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Active Touch in Infancy: Action Systems in Development

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Over the past 25 years, our understanding of newborn and young infant behavior has changed radically. The assumption that: "[neonate's] behavior is random, unstructured, and his responses are inconsistent" (Spitz, 1965, p. 54) no longer holds. Recent experimental work is continually expanding our estimation of the infant's capabilities. Although there is disagreement over how evidence of infant's precocity should be interpreted, few would argue that the newborn's world is the buzzing confusion depicted by William James.

From birth, infants are capable of performing actions of remarkable complexity and organization. Moreover, the behavior of the young infant is attuned to particular features of the environment. Neonates and young infants have been shown to orient to sound (Muir & Field, 1979), to track visual targets (Bullinger, 1977), to reach for objects moving close to them (von Hofsten, 1982), and to prefer simultaneous and synchronized events over those which are temporally and spatially disconnected (Spelke, 1976; Kuhl & Meltzoff, 1988). They attend

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preferentially to displays showing faces with organized rather than disorganized features (Maurer & Barrera, 1981), show preference for animate rather than inanimate objects (Gibson & Spelke, 1983), and systematically prefer high-pitched voices exhibiting dynamic speech contours ("motherese") over other human sounds (Fernald, 1985). In the realm of motor behavior, neonates are shown to be sophisticated actors, displaying complex patterns of movement (Thelen & Fisher, 1983), and demonstrating remarkable learning abilities (Zelazo, Zelazo, & Kolb, 1972). Socially, they are competent communicators, expressing from birth a broad range of emotions in clear, readable signs for their caregivers (Izard, 1978; Emde, Gaensbauer, & Harmon, 1976; Campos & Barrett, 1984). They display marked social attunement, and are capable of actively regulating and participating in ongoing nonverbal dialogues with others (Tronick, 1982; Stern, 1977). Evidence of early imitation (Meltzoff & Moore, 1977; Field, Woodson, Greenberg, & Cohen, 1982), suggests the existence of complex cognitive predispositions and perceptual attunements that challenge classic theories of cognitive development (i.e., Piaget, 1952, 1954).

In constellation, these findings call for a reassessment and reformulation of our understanding of infant behavior. New theoretical questions about early development need to be addressed.

The aim of this chapter is to present recent observations on active touch in infancy. These observations will be discussed within the general framework of action systems theory (Reed, 1982) and will address the following questions called for by recent findings in infancy studies: (a) What guides and controls action early in development? (b) What functions are served by early actions? (c) How organized is action from birth? (d) What changes in the preexisting and developing competence of the young infant?

Guiding our research approach to these problems is the assumption that infant behavior is not random, and that it is best modeled and understood as an ensemble of functional organizations. The view presented below is that the infant's repertoire of behaviors is a collection of "action systems" (Reed, 1982). These systems are defined by the hypothetical function they serve. For example, sucking behavior is viewed as part of the nutritional or feeding system. Infant behavior can thus be analyzed within a functional taxonomy. Further, behaviors are identified as "acts" rather than the more mechanistic "responses" or "reflexes." This perspective, validated by recent research, is one which demands a further understanding of the functional specificity of infant behavior. Reed outlined this approach, tentatively identifying eight basic action systems (orienting, appetitive, locomotor systems, etc.). This categorization is based on what appear, to an observer, to be differential orientations and attunements of an active organism toward particular aspects of the environment. Note that this approach to the neonate is one of a variety of levels of analysis for describing early behavior, one which is suited for the type of questions investigated here.

This functional taxonomy has great heuristic value and offers a powerful perspective on infant behavior by providing a holistic view of infant behavior inclusive of its relation to the environment. It is an alternative to a mechanistic view which conceives of infant behavior as a collection of predetermined sensorimotor loops or reflexes. Rather than occurring in a vacuum, infant action is seen as inextricably tied to the environment and its resources or affordances (J. J. Gibson, 1979; E. J. Gibson, 1982; Rochat & Reed, 1987c). Newborns are viewed as actively oriented toward the discovery of possibilities for action, that is, *affordances*, that are offered by the objects, events, peoples, and places that surround them (Gibson & Spelke, 1983). This is a drastic alternative to definitions of the neonate's environment in terms of stimulus configurations. It is our view that young infants are actors from birth, and as such they are acting in an environment of objects, people, goals, obstacles, and dangers.

In development, action systems define important axes or avenues of change. Considered as functional constraints, they canalize and support behavioral evolution.

TOUCHING IN INFANCY

Infants spend most of their waking hours touching their body and mouth with their hands. Although a major feature of infant behavior, active touch has received little attention from researchers. Between birth and 6 months of age, infant action appears unmistakably to gravitate toward the mouth (Gesell, 1940; Piaget, 1952; Spitz, 1965). Indeed, besides its nutritional function manifest in sucking, and the potential primacy of the oral zone as a source of eroticism (Abraham, 1927; Freud, 1905), the mouth is the primary instrument used to contact, capture, and explore objects (Spitz, 1965).

