly in both appearance and capacity, getting eventually recognized, evaluated, and labeled as an intrinsic part of the concept of “Me”. What characterizes these changes and what might drive them, both in terms of brain maturation and new socio-affective factors coming on-line as the child develops?

Selected infancy research is reviewed establishing that, rather than confused and disorganized, we are born with an implicit sense of the body as an entity that is differentiated, organized, and situated in the environment. Beyond such evidence, I then turn to my main point that is to show that the embodied self-awareness of infants is not just a private self-experience. Within a few months after birth, the perception and representation of the body become increasingly social: a public affair. I try to show that, quickly, self-

awareness is determined by the perception and representation of others as evaluators of the embodied self, including its possessions.

But first, as a general frame, I present a brief overview of the link emerging between neural maturation and levels of consciousness, including levels of *self-consciousness* in early development. Following this brief brain-based account, I will then turn for the rest of the paper to a behavioral account of such development that future research might more precisely correlate with neural growth.

1. Brain-based account of developing levels of (self-) consciousness

When children start explicitly to recognize themselves in mirrors or begin to manifest shame or embarrassment, they take a meta-evaluative stance toward the embodied self. They begin to show self-consciousness and this happens by the end of the second year (Lewis, 1999). Such new “meta-step” in development correlates with significant brain maturation, particularly regions of the prefrontal cortex.

In general, structural MRI studies document changes in brain structure over developmental time. Both the volume of neural connection density indexed by “gray matter”, and the volume of “white matter” or fatty insulation of nerve fibers (myelination) enhancing neuronal communication increase markedly and regularly across brain regions, through infancy and into adolescence (Giedd, 2004; Johnson, 1993).

In relation to behavior and cognition, recent works distinguish levels of cognitive consciousness in the developing child, linking them to particular neural functioning of prefrontal cortex regions. These regions are known to develop steadily, but at different rates, coming chronologically on-line through childhood (see Gogtay et

E-mail address: psypr@emory.edu.

al., 2004). Each of these prefrontal cortex regions would be linked to particular levels of cognitive control achieved by the child (Zelazo, Hong Gao, & Todd, 2007).

Bunge and Zelazo (2006) distinguish four types of rules (from simple stimulus-reward to complex higher order “meta” rules), indexing various levels of cognitive control children achieve in early development. These levels of cognitive control would also correspond to levels of self-awareness as they are directly linked to children’s executive functioning when for example they try to resolve a problem or anticipate events.

These four types of developmentally graded, more complex and abstract rules appear to be represented in four cortical regions that mature in succession: the orbitofrontal, ventrolateral, dorsolateral, and the rostrolateral regions of the prefrontal cortex. Based on both developmental neuroscience (EEG, PET), animal models, and neurological case studies, each of these regions controls for particular levels of executive functioning and rule use, from simple to more complex, eventually reflective and evaluative consciousness. This development is linked in particular to the maturation of the rostrolateral region of the prefrontal cortex (Bunge, 2004; Bunge & Zelazo, 2006).

This developmental model finds some supports in fMRI study testing 8–12 year-old children showing that activation of lateral regions of the prefrontal cortex increases as a function of rule complexity in sorting task games (Crone, Wendelken, Donohue, & Bunge, 2006; see also Zelazo, 2004). This provides indirect support to the brain-based model of developing levels of consciousness in children proposed by Zelazo (2004) and that Zelazo et al. (2007) extend to the development of self-consciousness.

The development of self-consciousness and bodily awareness, like the development of the ability to use rules at higher levels of complexity, would “mirror the protracted developmental course of the prefrontal cortex” (Zelazo et al., 2007, p. 412). Sensory evoked potential recorded in pre-term infants indicate that minimal level of phenomenal consciousness might be present already by 30 weeks of gestational age as thalamo-cortical connections become functional (Klimach & Cooke, 1988). Behaviorally, by 30 weeks gestational age, fetuses show marked changes in their habituation to acoustic vibrations, coupling of movement to heart rate, as well as some indications that they might begin experiencing pain (Anand & Hickey, 1987), all suggesting that there is a minimal experience of “what it is like” (Block, 2007).

Children would develop self-consciousness and recursive consciousness by “the iterative reprocessing of the contents of consciousness via thalamo-cortical circuits involving regions of prefrontal cortex” (Zelazo et al., 2007, p. 224). Each reprocessing of the content of consciousness, starting with minimal consciousness and self-consciousness at birth, would require the recruitment and “excitability” of yet another region of the prefrontal cortex.

