

Differential Rooting Response by Neonates: Evidence for an Early Sense of Self

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It is proposed that from birth, and long before mirror self-recognition, infants manifest a sense of self as a differentiated and situated entity in the environment. In support of this view, observations are reported suggesting that neonates discriminate between external and self-stimulation. Five newborns and 11 4-week-old infants were observed when they spontaneously brought one hand to their face, touching one of their cheeks (self-stimulation), or when the index finger of the experimenter touched one of the infant's cheeks (external stimulation). Microanalysis revealed that infants responded differentially to the two types of stimulation. Newborns tended to display significantly more rooting responses (i.e., head turn towards the stimulation with mouth open and tonguing) following external compared to self-stimulation. Four-week-old infants demonstrated an opposite pattern. These data are discussed as evidence of an innate ability to discriminate between self versus externally caused stimulation. The differential expression of this ability at birth and at 4 weeks is considered in relation to learning opportunities and the emergence of new functional goals guiding infant behaviour. ©1997 John Wiley & Sons, Ltd.

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Do infants from birth discriminate between self and external stimulation? Do they manifest a sense of their own body as a differentiated entity? It was traditionally assumed that children were born in a state of fusion or undifferentiation with their environment. Early behaviour was considered as

the expression of an original a-dualism between the infant and the world around (Piaget, 1953; Wallon, 1942/1970; Mahler *et al.*, 1975). Recent progress in infancy research suggests a different view, providing evidence that young infants are sensitive to perceptual information that specifies themselves as differentiated from other objects (Butterworth, 1990; Rochat, 1993a). Following Neisser (1991, 1995), infants from birth might already perceive an *ecological self*, a sense of the body as a differentiated, situated and agentic entity in the environment (see also Rochat, 1997).

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Until recently, experimental studies dealing with the developmental origins of self-knowledge have restricted this problem to the emergence of the identified or conceptual self. In these studies, children of different ages are typically confronted with their specular image, while the experimenter records signs of self-recognition. The most common experimental paradigm includes self-recognition in a mirror, in photographs or audiovisual recordings. The mirror technique (Preyer, 1887; Guillaume, 1926; Zazzo, 1981; Gallup, 1970) generated many studies, sometimes used to alter systematically the image of the self (Orbach *et al.*, 1980; Mounoud and Vinter, 1981). Using the procedure elaborated by Gallup (1970) in his study of self-recognition in chimpanzees, Lewis and Brooks-Gunn (1979) showed that between 15 and 18 months toddlers looking at themselves in a mirror show embarrassment upon noticing that a dab of rouge has been applied to their nose by the experimenter (the 'rouge' task). While staring at themselves in the mirror, they typically bring one of their hands to their nose. This behaviour is interpreted as a sign of self-recognition.

Researchers have expressed reservations regarding the use of self-recognition in a mirror as an experimental paradigm to capture the developmental origin of self-knowledge. These reservations are based on considerations regarding the complexity of the mirror situation and the difficulty of determining the relevant information picked up by the infant when looking at the mirror. Loveland (1986) observed that self-recognition in a mirror requires the child to have mastered the perceptual and conceptual problem associated with the mirror as a reflecting object in the environment. Furthermore, she noted that self-recognition in a mirror is by definition indirect, based on the perception of a two-dimensional projection of the body which is inverted around its axis of symmetry. It affords visual perception pertaining to regions of the infant's own body that are not otherwise directly accessible to this modality (e.g., the face). For all these reasons, self-recognition in a mirror might imply a particular perceptual learning that adds up to the expression of an explicit sense of self. Mirror self-recognition probably consists of more than what is required for knowledge of an 'implicit' sense of self (see Case, 1991). Further suggesting that there is an intrinsic complexity attached to the perception and understanding of the specular image, Zazzo (1981) showed that although 18-month-olds manifest self-recognition in the rouge

task, it is only 3-6 months later that toddlers placed in front of a mirror will turn around to look directly at a light they see blinking in the mirror. When presented with photographs or video recordings, it is also around 18 months that children start spontaneously naming and pointing at themselves (Lewis and Brooks-Gunn, 1979).

It is now well established that at around 18 months of age children manifest unequivocal self-recognition and self-identification in front of a mirror. Nevertheless, this fact should not necessarily be understood as the developmental origin of the sense of self. The basic theoretical assumption guiding the present research is that prior to self-recognition, or explicit self-identification of any kind, infants manifest an early (implicit) sense of self, and in particular of their own body (Rochat, 1993b; Butterworth, 1990).