Oral capture and the mouthing of objects appear to drive and organize early exploratory behavior. The impetus of the young infant to explore objects orally, to bring hands to mouth, and to transport objects within the oral vicinity is a central and recurrent fact (Kravitz, Goldenberg, & Neyhus, 1978; Korner & Kraemer, 1972; Rochat, 1989).

Four bodies of observation are reported here. First, empirical evidence is presented showing that infants from birth use their mouth as a perceptual/haptic instrument, not merely as a "sucking device." Second, neonates' differential haptic responding (oral versus manual) to object properties is considered. Third, hand-mouth coordination at birth is discussed. Finally, consideration is given to the role of posture in determining the morphology of infant grasping and reaching.

Overall, these observations suggest a clear developmental progression representing a shift in dominance from the feeding to the exploratory system. At birth, there is a powerful organization of hands and mouth linked to the feeding system. By two months, this coordination is reoriented toward exploration, manifest first in the transport of objects to the mouth, and later in visually guided reaching. These observations have in common the primacy of touching, and demonstrate that active touch in infancy serves multiple and changing functions in the course of early development.

ORAL EXPLORATION IN THE NEONATE

Among the repertoire of sensorimotor activities displayed by the neonate, oral action and in particular sucking behavior is certainly the most prominent. The prominence of sucking, an integral part of the feeding system, and serving a basic survival function, renders the mouth the major interface or zone of linkage between the neonate and the environment. Sucking behavior forms during fetal development and is observed by 24 weeks of gestational age (Humphrey, 1970). It is both readily identifiable and functional moments after birth.

The sucking response of the neonate has been studied extensively by students of infancy (see Crook, 1979, for a review). Up to a decade ago, infant's oral activity was essentially considered as serving a nutritive function. In recent years, however, researchers have started to consider the mouth of the infant not simply as a feeding device, but also as a potential instrument for haptic exploration and perception. Support for this view of oral behavior was reported by Meltzoff and Borton (1979), Gottfried, Rose, and Bridger (1977), and subsequently by the studies of Gibson and Walker (1984); Rochat and Gibson (1985a); Pecheux, Lepecq, and Salzarulo (1988).

Some authors have reported that infants as young as one month of age show oral-haptic discrimination of invariant properties of an object and cross-modal transfer of this discrimination via the visual modality (Meltzoff et al., 1979; Gibson et al., 1984). In these studies, infants were presented with different objects introduced in their mouth for exploration. After oral familiarization with the object, the baby was tested on a visual display where the same object previously explored orally was presented in a paired comparison with another object varying in shape and texture (Meltzoff & Borton, 1979); rigid vs. elastic motion (Gibson & Walker, 1984). Reported data imply that infants as young as one month of age did manifest visual preference for the object that matched the one they previously mouthed. Note that the claim of an oral/haptic-visual transfer of information pertaining to organizational properties of an object prior to 6 months of age is controversial and that more parsimonious explanations have been proposed (Turkewitz, Gardner, & Lewkowicz, 1984). Nevertheless, these findings were interpreted as demonstrating that at an age where haptic exploration by hands and fingers is yet undeveloped (Rochat, 1989), infants are effectively using the haptic potential of the mouth to detect object properties.

From a physiological point of view, it is reasonable to consider the mouth, like the hands, as a perceptual instrument. The highest concentration of tactile receptors on the body surface are found in and around the mouth, as well as on the extremities of the fingers. Like the hands, the mouth has a high perceptual potential, combining tactile as well as kinesthetic reception from the mobility of jaws, tongue, and lips (Gibson 1966). Somatotopic and motor homunculus representations indicate that fingers and lips have a relatively large cortical projection corresponding to the greater tactilokinesthetic sensitivity of these regions (Carlson, 1986). Although works such as the one of Meltzoff and Borton (1979) were instrumental in providing empirical evidence for the oral/haptic potential of the young infant, this evidence was indirect. Indeed, within the context of a transfer or cross-modal paradigm, such potential can only be inferred based on the infant's response in another modality of recognition (visual).

At a more direct level of observation, further evidence has been collected which suggests the existence of a perceptual-exploratory function guiding oral activity early in development (Rochat, 1983, 1984). In a series of studies, rubber nipples of varying shape, texture, and taste were presented intraorally to young infants whose oral responses were analyzed. The oral activity of the young infants was recorded polygraphically using an air pressure transducer, a classic technique which records the variation of both negative and positive pressure applied to the nipple by the infant. The simultaneous application of both positive and negative pressure is common, and corresponds to the mechanical transformation of the nipple during mouthing. Recordings of positive and negative pressure applied by neonates to non-nutritive nipples indicated differential functioning of the mouth from birth. An excerpt from a newborn's polygraphic recording is illustrated in Figure 14.1. Negative (−) pressures of *suction* (SUCT) are always accompanied by positive (+) pressures of *expression* (EXPR). Indeed, infants' sucking activity by necessity entails positive pressures or mechanical transformations of the nipple.