An important aspect of the proposed brain-based model of developing consciousness is that such development starts off with the innate prescription of a minimal level consciousness. In relation to the own body and self-consciousness in general, such development does not start from scratch, but rather rests on the primary requirement of a minimal experiential awareness of the embodied self. The questions are: what might be the content of such minimal level of self-consciousness expressed from birth, even probably in the womb? What kind of behavioral evidence is there to support such minimal level of consciousness about the body, presumably the starting state of developing self-consciousness? Furthermore, how does it develop? We discuss these questions next.

2. Primordial perception of a postural schema

When we speak of body representation, we typically think of the body as an objectified entity that can be categorized as big,

small, fat, or amputated of one of its parts. This view equates the concept of body representation to “body image”, to the exclusion of something that is more implicit and pre-conceptual corresponding to “body schema” (Gallagher & Meltzoff, 1996) or “postural schema” (Merleau-Ponty, 1967; Wallon, 1942/1970).

In his work on the phenomenology of perception, Merleau-Ponty insists that what we perceive of the body, presumably from birth on, is primarily a “postural schema”, in other words forms and patterns of whole body posture in adjustment to the forces of both the external and the internal environment: gravitational and other physical forces exerted from the outside onto the body, as well as affective and emotional forces exerted on the body from the inside, as proposed by Wallon in his writing on early emotions as they relate to postural shaping and tonus (Wallon, 1942/1970). Merleau-Ponty states in one of his lectures on child development he gave at the Sorbonne some 50 years ago:

“The awareness of my body is not the awareness of an isolated entity or “block”, it corresponds instead to the knowledge of a *postural schema*, it is the perception of my body’s position in relation to the vertical, the horizontal, and to certain important axes of the environment’s coordinates in which my body is embedded.” (Merleau-Ponty, 1967, p. 23, author’s translation from French).

There are two important ideas in this statement, upheld by current infant and child development research. The first idea is that the awareness of the body, at an implicit, hence pre-conceptual or cognitively inaccessible level (see Block, 2007, for an in-depth discussion of such distinction), is not an awareness of something that exists in itself. It is not experienced as an isolated entity among other entities. The second idea deriving from the first is that body awareness is *relational*. It rests primordially on the experience of the relations between the embodied self and the environment: the physical environment, but also the social environment as I will insist.

The past 3 decades of infancy research provide multiple evidence that indeed, as suggested by Merleau-Ponty, body perception from the very beginning pertains to an implicit awareness of relations between the body (the embodied self) and the environment in which it is embedded, made of objects, people, layouts, movements, events, and the force of gravity. Such awareness is evident in the way newborns orient their actions in relation to these perceived features of the environment.

2.1. Oriented and differentiated sense of the body at birth

The rooting response of few hour old healthy newborns (i.e., head orientation with mouth opening in the direction of a tactile stimulation on one of the cheek) is significantly more frequent and predictable when the tactile stimulation comes from the outside (single touch stimulation), as opposed to the spontaneous self-stimulation from the baby’s hand touching the cheek (double touch stimulation) (Rochat & Hespos, 1997).

Such evidence of a differentiated rooting response in newborns suggest that not only do they show orientation in their rooting act, but also that they are capable of discriminating, at a very basic perceptual level, what corresponds to their own body, and what corresponds to the bodies of other people or things existing in independence of the embodied self.

2.2. Situated body of the young infant

It is well documented that by 4 months of age, infants begin to be proficient in eye–hand coordination (Piaget, 1936). Systematically, and with clear anticipation of physical contacts, they reach for objects in their environment for manual grasping and exploration, typically transporting them to the mouth for even further exploration (see Rochat & Senders, 1991). By this age, infants factor

with astonishing precision the relative *distance* that separate them from the object that is the target of their reach acts. For example, we found that 4-month olds are significantly more inclined to reach for an object presented within or just at the limit of their prehensile space (i.e., their own sphere of manual reach-ability from their current situation in space with a maximal extension of arms and trunk without losing whole body balance, Rochat & Goubet, 1995). From 5 to 6 months, infants show more hesitation and less inclination to reach for objects presented 1 or 2 in. outside the limit of their prehensile sphere, a sphere that is schematic and virtual, represented based on passed bodily experience. It is also the product of a precise and rapid postural calibration, infants adjusting their perception of an object's reach-ability as of function of various weights attached to their wrists that bring back more or less their body's center of mass as they are placed in a sitting posture (see Rochat & Goubet, 1995; Rochat, Goubet, & Senders, 1999).