Numerous studies have demonstrated that from birth infants are capable of processing information that is not specific to a particular sense modality but rather that is 'a-modal' (Gibson and Spelke, 1983; Meltzoff, 1993; Stern, 1985; see also Slater *et al.*, this volume). From the earliest age, babies are tuned to and capable of extracting perceptual information that corresponds to spatiotemporal invariants of the stimulation, such as learning and remembering to kick with their legs in a certain way to activate a mobile (Neisser, 1985). In this particular example, learning is based on infants' sensitivity to the co-occurrence of visual and proprioceptive feedback that specifies their own agency in relation to the mobile. This early capacity allows young infants not only to perceive objects and events, but also to situate themselves as perceiver and actor in the environment. This capacity is probably at the origin of infants' ability to perceive themselves as differentiated and situated entities (Donaldson, 1992; Rochat, 1993b; Butterworth, 1990).

From birth, infants experience contrasted perceptual and sensorimotor events that inform them about their own body as an object among other objects in the environment. When infants cry, the sound they hear is combined with kinaesthetic and proprioceptive feedback. This intermodal combination uniquely specifies their own body. Sounds originating from another person or any other objects in the environment tend not to share the same intermodal invariants. Aside from vegetative sounds such as crying, coughing or sneezing, by 2-3 months infants produce pre-speech vocalizations (i.e., cooing sounds rapidly becoming more articulated,

precursors of speech-like production), and explore the specificity of their own voice and the potentials (or affordances) of their own vocal tract (for reviews of early vocal development, see Oller, 1980; Stark, 1980).

Neonatal imitation (Meltzoff and Moore, 1977; Vinter, 1985; Field *et al.*, 1982) suggests that young infants have some ability to differentiate between themselves as imitators and the model they imitate (see also Meltzoff and Moore, this volume). The capacity of infants from birth to use innate sensorimotor activities such as sucking to control auditory events (de Casper and Fifer, 1980; Eimas, 1982; Jusczyk, 1985), as well as visual events (Siqueland and DeLucia, 1969; Kalnins and Bruner, 1973) shows that they have a sense of their own body as agent in the environment. Contrary to classical views on development, these findings point to an initial dualism, rather than an early state of fusion between infants and their environment. The rationale for the present research was to provide more direct evidence of the early expression of a differentiation between exteroceptive and interoceptive stimulation (i.e., external versus self-stimulation).

Newborns manifest a robust propensity to bring their hands in contact with their face and mouth (Rochat *et al.*, 1988). Some authors have observed that newborn infants spend up to 20% of their waking hours contacting the facial region with their hands (Korner and Kraemer, 1972). This simple observation might have implications regarding the perceptual basis of an early experience of the body as a differentiated object. As in the case of self-produced sound, when manually touching their own face, newborns are potentially experiencing a sensorimotor and perceptual event which uniquely specifies their own body as a differentiated object. This intermodal event is the *double touch*, of the cutaneous surface of the hand contacting the cutaneous surface of the facial region (which could be any other region of the body surface; von Glasersfeld, 1988). Contacts of the baby with any other physical objects, surfaces, or persons in the environment will never correspond to a double-touch intermodal event.

But when do young infants start to show discrimination of unique perceptual events that specify their own body as a differentiated object among other objects in the environment? Based on an analysis of hand-mouth coordination by newborn infants, Butterworth and Hopkins (1988) reported that when infants bring their own hand(s) in contact with their face, this cutaneous

self-stimulation is not accompanied by any of the rooting reflex response normally observed when an external object contacts the same facial region (marked head turn towards the cutaneous stimulation with mouth open). These observations point indirectly to an early ability to discriminate between environmental stimulation (single touch), and self-stimulation (double touch+proprioceptive stimulation). These findings corroborate our own (Rochat *et al.*, 1988) and suggest that there is maybe an ability to discriminate between tactual and tactual-proprioceptive (self-)stimulation in the neonate. The present research was specifically designed to address this issue, beyond the evidence of hand-mouth coordination by neonates reported by previous studies (Butterworth and Hopkins, 1988; Rochat *et al.*, 1988).