What is interesting, however, is that the reverse is not true; positive pressures are often observed in the absence of any negative pressures or sucking responses (shown by the arrow in Figure 14.1). This demonstrates that EXPR is not exclusively associated with the sucking response, and is thus not directly linked to a nutritive function. Considering the high tactile and proprioceptive (haptic) potential of the mouth, movements of tongue and lips associated with EXPR can be viewed as exploratory action, and the oral region generally as serving a perceptual, as well as a nutritive function.

Mouthing (i.e., tonguing, gumming, and lipping) is one of the infant's primary means for discriminating among objects, and for detecting what they afford for action. Based on this distinct pattern of oral action, Rochat (1983) reported that the potential perceptual/exploratory functioning of the mouth is apparent at birth, and increases in frequency and importance during the first four months of life. Rochat recorded the oral activity of neonates and young infants presented successively for 90 seconds with nonnutritive rubber nipples varying in shape, texture, and substance. Even in few-hours-old neonates, variation was found in

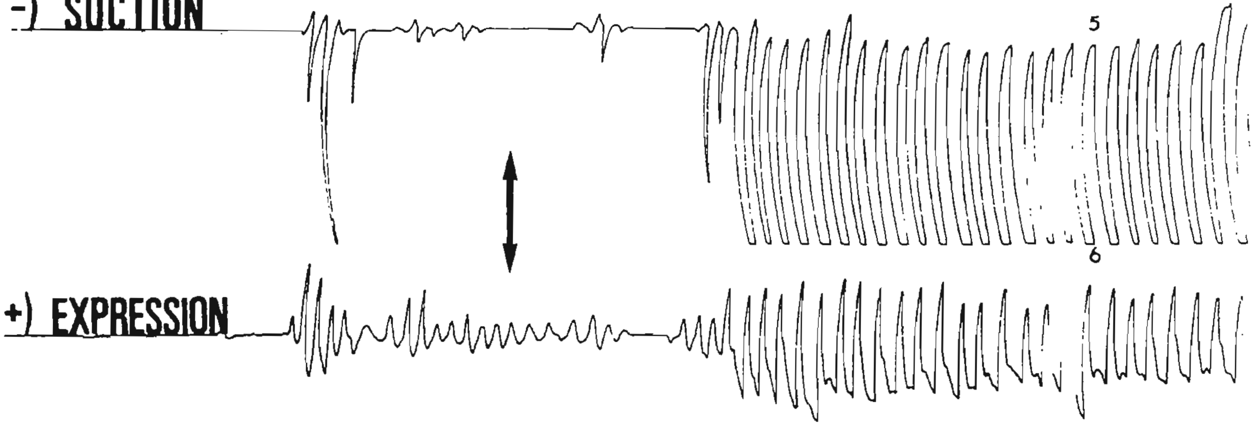

Figure 14.1. Sample of the simultaneous polygraphic recording of negative pressures (SUCTION) and positive pressures (EXPRESSION) applied by a 40-hour-old newborn infant on a nonnutritive rubber nipple. The arrow indicates a portion of the recording in which mouthing (EXPRESSION) occurs independently of any sucking.

oral response (EXPR and SUCT) corresponding to variation in the nipple's physical characteristics. Compared to a rubber pacifier approaching the biological characteristics of the natural nipple, infants respond with significantly more mouthing (EXPR) and less sucking (SUCT) to various intraoral objects with excentric shapes and textures. Furthermore, the ratio of SUCT to EXPR varied according to both the age of the infant and the characteristics of the nipple. One-month-olds, for example, appear sensitive to changes in both texture and shape of the nipple, while newborns show sensitivity to changes in texture only. These observations indicate that in the course of early development, the nutritive function of sucking changes in relative importance as the young infant actively develops the perceptual/exploratory potential of the mouth. It is worth noting that infants respond differentially to changes in the shape, texture, and substance of the intraoral object (nipple), but not to changes in the relative sweetness of its taste. In one study (Rochat, 1984), 1- to 3-month-olds were presented for 90 seconds with a nonnutritive rubber nipple that had been dipped either in water (neutral taste), or a sucrose solution (sweet taste), and their oral responses were compared. The nipples were common bottle nipples manufactured and conceived to approximate the biological shape and substance of the breast. In contrast to the previous studies, no significant differences were found in the ratio of EXPR to SUCT between conditions.

A COMPARISON OF ORAL AND MANUAL/HAPTIC RESPONDING AT BIRTH

There are good reasons to compare the oral and manual activities in early infancy. As will be illustrated later in this chapter, hands and mouth do not function independently, but appear functionally linked from birth. Moreover, by the time infants begin exploring and manipulating objects, hands and mouth appear to be actively coordinated.