In relation to reaching, there is evidence that such situated and embodied perception is already present at birth. When well supported in a seated posture, while calm and visually attentive, 1–2-day-old neonates not only do coordinate eyes and head to track a target moving in front of them, but also, if the target is within reach, they throw their hands toward it in apparent attempts at bringing one hand in contact with the target (vonHofsten, 1982, 1984). Neonates are still clumsy in their attempts, but the fine kinematic analyses provided by von Hofsten's studies reveal newborns' "pre-reaching" behaviors as remarkably well attuned to the movement of objects. Newborn's reaching attempts do show some coordinated anticipation of trajectory to permit manual contact with the moving object.

These observations show that very early on, infants manifest an implicit sense of their own embodied "effectivity" on things in the environment, learning to perceive what these things do or do not afford them to do. Infants, from birth, perceive and learn to perceive objects affordances for actions (i.e., sucking, reaching, grasping) in relation to their own current capacities and relative situation in the environment: their spatial placement in relation to things and their current postural situation in the environment where they and these things lay.

2.3. *Early sense of the body as bounded and substantial entity that occupies space*

As pointed by Neisser (1995), criteria for the ascription of an ecological self rests on the behavioral expression by the individual of both an awareness of the environment in terms of a lay out with particular affordances for action, and of its own body as a motivated agent to explore, detect, and use these affordances.

Newborns fill the criteria proposed by Neisser for such awareness. They also seem to possess an a-priori awareness that their own body is a distinct entity that is bounded and substantial, as opposed to disorganized and "airy" (not occupying space).

As an illustrative case in point, newborns perform self-oriented acts by systematically bringing hand to mouth, as already mentioned. In these acts, the mouth tends to open in anticipation of manual contact and the insertion of fingers into the oral cavity for chewing and sucking (Rochat, Blass, & Hoffmeyer, 1988; Watson, 1995). What is instantiated in such systematic acts is, once again, an *organized body schema*. These acts are not just random and cannot be reduced to reflex arcs. They need to be construed as functionally self-oriented acts proper. Because they bring body parts in direct relation to one another, as in the case of hand–mouth coordination, they provide neonates with invariant sensory information specifying the own body's quality as *bounded substance*, with an inside and an outside, specified by particular texture, solidity, temperature, elasticity, taste, and smell.

The a-priori awareness of the own body as a bounded substantial entity is evident in neonates' postural reaction and gestures when experiencing the impending collision with a looming visual object, an event that carries potentially life-threatening information.

Years ago, Ball and Tronick (1971) showed that neonates aged 2–11 weeks manifest head withdrawal and avoidant behavior when exposed to the explosive expansion of an optic array that specifies the impending collision of an object. Infants do not manifest any signs of upset or avoidant behavior when viewing expanding shadows specifying an object either receding or on a miss path in relation to them. Consonant with Ball and Tronick's findings, Carroll and Gibson (1981) report that by 3 months, when facing a looming object with a large aperture in the middle, as an open window in a façade, they do not flinch or show signs of withdrawal as they do with a full textured solid object. Instead, they tend to lean forward to look through the aperture.

In all, the detection of such affordance in the looming object indicates that there is an a-priori awareness that the own body is organized and substantial. There is an innate sense that the own body occupies space and can be a physical obstacle to other objects in motion.

2.4. *Infants' embodied sense of own agency*

Infancy research documents that from at least 2 months of age, children manifest the feeling and experience of their own agency: they act with purpose on objects to transform them and to produce perceptual effects with them that they tend to reproduce. In doing so, they further explore these objects but also the sense of their own bodily effect on them. As an illustration, in one study we compared newborns aged less than 48 h and 2-month olds' sucking behavior on "musical" rubber nipples. In this research (Rochat & Striano, 1999), every pressure applied by the infant on the nipple was associated with a perfectly contingent succession of sounds that were more or less the auditory analog of the oral pressures the infants generated on the pacifier. In one condition (analog), the pitch variation of the successive sounds heard by the infant was proportional to the variations of pressures applied by the infant on the pacifier. In another (non-analog) condition, the pitch variation of the sounds varied randomly. We observed that by 2 months (8–10 weeks), infants manifest a differential modulation of their sucking of the pacifier in terms of frequency and amplitude, depending on the analog or non-analog auditory consequence of sucking. In contrast, newborns did not show any evidence of such differential responding, hence no evidence of systematic exploration of the auditory consequences of their own oral (sucking) activities (Rochat & Striano, 1999).