The rationale for the present experiment was the following. In the healthy full-term infant there is a robust association between *tactile (external)* perioral stimulation and *rooting responses*. This association is predictably expressed from birth and up to 6 weeks, when the rooting response tends to weaken and disappear (Koupernick and Dailly, 1968). Considering that up to 6 weeks the rooting response is highly predictable following external cutaneous stimulation of the perioral region, and that rooting might not be systematically observed following self-stimulation (*proprioceptive+ double-touch stimulation*), rooting can be used as a reliable dependent measure to assess the discrimination between *self- and external stimulation* at the origin of development.

METHOD

Participants

Two groups of infants were tested. One group included 5 full-term, healthy newborns, aged less than 18 hours. These infants had a 1- and 5-minute APGAR score of 8 or higher and a birth weight equal to or larger than 2500 g. Three were girls and 2 were boys. The other group included 11 healthy full-term infants aged between 3 and 5 weeks with an average of 4.1 weeks. Six were girls and 5 were boys. The newborn infants were tested in their nursery at the Northside Maternity Hospital in Atlanta where they were born. The older infants were tested either at the infant's home or at the Infant Laboratory at the Department of Psychology of Emory University. Infants of both age groups were predominantly of white middle class. For this study, an original sample of 9 newborns and 15

4-week-old infants were tested. Infants were eliminated from the final sample because of persistent sleeping, fussing or absence of any spontaneous hand-to-face contact (see procedure below).

Procedure and Design

The infant's rooting response, and in particular head movements following self- or external perioral touch, was recorded. Infants were videotaped while lying supine in their bassinet (group of newborns) or sitting 60° reclined in an infant seat (older group). Each posture was chosen as they were the most convenient for testing at either the home of the infant or at the Emory Infant Lab (older participants); or at the maternity hospital for the newborns. At the beginning of each trial, their head was oriented at midline by the experimenter and free to move either to the right or to the left, simply resting on the hard mattress of the bassinet. Following a 30-second baseline, the experimenter performed regular touch strokes with the tip of her index finger at the right or left corner of the infant's mouth (3–10 gentle strokes over a period of approximately 10 seconds over the corner of the lips and the region immediately adjacent to it). Stimulation occurred while there was no hand(s)-to-face contact and with the head oriented at midline. Tactual stimulation periods were separated by 30 seconds and repeated between 4 and 8 times depending on the infant's state and engagement, ending with a final 30-second observation period. External stimulation corresponded to touch of either the right or left side of the infant's face. Side of stimulation was alternated with order counterbalanced among infants of each group. During testing, a video camera recorded a close-up view of the infant's face, including his/her arms, for later analysis.

Scoring

Instances where infants spontaneously brought one of their hands in contact with the face (oral or perioral contacts, i.e. cheeks) were used as self-stimulation episodes. Infants' responses to self-stimulation of the face were compared to their responses following external stimulation episodes. Manual contact with the face that occurred within 15 seconds following external stimulation was not considered as a self-stimulation episode. Also, manual contacts with the side of the face when infants were already oriented towards this side by more than 45° relative to midline were not considered self-stimulation episodes. The reason

for this selection was that infants needed to have room to demonstrate a head turn and a root towards stimulation.

External stimulation episodes were considered for later analyses when infants had no hand(s) in contact with the face, and the head was oriented within approximately 15° from midline. Hence, the number of self-stimulation and external stimulation episodes included in the final analysis varied for each infant. Newborns had an average of 4.4 self-stimulation and 6.6 external stimulation episodes in the final analysis, with standard deviations of 3.5 and 1.3 respectively. The older group of infants had an average of 2.3 self-stimulation and 2.7 external stimulation episodes, with standard deviations of 1.1 and 1.0 respectively.

Each of the self-stimulation and external stimulation episodes was analysed individually, frame by frame, from the moment of the first tactual contact and for the next 15 seconds (group of newborns) or 8 seconds (group of 4-week-old infants). The sampling rate of the frame-by-frame analysis was 1 second for the group of newborns and 0.5 seconds for the older group (16 frames per episode). The rationale for these different sampling rates was that based on pilot observations older infants tended to respond much faster and displayed quicker head turns that required a finer-grain analysis over a shorter period of time. Overall, the sampling rate was considered as adequate to capture relevant behaviour in relation to our questions. Pilot observations indicated that a finer sampling was not necessary and would not have added further information.

For each analysed frame of these episodes, the following six measures were recorded:

1. *State*: The state of the infant was recorded along the Brazelton scale: deep sleep, light sleep, drowsy, quiet alert, active alert, fussing and crying.
2. *Head movement*: The movement of the infant's head following either self- or external stimulation was recorded as turning towards the stimulation, away from the stimulation, or no movement.
3. *Mouth activity*: The infant's mouth movements were recorded as wide open, slightly open, tongue protrusion or closed.
4. *Eye activity*: The infant's visual engagement was recorded as eyes open, slightly open or closed.
5. *Hand posture*: Hand posture was recorded as wide open, slightly open or closed (fisted).