Grasping behavior can be clearly seen in the neonate, and like mouthing, manual grasping is another potential means for the young infant to haptically perceive affordances of objects. Newborns systematically apply positive pressure to objects introduced into either their mouth or hands. This action can theoretically inform the infant about the substance and affordance of the object. The research of Gibson and Walker (1984) supports this, indicating that infants as young as one month of age can detect the invariant (amodal) property of rigid vs. elastic objects by mouthing or grasping. In a recent study (Rochat & Gibson, 1985a; Rochat, 1987a), oral-haptic and manual-haptic activities were compared early in development, investigating whether young infants would respond differentially when grasping or mouthing objects varying in substance (hard vs. soft). If infants showed differential responding to different substances, similarities between the oral and manual modalities would be evaluated. In this experiment, objects were presented either orally or manually to the newborn for a three-minute period while positive pressure variations were recorded using an air pressure transducer. As a dependent measure, frequency of positive pressures applied either orally or manually by the infant on the hard or soft object was calculated. A squeeze of the object was operationally defined as a positive pressure response to the object above a threshold corresponding to one third of the maximum signal amplitude obtained with each of the individual infants (Rochat, 1987a). The objects were identical in shape, color, texture, and weight, but one object was made of a soft foamy material, and the other of a rigid lucite tube.

Analysis of the infant's responses over the three-minute period indicate that the frequency of positive pressures (squeezes), both within the oral or the manual modality, vary systematically according to the hardness of the object. From birth, infants are shown to respond differentially to the two objects. Furthermore, differential responding was found in both mouthing and grasping, and this difference was reverse according to the modality. In particular, infants sucked at the soft object (increased frequency of squeezes), and impressed the hard one with protracted bites (decreased frequency of squeezes and particular morphology of the positive pressure's signal). The reverse was found when infants acted manually on the object; infants made repeated grasping motions on the hard object, and clutched the soft one. This finding suggests that soft or hard objects present the infant with different affordances for oral and manual action.

These results demonstrate that from birth, infants show differential haptic responding with mouth and hand toward various qualities of an object. In addition, it appears that mouth and hands are differentially oriented in their haptic response. Manual-haptic response is oriented toward the object's affordance for clutching with the hand tightly closed (afforded by the soft object). Oral-haptic response, including exploration, is framed by the nutritive function of the mouth, and is oriented toward objects' affordance for sucking.

HAND-MOUTH COORDINATION IN THE NEONATE

Oral and manual activities are linked from birth. The Babkin reflex, the opening of the mouth following pressure applied to the palm, can be observed moments after birth. Besides this neonatal stimulus-response connection linking hand and mouth, there is strong evidence for active hand-mouth coordination as well. Hand-mouth contact in the neonate is frequent and often protracted, and is one of the earliest manifestations of a behavioral pattern that integrates two separate motor systems. Neonates often bring their hands to the facial region, sometimes contacting the mouth and eventually introducing finger(s) for sucking. This behavior remains prominent all through the first year, and some authors report that neonates spend up to 20 percent of their waking hours with their hands contacting the oral region (Korner & Kraemer, 1972). Performing a microanalysis of the spontaneous motor activity of newborn infants, Butterworth and Hopkins (1988) showed that the act of bringing the hand to the mouth is independent of the Babkin reflex or the rooting reflex. These authors report remarkable episodes of coordination where infants bring their hand(s) directly to the mouth without prior contact with the perioral region. In these episodes, Butterworth and Hopkins reported that the infant's mouth is often open in "anticipation" of arrival of the hand. Furthermore, trajectory analysis of the hand in its excursion to the mouth reveals great variability, showing it to be a flexible action rather than a spatio-temporally fixed response (Butterworth, 1986; Blass, Fillion, Rochat, Hoffmeyer, & Metzger, 1989). These observations suggest that hand and mouth are actively coordinated from birth, and that the motor control mechanisms underlying their coordination are not reflexive or automatic in nature.

Some authors have suggested that hand-mouth and hand-face contacts are primarily a form of early haptic self-exploration (Kravitz, Goldenberg, & Neyhus, 1978). Others propose that sucking of hand and finger(s) by the neonate serves a self-calming function, and is related to hunger mechanisms (Feldman & Brody, 1978). From the perspective of action systems in development, neonatal hand-mouth coordination has also been considered as an early form of oral capture, and a possible precursor of self-feeding activity (Rochat, 1987b; Butterworth & Hopkins, 1988). All of these interpretations have yet to be substantiated experimentally.