From the second month, infants test systematically and explore their own embodied agency on things, here an object introduced in their well coordinated and highly sensitive oral cavity, in association with audition, a sense modality that is almost fully developed at birth. They begin to take a contemplative stance toward objects as well as toward themselves as agent in the environment. This stance is new compared to the immediate stance of newborns immersed in the here and now of perception and action.

Other evidence of a precocious embodied sense of agency can be observed in 3-month-old infants coordinating one of their leg to reach and eventually set in motion a colorful mobile dangling over their crib. Such common observations (Watson, 1995), were already described by Piaget (1936) on his own children, although only by the end of the first year as "tertiary circular reactions", therefore much later in development compared to what we now know.

Other research demonstrate that from at least 3 months, infants have a calibrated sense of their own body, integrating multiple perceptual modalities, in particular visual, tactile, auditory, and

proprioceptive modalities. By 3 months, infants for example discriminate either the inversion, or an artificial temporal delay in the visual feedback of their own body in action that is introduced via an experimental video display (see Rochat & Morgan, 1995; Rochat & Striano, 2001).

In a series of studies, we demonstrated that infants from at least 3 months of age, are aware of complex aspects of their own body as a dynamic and organized entity with particular feature characteristics (Morgan & Rochat, 1998; Rochat & Morgan, 1995; Rochat, 1998; but see also for analogous evidence Bahrick & Watson, 1985). For example, we measured 3–5-month-old infants' preferential looking to different views of their own body. Facing two television screens, infants saw on each of them their own body videotaped from the waist down. Both views were on-line, thus perfectly contingent. When infants moved their legs, they saw them moving simultaneously on either of the screens. Within this experimental set up, we measured infants' preferential looking for either view. One of the views presented their own legs as they would be specified via direct visual-proprioceptive feedback, for example by bringing them in the field of view while laying supine in their crib. The other view provided an experimentally modified on-line view of their own legs.

In general, what we found is that from 3 months of age, infants tend to look significantly longer at the view of the legs that is unfamiliar, violating the visual-proprioceptive calibration of the body in terms of general movement directionality, relative movement of the limbs, as well as overall leg configuration in relation to the rest of the body (Rochat, 1998). We documented that infants tend to look significantly longer as well as to move their legs more, while looking at a view of their legs that reverses by 180 leg configuration in relation to the rest of the body.

The intermodal redundancy specifying the body is experienced and explored by infants from birth. Considering the rich behavioral repertoire of fetuses 20 weeks and older, it may even be experienced in the confines of pregnancy (e.g., Prechtl, 1984).

In all, these empirical observations reveal in their own way the precocious expression of a postural and body schema. This schema is expressed in the early intermodal calibration of the body in relation to things that co-exist in the environment with *it* (i.e., the embodied self). Infancy research does show indeed that from the earliest age, babies perceive things in their potentials for effecting embodied actions. Following James J. Gibson's (1979) theory of affordances in his ecological approach to visual perception, infants from birth would therefore *co-perceive* themselves in the things they interact with and act upon in the environment.

A postural schema is the necessary by-product of the process of co-perception, this process itself being inseparable from an early inclination to detect what objects afford for embodied self-generated actions.

In all, this research shows that by moving and acting, young infants manifest an intermodal calibration of the own body, developing an intermodal body schema. This body schema is an implicit, perceptually based "proto-representation" of the body as specified by the intermodal redundancy accompanying perception and action.

This body or postural schema is not yet the objectified bodily representation or body image expressed by young children passing the rouge task, recognizing themselves in a mirror by claiming this is "Me" or showing embarrassment or shame (the conceptual distinction between body schema and body image introduced by Gallagher, 1986, see also Gallagher & Meltzoff, 1996).