6. *Hand location*: Hand location in relation to the infant's face was recorded as away from face, in contact with the face or in contact with the mouth.

For assessment of reliability, the scoring of the videotapes of three infants was performed by two independent coders. One of them was the primary coder who scored all the infants. Both coders were trained together for this task. For all measures, percentage agreement between the two coders was greater than 0.92.

The data presented here pertain only to measures 1, 2 and 3, the only measures that yielded significant results.

The hypothesis guiding the research was that young infants would show signs of a differentiation between self and external perioral stimulation. In particular, we hypothesized that young infants would tend to show more rooting responses (head turn towards the somaesthetic stimulation: Prechtl, 1958; Lewkowicz *et al.*, 1979), following external compared to self-stimulation. We did expect that this differential rooting response would be more pronounced in the older group of infants. These expectations were based on the assumption that from birth infants tend to show some overall discrimination between tactual and proprioceptive+double-touch stimulation (see observations by Butterworth and Hopkins, 1988) and that there is clearer evidence of such discrimination as a function of early development.

RESULTS

Based on the scoring sheets, self- and external stimulation episodes were compared regarding the relative frequency of four different behaviours occurring when infants were either in a state of drowsiness, quiet alertness, or active alertness *only*. These behaviours were the following: (1) head movement either away or towards the facial stimulation; (2) head movement towards the stimulation; (3) head movement either away or towards the facial stimulation with mouth either open, slightly open or with tongue protrusion; and (4) head movement towards the facial stimulation with mouth either open, slightly open or with tongue protrusion. These different types of behaviour are increasingly specific to the canonical expression of a rooting response which is represented by behaviour (4) in which the infant turns towards the tactual stimulation with mouth

open, and/or tonguing (Koupernik and Dailly, 1968). Separate analyses were performed for each of these behaviours. The *average proportion of scored frames* in which an infant displayed a particular behaviour was calculated and compared in relation to self- or external stimulation episodes. For each behaviour and each infant, we calculated an average score corresponding to the number of scored frames in which the infant displayed the behaviour over the total number of scored frames for either self- or external stimulation episodes. This score indexes the relative frequency of a particular behaviour following either self- or external cutaneous stimulation.

A 2 (Age group: newborn vs. 4-week-old infants) \times 2 (Condition: self vs. external stimulation) mixed-design analysis of variance (ANOVA) was performed on this score for each of the four analysed behaviours. ANOVA on the average proportion of scored frames corresponding to behaviour (1), (2) and (3) yielded no significant age group or condition main effect, nor any group-by-condition interaction (for all main effects and interaction $F(1,14) < 1$). There was no evidence of a differential responding to either self- or external stimulation, and no effect of age in relation to these behaviours. Note that these behaviours do not correspond to a rooting response in the strict sense of a head turn towards the tactile stimulation with mouth open (behaviour 4).

ANOVA regarding the average proportion of scored frames capturing behaviour (4) yielded a significant group-by-condition interaction ($F(1,14)=5.16$, $p < 0.039$). As illustrated in Figure 1, newborn infants tended to show more occurrences of this behaviour (head movement towards the

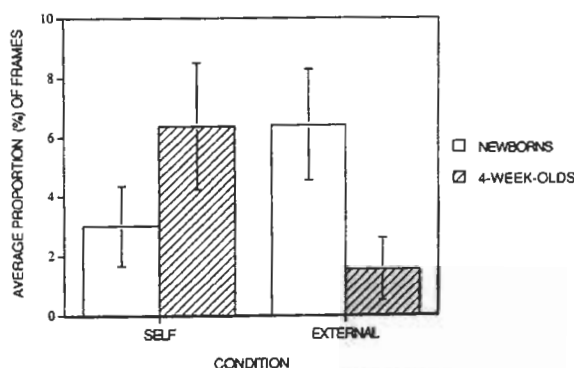


Figure 1. Average proportion in per cent and standard errors of scored frames in which newborns and 4-week-old infants were turning their head towards either self or external perioral stimulation, with mouth open and tonguing (Behaviour 4, see scoring categories).

facial stimulation with mouth either open, slightly open, or with tongue protrusion) following external compared to self-stimulation. The reverse is observed with the group of 4-week-old infants. Analysis of the simple effects yielded a significant condition effect for the group of 4-week-old infants only ($F(1,14)=5.685$, $p<0.032$). Note the reduced power of this analysis regarding the newborns ($N=5$), probably explaining the fact that the simple effect of condition for this group did not reach significance ($F(1,14)=1.28$).