Accidental observations collected while classically conditioning newborn infants (Blass, Ganchrow, & Steiner, 1984; Blass & Hoffmeyer, manuscript under review) indicated that hand-mouth contacts increased following the oral delivery of a small dosage of sucrose solution (0.2 ml of water with 12 percent sucrose). Following sucrose administration and attendant mouthing activities—including tonguing responses—it was frequently observed that the infant would bring one hand to the mouth, initiating protracted hand-mouth as well as hand-face contact. This accidental observation suggested that hand-mouth coordination was enhanced following sucrose administration. A recent series of studies attempted to replicate these incidental observations and assess the function and possible mechanisms controlling hand-mouth coordination in the neonate (Rochat, Blass, & Hoffmeyer, 1988; Blass, Fillion, Rochat, Hoffmeyer, & Metzger, 1989). In particular, consideration was given to whether this behavioral pattern could eventually be brought under the control of certain stimulus conditions.

In these experiments neonates (average age approximately 40 hours) were videotaped as they lay supine in their bassinets. In between two baseline periods of observation, infants were successively presented with oral, olfactory, manual, or vestibular stimulation. Changes in frequency, duration, and type of hand-mouth contact were analyzed, comparing baseline and test periods.

The incidental observations reported by Blass et al. (1984) and Blass and Hoffmeyer (manuscript under review) were verified and replicated experimentally, showing that following the delivery of 0.2 ml of sterile water with 12 percent sucrose, both frequency and duration of hand-mouth contact increased by 50 percent, returning to baseline levels when sucrose stimulation ended (Rochat et al., 1988). During test phases there was also a significant shift in the proportion of hand-mouth contacts compared to hand-face contacts. Hand contacts with the oral region increased as contacts with the rest of the face decreased, and once the hand was in contact with the mouth, it rested there for longer period of time.

Qualitative analysis of the video recordings suggested that sucrose delivery typically had a calming effect on the overall motor activity of the infant. This is important in that sucrose facilitated increases in hand-mouth contacts. These contacts were not likely due to generally enhanced arousal that would have increased the probability of accidental hand-mouth encounters. Furthermore, hand-mouth contacts following sucrose administration were protracted, and appeared to close episodes of superior limb movement. By contrast, hand-mouth contacts were fleeting during baseline periods.

These findings point at a new orientation of manual action centering around the mouth. Based on the apparent termination of limb movements at the mouth, hand transport to the oral region emerges as an unambiguous pattern of oriented behavior. Experimental control over hand-mouth coordination in newborns enabled us to test hypotheses concerning the underlying mechanisms and functions guiding this behavior.

As mentioned above, neonates responded with tonguing and mouthing following sucrose administration. The high predictability of this response, and the fact that it is rythmical, resembling nutritive sucking, lead to the hypothesis that hand-mouth coordination is an integral part of the neonate's feeding system. This hypothesis was tested against another possible interpretation; that hand-mouth coordination is stimulated by the infant's change of state following sucrose administration. Indeed, following sucrose delivery there was a significant reduction of crying episodes, a softening of facial features, and a slowing of side to side head movements (Blass et al., 1989). This general calming could be part of an alternative explanation of the control mechanisms underlying the hand-to-mouth phenomenon. To assess these two hypotheses, infants who cried during the first baseline observation were presented with various stimulations in a series of attempts to calm them (Blass et al., 1989). Attempts to sooth the infants were performed with gentle stroking, quieting sounds, and rocking (vestibular stimulations). Following 5 minutes of these soothing attempts, five deliveries of 0.1 cc plain water were administered to the neonate at a rate of one per minute. The infants were then presented with 5 sucrose deliveries, followed by 5 water deliveries, culminating in a final observation baseline. Results showed that neonates were calmed by all soothing, water, and sucrose treatments. But in spite of the success that these manipulations had in changing the state of the infants (i.e., cessation of crying, and slowing of arm movements), *except for sucrose*, none of them was sufficient to elicit significant increases in hand transport to the mouth (Blass et al., 1989).

Confirming previous findings, sucrose delivery, as opposed to calming per se, appeared to significantly increase the likelihood that the hand will be brought to the mouth. It is interesting to note that it is not simply the administration of fluid that causes the phenomenon, as it is not elicited with plain water. Thus, gustatory stimulation, at least with sucrose, appears to play a primary role in determining coordinated hand-mouth behavior in the neonate. Further support is provided by other observations showing that neonates, when exposed to olfactory stimulation or tactile stimulation of the hand, showed no increase in hand-to-mouth contact. In particular, no significant correlation was found between presentations of chocolate or lemon odor, and enhanced hand-mouth coordination (Rochat, Hoffmeyer, & Blass, 1987d). The odor was presented via a cotton swab dipped into either chocolate or lemon concentrate solutions and moved back and forth under the neonate's nostrils for 10 seconds. Following chocolate odor presentation, some infants were observed mouthing and protusing their tongue. Note that only these two types of olfactory stimulation have been tried out. It is feasible that others might be followed by an increase of hand-to-mouth activity. Similarly, delivery of room temperature water to the ipsilateral hand (relative to face orientation) is not systematically associated with its subsequent transport to the mouth (Rochat & Blass, unpublished observations).