3. Sense of the body and of others

In another insightful philosophical reflection, Merleau-Ponty points to the fact that the perception of the body and the perception

of other people as distinct embodied entities are basically inseparable. In resonance with current simulation theories of mind and the flux of research inspired by the discovery of mirror neuron systems (Gallese, 2007; Lepage & Théoret, 2007; Rizzolatti, Fadiga, Gallese, & Fogassi, 1996) Merleau-Ponty describes this phenomenon as the *mutual alienation* of the perception of the own body and the body of others. Merleau-Ponty's intuition is that the own body perception and representation is fundamentally inseparable from the perception and representation of others: "In the perception of others, my body and the body of others are coupled, as if performing and acting in concert: this behavior that I only can see in others, I somehow embody it at a distance, I make this behavior becoming mine, I take it over and understand it. Inversely, I know that the gestures I myself execute could become object of intention for others. It is the transfer of my intentions into the body of others, and of others' intentions into my own body, this alienation of others by me and of me by others that renders possible the perception of others" (Merleau-Ponty, 1967, p. 24; author's translation from French). Next, I try to show that the mutual alienation of others by me and of me by others is an early fact of life. It quickly becomes a core determinant of perceived embodied self, particularly when, by the end of the second year, this perception becomes explicit and conceptual.

3.1. Early mutual alienation of embodied self and embodied others

It is now well established that infants are capable of imitating the facial expression of an adult model, such as a tongue protrusion (an imitative act not directly controllable by vision, Meltzoff & Moore, 1977), or even emotional expressions of sadness or surprise (Field, Woodson, & Greenberg, 1982; see also Rochat, 2001 for a review of the research in this area). However, it is only with the emergence of the social smile (i.e., socially elicited smiling) at around 6 weeks (Wolff, 1987) that the child begins to manifest active affective and inter-subjective resonance with others. In the early face-to-face exchanges and emotional turn taking that emerge by 6 weeks, infants show first signs of shaping their own body and the body of others by "becoming coupled, as if performing and acting in concert (...)". They do start to express the mutual alienation proposed by Merleau-Ponty.

This expression of mutual alienation becomes evident in the fine analyses of first dyadic face-to-face exchanges emerging the middle of the second month that rejoice infants and adults equally, both instinctively tapping into such exchanges to assert connectedness and shared affective bounding (Stern, 1985). It is in this primarily dialogical context of reciprocal exchanges that infants express first embodied experiences that are mutually shared with others. In the context of these first affective dialogs are expressed a complex emotional co-regulation from which arises social norms and expectations. Very quickly indeed, infants form social expectations regarding dialogical rules and norms of communicative exchanges with others. These are rules of a social game, essentially a pragmatic game that the child is prompt to internalize and use to create meanings in reference to perceived others as well as to social exchanges in general.

From 2 months, for example, research shows that the child will respond negatively with fuss, frown, avoidant gazes, even cry if an on-going face-to-face interaction is surreptitiously interrupted by the adult adopting a sudden still face (Tronick et al., 1978). From 4 months, infants also show a marked sensitivity and switch to negative affects when the adult suddenly scrambles the narrative structure of a peek-a-boo game she is performing for the infant (Rochat, Querido, Striano, 1999). In general, the young infant reacts as if she detects a "violation" of the implicit, pragmatic rule of the dialogical affective game proposed and initiated by the adult.

It is in this dialogical context of reciprocal affective exchanges that the infant starts to develop a sense of embodied others, and *a fortiori* a sense of embodied self that is differentiated while subjectively analog or comparable to embodied others. There is ample empirical evidence that between 2 and 8 months, infants develop folk understanding and social expectations. For example, 5-month olds start to discriminate between purposeful and accidental actions performed by others (Woodard, 1999). Such ability contributes to the discrimination of unfamiliar vs. familiar persons in their social environment, persons they invest more or less affectively and to whom they show more or less attachment (e.g., the mother or primary care taker vs. a stranger). The early need for attachment, and in general the basic need for affiliation expressed by the infant is accompanied by remarkable perceptual learning.

By 7 months, for example, infants discriminate their mother from a stranger female in a dynamic video display where internal facial feature characteristics are blurred, thus cancelled as perceptual cues (Layton & Rochat, 2007). In the Layton and Rochat study, we used a visual habituation/dishabituation paradigm, 4- and 7-month olds presented repetitively with a static or moving image of their mother, then tested with alternated presentation of either their mother or a female stranger, both wearing a scarf hiding the hairline. We found that by 7 months, and not 4 months, infants recovered visual attention in the post-habituation tests to the female stranger, even when the image was dynamic but with a negative contrast that blurred feature cues. No such discrimination was found in the same “negative contrast” condition but when the image was static.