Overall, these results indicate that in relation to the behaviour that captures a rooting response in the strict sense (Koupernik and Dailly, 1968), infants demonstrated a differentiation between self- and external stimulation. Furthermore, the pattern of this differentiation is shown to depend on the age of the infant.

DISCUSSION

Do young infants discriminate between self and external tactile stimulation on the perioral region? The results presented here suggest that they do. This evidence is striking, considering the great variability and fluctuation of behavioural state and the difficulty to control for individual differences in the expression of the rooting response. Some infants appeared to be highly responsive to external tactile stimulation, others did not, probably due in great part to their varying state of hunger. We attempted to control for hunger by testing infants in between feedings, but most infants, and in particular the newborns, were on different feeding schedules which made this control difficult. In a recent study, Lew and Butterworth (1995) demonstrated the effects of hunger in the expression of hand-mouth coordination and its variability in newborn infants. When hungry, infants tend to manifest an increased frequency and longer bouts of hand-mouth contact. Hunger is also an important factor in the expression of rooting responses (Prechtl, 1958). If the level of hunger could have been better controlled, the results might have been even clearer. With a better control of state, more episodes could have been included in the final analysis with a larger number of infants that would have increased the power of the analysis. Finally, future research should consider varying systematically the posture in which the infant is placed (e.g., supine, reclined, semi-upright or prone) to find, perhaps, an optimum postural

condition for the occurrence of hand-mouth coordination and rooting responses.

Despite these difficulties, our results provide further evidence that from birth infants do not blend intero- (self-) and exteroceptive stimulation, thus showing signs of a basic dualism between what originates from their own body and from the outside world. If infants were in a state of fusion with the environment, they would not respond differentially to either stimulation. We conclude that from birth infants appear to be sensitive to somesthetic stimulation that implies both double-touch and proprioceptive feedback, compared to touch only. The former specifies what pertains uniquely to the ecological self, namely the body as a differentiated and agentive entity in the environment. In contrast, the absence of both the proprioceptive and double-touch component in the single-touch condition specifies uniquely a sensory event with an extracorporeal (external) origin. The results presented here suggest that young infants pick up this fundamental, invariant difference, demonstrating a basic perceptual discrimination between what originates from the self or from the world around. Obviously, this differentiation is rudimentary and will develop. The evidence provided here, however, questions the idea of an infant at birth that is in a state of fusion, confusion or a-dualism in relation to stimulation originating from the body or objects external to the body.

The opposite pattern of discrimination between the two conditions expressed by the newborns and the 4-month-olds suggests different functional orientations attached to the response following self- and external stimulation. The rooting response of the newborn is tightly linked to feeding and the engagement of sucking (Prechtl, 1958; Koupernik and Dailly, 1968). By the second month, infants tend to use their mouth increasingly to explore objects aside from sucking (Rochat, 1983, 1993a). The development within the first weeks of life of perceptual function of oral activity, as well as the developing activity of transporting grasped objects to the mouth for exploration (Rochat, 1989), might account for the fact that 4-week-old infants appear more responsive to self compared to external stimulation. At this stage of development, hand-mouth contacts have a different functional status linked to the emergence of novel action systems (e.g., combined manual and oral exploration, Rochat and Senders, 1991). Simultaneously, the strength of the rooting response following external, perioral stimulation

decreases as the infant becomes motorically more advanced in controlling nipple search and food ingestion. By 4 weeks, infants manifest enhanced responding to hand-face contact, probably because it becomes part of a larger exploratory scheme.

In conclusion, long before infants recognize themselves in front of a mirror, they manifest signs of a differentiation between self- and external stimulation. In the context of this experiment, it is feasible that this ability might have developed prenatally in the confines of the womb where self-stimulation, and in particular hand-face contacts, are observed during the last trimester of pregnancy (de Vries *et al.*, 1982). However, it is as of yet unclear what information underlies the early perception of the ecological self. In relation to the present research, future studies should capture young infants' basis for their discrimination of self-stimulation: whether it is based on the double touch, the proprioceptive component or some combination.

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