To further understand what guides hand-mouth coordination at birth, potential determinants of the apparent cessation or "closure" of limb movements that followed hand-mouth contact were investigated. In particular, the question addressed was whether only hand-mouth contact would initiate the closure of the action, or whether anything substantial entering the mouth would have a similar effect. To test this, a rubber pacifier was placed inside the infant's mouth one minute after the last sucrose delivery (Blass et al., 1989). Scoring of hand and mouth movements showed that immediately following the insertion of the pacifier, the level of activity in the hands and head decreased dramatically, and in particular, the hands generally came to rest at some distance from the mouth. This observation demonstrated that the completion of this behavioral pattern does not necessarily require hand-mouth contact. Blass et al. (1989) concluded that, "head and hands continue to move until the activated suckling system is brought to balance by the presence of a firm yet soft object to the mouth." Sucrose stimulation appears to engage the neonate's feeding system, which in turn recruits hand-mouth coordination. This coordinated action may be oriented toward providing the infant with an object on which to suck. This orientation is implied in that the substitution of another object (pacifier) for the hand interrupts the coordination. This observation does not support the idea that early hand-mouth coordination is primarily oriented toward self-exploration. Instead, these rudimentary oral explorative behaviors appear to be an integral part of the feeding/sucking system, which, once it is engaged, orients the newborn towards objects affording sucking.

In general, these observations suggest that hand transport to the mouth is perhaps the earliest expression of goal directed action, and one which has been tentatively described as featuring elements of "intentionality" (Butterworth, 1986). It lays the groundwork for later self-feeding and, as discussed below, heralds later developments in object exploration.

THE TRANSITION FROM HAND TO OBJECT TRANSPORT TO THE MOUTH

In this section, some recent observations are presented which suggest that the mouth continues to be central to the control of manual action, and has particular importance in the control of object manipulation early in development. At birth, hand-mouth coordination appears to be controlled by oral stimulation, and as mentioned above, depends primarily on the engagement of the feeding system. During early development, however, there is a rapid and robust change in patterns of oral control of hand-mouth coordination. From two months of age, an infant will bring an object introduced into the hand for grasping to the mouth for oral contact. By five months, this behavioral pattern is the main feature of the infant's spontaneous exploration of objects (White, 1969; Rochat, 1985b, 1989).

Recently an attempt was made to replicate the study of neonatal hand-mouth coordination (Rochat et al., 1988) with a group of 1- to 3-month-old-infants (Rochat, unpublished observations). Preliminary results show that sucrose stimulation has a very different effect on these infants. Instead of calming them, oral delivery of sucrose appears to cause global agitation and even initiates bursts of crying. Rather than sucking, infants frown and express disgust or negative surprise accompanied by apparently disorganized manual and oral action. Out of eight babies that have been tested, only one appears to bring both hands to the mouth following sucrose stimulation. In general, when compared to the baseline periods, no apparent increase in hand contacts with the mouth was observed. Further observations support these apparent changes; following the second baseline, a plastic key-ring was introduced into the supine infant's right hand. Within one minute, the majority of infants brought the object to the mouth for contact. These observations suggest that by the second month there is a change in the control and orientation of hand-mouth coordination. This change finds a new expression, oriented towards bringing grasped objects to the mouth for oral contact and haptic exploration. The root of this action is not the engagement of the sucking/feeding system via oral stimulation, but rather manual/haptic contact with the object as an integral part of the infant's exploratory or investigatory action system.

This transition captures the progression of a precocious coordinated structure of action toward a new functional orientation. Hand-mouth coordination can be described as "self- or body-oriented" at birth and becomes progressively more *object-oriented.* This progression corresponds closely to Piaget's account of the transition from primary to secondary circular reactions (Piaget, 1952). In particular, Piaget interprets hand-mouth coordination as a combining of originally independent schema (i.e., sucking, and grasping), and he views hand-mouth contact in the neonate as accidental and fortuitous (Piaget, 1952). The evidence presented above challenges this view, and in the process raises new developmental questions. In particular, if a coordinated action integrating different sensorimotor systems is present at birth, how is this coordination used and transformed to serve new functions? To tackle this question, consideration was given to whether the new functional orientation of hand-mouth coordination at around 2 months of age is accompanied by a structural change. The observations reported below show that functional orientation as well as changes in the control of posture result in new expressions of hand-mouth coordination.