This research shows that by 7 months, infants discriminate their mother by detecting learned, albeit subtle characteristics of her “motor signature”, the way they bob their head and move their body as they silently tell a story (no sound involved) with facial features blurred on the screen (negative contrast) (Layton & Rochat, 2007).

It is also by 8 months that infants begin to manifest untamed stranger anxieties, what Spitz (1965) coined the “8-month anxiety”. It is also around this age that infants begin to imitate, not only what people can do with objects, but also how they *intend* to do it, engaging in so-called secondary inter-subjectivity, starting to communicate with others *about things* in the environment (i.e., joint attention, understanding of deictic pointing, social referencing, see Tomasello, 1999, 2008).

From this point on (approximately 9 months), infants begin to show clear signs that they construe others, as well as publicly behave themselves, with explicit intention and planning in mind. In other words, from 9 months on, infants construe others as well as themselves not only as reciprocal, but also as intentional entities (see some precursor signs of this development in 5–6-month olds in Woodard, 1999). When alone, they coordinate in increasingly systematic ways means and ends to resolve physical problems, such as pulling a blanket to bring an object closer, as shown by Piaget years ago with his own children (Piaget, 1936).

The perception of others by the child as intentional entities opens a new horizon in development, particularly the developing sense of the body. This new horizon is an “*evaluative*” horizon of the self, experienced in comparison and in relation to others: what is construed here as the emergence of a *public sense of the body*. With this new experiential horizon, others become for the child a mirror of the self: a social mirror in which the embodied self becomes objectified and evaluated, as we will see next (see also Rochat, 2009a,b for an extensive discussion of this new emerging psychological and experiential horizon in the life of the child).

By 14 months children begin to *identify* themselves with particular others, able to recognize, thus objectify their embodied self in others. For example, they start to show clear sign of discrimination whether someone is *imitating* their own actions on an toy,

as opposed to simply being contingent (Agnetta & Rochat, 2004; Meltzoff & Moore, 1999).

In this emerging process of social identification, there is concomitantly a new propensity in children to compare and evaluate themselves in relation to others. This propensity prefigures the alienation of embodied self-perception and representation in the quest for social recognition that seems to emerge in the course of the third year when children show first unmistakable signs of a care for reputation, an embodied sense of self that becomes filtered through the evaluative gaze of others (Lewis, 1992).

By 24 months, as toddlers begin to identify themselves in mirrors and literally “re-cognize” themselves (literally: “to know themselves again”), it is now well established that they often also manifest embarrassment, either by hiding their face or avoiding gaze from the specular image, or alternatively, by acting out or “cowering” in a self-conscious way (Lewis, 1999).

From then on, what the child recognizes in the mirror is not merely his own perfectly contingent embodied self, but also the objectified public representation of his own body: what people actually see, and more importantly, what they eventually *judge and evaluate*. This could explain, in part, why there seems to be a universal expression of un-ease and embarrassment across cultures when confronted with the own specular image (see for example Carpenter, 1975; Rochat, 2009a,b).

Embarrassment, but also shame, pride, or contempt are all secondary, “self-conscious” emotions emerging by the third year of life (Lewis, 1995, 1999). It is at this developmental juncture that the mutual alienation of self and others discussed by Merleau-Ponty takes its final “self-conscious” and secondary form. However, as was suggested prior, the actual “proto” roots of such alienation are to be found already at birth, particularly from the second month with the emergence of socially elicited smiling and the first signs of an inter-subjective sense of the embodied self, when infants acts are coupled and engaged in affective co-regulation with others.

4. Developing sense of possession: the public drive to incorporate objects to the self

By 21 months, as children become proficient speakers and as the volume of their vocabulary explodes, their mouth also becomes full of personal pronouns and adjectives like “I”, “Me”, and “Mine” (Bates, 1990; Tomasello, 1998). Not only does the child recognize or identify himself as author of his own action (objectified self-agency), he also begins to recognize himself as proprietor of particular things. In the same way that he experiences himself as the author of what he does, by the end of the second year the child becomes forcefully explicit about what belongs to the self, *de facto* to nobody else (the Mine stance). When the child begins to claim “that is mine!”, it is also to say “that is not yours!”, and not just to bring attention to the object or just the forceful ostentation of a request for it (Tomasello, 1998). The first claim of possession is an assertion of power over objects in relation to others. It is an ostentatious act of incorporation whereby the mine (the object of possession) becomes Me, henceforth gives it solidity as suggested already years ago by Dewey (1922).

The claim of possession emerging by 21 months does indeed give solidity to the embodied self in relation to others. It is primarily an expression of social self-assertiveness (Rochat, 2009a,b), being first and foremost *self-elevating* and *self-magnifying* in relation to others. There is an absolutist connotation in the first identification of the young child with objects and their forceful claims as proprietor, a typical trait of the so-called “terrible two’s”. In stating that it is Mine!, children tell to who wants to hear that it is nobody else’s, thus absolutely *non-alienable*. But this first inclination changes rapidly in the context of social exchanges and reciprocation.

The young child eventually learns the central notion that objects that are possessed by the self can be *alienable*, brought into a space of exchange that is guided by principles of fairness and reciprocity. Recent research on sharing in children from various cultures and socio-economic backgrounds show that this development appears to occur universally between 3 and 5 years of age (see Rochat et al., 2009).

The notion of property from being primarily a claim of unalienability and self-edification (end of second year and in parallel to self-recognition), becomes also alienable or shareable. From this point on, children discover the social power of property in the context of exchanges (Faigenbaum, 2005). If they show an original trend for self-maximizing gains, consistent with an absolutist *unalienable* sense of property, research shows that from 36 months on children begin to develop a complex sense of equity and fairness in sharing, developing a sense of justice that tends to favor protagonists based on ethical principles (e.g., first possession principle, Friedman & Neary, 2008; relative wealth, Rochat, 2009a,b). During the preschool years (3–5-year olds), emerge the ability to apply rules of equity in sharing desirable goods with others, particularly “in-group” others, overriding the strong self-maximizing propensities (i.e., self-assertiveness in relation to others) that prevail in 2-year olds. Preschoolers develop an ethical stance in relation to possession, a notion now defined by its alienability in the context of balanced social exchanges increasingly guided by principles of reciprocity and inequality aversion, the basic ingredients of human sociality (Fehr, Bernhard, & Rockenbach, 2008; Olson & Spelke, 2008; Rochat, 2009a,b).

Reciprocity requires a concept of self that is enduring in a moral space made of consensual values and norms, a space in which the child becomes accountable and in which reputation starts to play a central role. Self-consciousness, in particular the valued (ethical) sense of self in relation to others does appear to develop in parallel to the early development of reciprocal exchanges, although much more empirical work is needed to document such developmental link (Rochat, 2009a,b). Changes in self-concept, hence of an objectified sense of the embodied self, would accompany the development of reciprocal exchanges and presumably the development of an alienable sense of property. Reciprocal exchanges constrain children to project themselves, as well as what they perceive of others, in the context of on-going social transactions. Exchanges based on reciprocation require that the protagonists keep track and agree on who owns what and when, at all time. Engaging in such exchanges, starting approximately 3 years of age (preschool age) force children to objectify themselves as embodied entities not only in the here and now of perception and action, but also into past and future social situations. Indirect evidence supporting such interpretation is for example provided by the work of Povinelli and Simon (1998) on early self-concept development.

The careful empirical work of Povinelli and colleagues (see Povinelli, 2001 for a review) on delayed self-recognition shows that it is not prior to approximately 3 years that children begin to grasp the temporal dimension of their enduring body. From this age on, they develop a concept of the embodied self that does not pertain only to what is experienced here and now, but also to what was experienced then: what can be seen in a mirror now, but also in a movie tomorrow or days later. From 3 years old, children begin to express the notion of a self that is enduring over time. They will recognize themselves in a pre-recorded video, taken days ago, wearing a sticker on their forehead. However, they will not reach for it on their own body while watching the video of themselves. Younger children tend to do so, not differentiating past and present embodied self, thus not yet expressing an enduring sense of who they are in time, the embodied self projected into the past or into the future, beyond the here and now of bodily experience. Povinelli reports, for example, the commentary of a 3-year-old viewing herself on a

pre-recorded video with a sticker on her forehead. She says: “it’s Jennifer. . . it’s a sticker” and then adds: “but why is she wearing my shirt?” (Povinelli, 2001, p. 81). The paradox of seeing oneself as an other is expressed by the child, who clearly identifies that what she sees on the TV relates to her, but trying with confusion to construe that it is not in the present.