At birth, hand-mouth coordination is expressed in the transport of one hand to the oral region with rare instances of bimanual involvement. This fact can only be understood in relation to the dominance of asymmetric postures in the neonate. In a supine position, newborns tend to shape their body in an asymmetrical tonic neck posture (ATNP) or "fencing" posture, with the head oriented toward the extended hand and one arm flexed towards the back of the head (Casaer, 1979). In the vast majority of cases, it is the ipsilateral hand relative to head orientation that is brought to the mouth for contact (Butterworth & Hopkins, 1988; Rochat et al., 1988; Blass et al., 1989). Hand-mouth coordination in the neonate generally involves the transport of the hand aligned with the mouth toward the oral region; there is no apparent orchestration or synergy of both hands moving together toward the mouth. Infant action at birth is generally asymmetric relative to the body axis. However, by two months of age, infants in a supine position start shaping their body in a symmetrical posture with the head oriented toward midline. Asymmetric reflexes such as the tonic neck are frequently observed during the first weeks and start to disappear from 2 months on (Peiper, 1962; Bullinger, 1983). When the infant is at rest, both arms are often flexed upward or spread to the sides as in a mirror image. The emergence of symmetrical postures, and the accompanying progress in postural control, parallels changes in the expression of hand-mouth coordination. By three months of age, infants transporting a grasped object to the mouth for oral contact mobilize both hands in synergy, exhibiting a predictable bi-manual pattern (see Figure 14.2 below for illustration). In general, the grasping hand meets the other at midline, and they move together toward the mouth. These later observations are part of a recent investigation that focused on the transport of object to the mouth by 2- to 5-month-old infants (Rochat & Avery, manuscript in preparation).

Based on video recordings of 2- to 5-month-olds freely exploring an object introduced in one hand for grasping, a micro level analysis was performed (5 images/sec) of the first instance where the object was transported to the mouth. Change in hand-to-mouth distance was plotted during the two seconds preceding and the second following object-mouth contact. Figure 14.2 illustrates the simul-

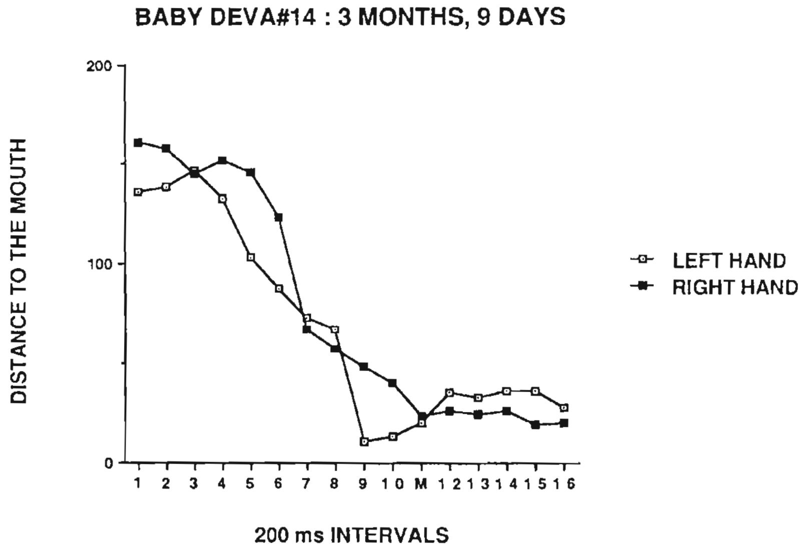

Figure 14.2. Successive changes in relative distance to the mouth of left and right hand during the transport of an object to the mouth by a 3-month-old infant. The graphic representation is clearly indicative of a synergistic involvement of both hands during transport (bimanual transport). The relative distance of each hand to the mouth was calculated every 200 milliseconds during the 2 seconds prior and the 1 second after the moment (M) of contact of the object with the mouth (Rochat & Avery, in preparation).

taneous motion of the hands during transport in a 3-month-old infant. In this figure, the successive changes in relative distance of hands to the mouth are plotted indicating that hands move in a remarkable synergy during the journey of the object to the mouth.

This type of bimanual engagement can be observed in infants from two months on, but over the next few months one can witness rapid changes in the expression of object transport to the mouth. From a synergy where one hand mirrors the other, the hands begin to move independently. This is illustrated in the Figure 14.3 where the performance of a 5-month-old in her first transport of the object to the mouth is represented. Again, change in distance of the hands relative to the mouth was plotted, clearly showing the independent functioning of the hands. The hand grasping the object is involved exclusively in the transport, while the other hand remains relatively still. By 5 months, more instances of unimanual engagement in object transport were found, and less synergistic bimanual involvement. Figure 14.4 shows the proportion of one-handed vs. bimanual transport of object to the mouth in 2-, 3-, 4-, and 5-month-olds (10 infants per age, $n = 40$). Again, the first transport of the object to the mouth was considered in this analysis. As clearly indicated on Figure 14.4, by 5-months of