In short, there is an apparent synchrony between the developmental emergence of the notion of alienable possession brought into a space of reciprocal exchanges with others, and the notion of an embodied, physical self that is permanent and enduring over time. Much more research is needed to document this synchrony, in particular the mechanisms of cross-fertilization and mutual determination of the *Me* (objectified sense of the embodied self) and of the *Mine* (objectified sense of what belongs to the embodied self) starting 2 years of age.

5. Conclusions

The paper started off with a brief presentation of a recent brain-based model of developing consciousness and by extension, embodied self-consciousness (Zelazo et al., 2007). This model links beginning and ontogenetic changes in self-consciousness, to both the emergence of thalamo-cortical connections and the orderly as well as protracted post-natal maturation of the rostralateral region of the prefrontal cortex. The aim of the paper was to provide behavioral content that future brain-based models of developing self-consciousness would need to account for.

I tried to show that if there is indeed good evidence that infants from birth have a complex sense of their body as differentiated, organized and agentive entity in the environment, they quickly develop a sense of themselves as embodied not only in their own physicality, but also in the sense of what *others* perceive and represent of them. During the first year already, and starting 2 months, infants develop a sense of their embodied self that is not just solipsistic in nature, but starts to refer primarily to the social mirror of others (Rochat, 2009a,b). The sense of the body grows to become public, revealed and gauged in mutual social exchanges and ultimately, mutual recognition.

A brain-based model of such development should take into consideration the fact that, at a behavioral level, the development of self and social cognition are not mutually exclusive, but rather two sides of the same coin. Furthermore, because matters of consciousness and self-consciousness develop to become highly public and socially shared, it might not be sufficient to look at individual brains. It might be also necessary to look at how, as a function of their maturation, brains interact and shape each other. This would be another necessary step to better approximate the nature of embodied self-consciousness in development.

Behaviorally, the implicit, embodied “ecological” sense of the own body expressed from birth, which would correspond to a minimal self-consciousness presumably linked to thalamo-cortical connections, turns quickly in development to a public, socially shared, hence highly meta-cognitive and mediated affair, all of it supported by the emergence of language and sophisticated folk psychology, including theories of mind. It also maps onto the rather general link with the orderly maturation of the rostralateral region of the prefrontal cortex that would accompany children growth toward meta-cognition (Bunge & Zelazo, 2006). But this link still remains coarse and we are far yet from mapping brain growth onto the development of the innate sense of the body discussed here, as well as in other articles that distinguish at least 5 markedly distinct levels of self-awareness unfolding between birth and only 2–3 years of age (Rochat, 2003).

The public or social development of self-consciousness emphasized here is in contradistinction to the private experience approach that researchers interested in the origins of body awareness often

continue to adopt when studying the sense of the body in the social vacuum of laboratories (e.g., artificial phantom limb, optical “prism” experiments, virtual dissociation, and displacement of embodied experience). Future research on body awareness, including brain-based model of its development, should put more emphasis on social factors and the social context as determinants of such awareness (e.g., the role of group practices, norms, and socially shared values as social affordances individuals are embedded).

Before becoming predominantly social and public (third year), mediated by marked progress in language development, the early sense of the body, refers to a complex postural schema, a representation that is based on an intermodal calibration. The early intermodal calibration of the body expressed already in neonates does transcend – as intuited by Merleau-Ponty over 50 years ago – the sum total of multisensory information that constantly arises as we move and act in the environment. There is now good empirical evidence that from birth, infants manifest an ecological sense of self as an implicit sense of the body: a differentiated, situated, agent, organized and substantial entity. I presented research suggesting that minimal self-consciousness accounted for by brain-based models is supported by the fact that infants act from birth in relation to functional goals, and are not just automatically triggered in their responses by what would amount to ecologically non-specific, non-meaningful stimulation.

In short, the infancy research of these past 3 decades offers ample evidence that infants from birth are more than just responsive, more than a mere collection of prewired reflexes, indeed expressing minimal consciousness and self-consciousness. Infants, from the outset, behave as oriented actors in a meaningful environment, an environment they perceive as constituted by particular affordances, but also by objects that they are quick to incorporate and publicly claim as their own to assert their embodied existence in relation to others.

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