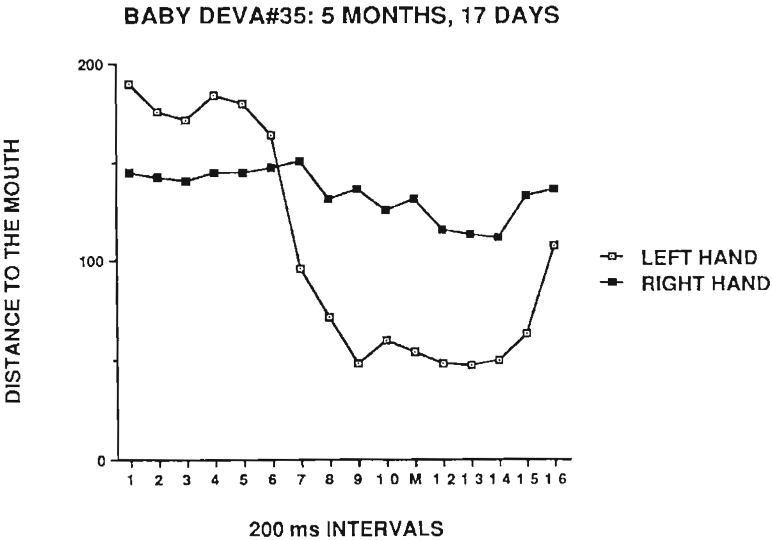

Figure 14.3. Successive changes in relative distance to the mouth of left and right hand during the transport of an object to the mouth by a 5-month-old infant. The graphic indicates a one-handed transport by the left hand, the right hand remaining relatively still in relation to the mouth (Rochat & Avery, in preparation).

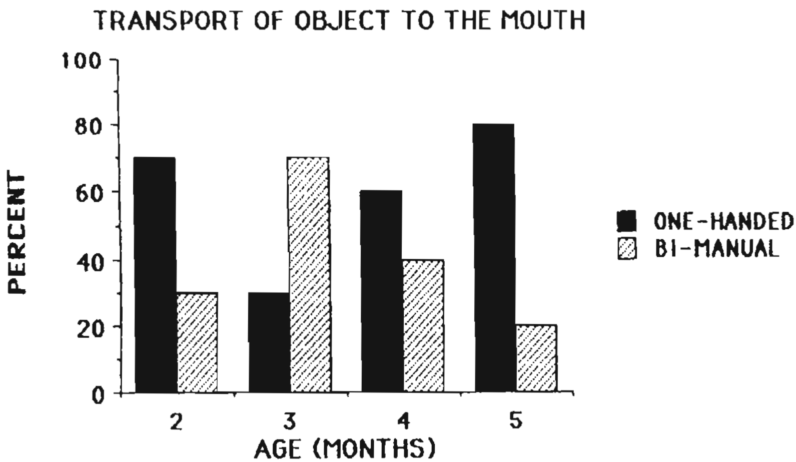

Figure 14.4. Percent of one-handed versus bimanual transport of an object to the mouth in 2-, 3-, 4-, and 5-month-olds (n = 40, 10 infants per age). This analysis included each infant's first transport of the object to the mouth which terminated with an oral contact (Rochat & Avery, in preparation).

age asymmetry was again the primary expression of hand-mouth coordination in the transport of objects to the mouth. This resurgence of the independent involvement of the hands is nevertheless fundamentally different from that displayed by the newborn, and infants up to two months of age. It is no longer linked to reflex postures and the engagement of the feeding system, but instead corresponds to progress in object manipulation and exploration. Indeed, by five months of age infants show systematic asymmetrical use of hands in their manipulation and exploration of objects (Rochat, 1989). Typically, they support graspable objects with one hand and finger it with the other. At this age, manual behavior displaying functional differentiation of hands is part of a new repertoire of exploratory actions (Rochat, 1989).

RELATIONS BETWEEN THE TRANSPORT OF OBJECTS TO THE MOUTH AND EARLY REACHING BEHAVIOR

Object transport to the mouth precedes the mastery of visually guided reaching in development (Piaget, 1952). Only around 4 months of age do infants start to systematically and successfully reach for objects they have identified visually (White, Castle, & Held, 1964; Gesell, 1940; von Hofsten, 1979, von Hofsten and Lindhagen, 1979). Nevertheless, there are earlier signs of eye-hand coordination. Some recent studies demonstrate incipient reaching during the first months and even in neonates (von Hofsten, 1982; von Hofsten & Fazel-Zandi, 1984). Both hand-mouth and eye-hand coordination appear to originate from organizations present at birth, but typically develop at different rates, exhibiting a reliable order in development.

Some authors have suggested that the developmental precedence of hand-mouth coordination is preparation for later eye-hand coordination (Piaget, 1952; Korner & Kraemer, 1972). In Piaget's view, for example, manual grasping would be first actively coordinated with oral activity, then further integrated with vision via a process of reciprocal assimilation (Piaget, 1952). Such a constructionist interpretation, however, cannot accommodate recent evidence of organized patterns integrating visual, oral, and manual actions from birth.

In the following section, the relationship between object transport to the mouth and reaching will be assessed, focusing on their chronological appearance in development. It is suggested here that the development of visually guided reaching observed between 4 and 8 months of age repeats the development observed for manual transport of objects to the mouth occurring between 2 and 5 months. Observations are provided indicating that there is indeed a powerful analogy between the development of these actions. Some observations are provided which indicate that visually guided reaching is another form of integrated action oriented toward the transport of objects to the mouth.

A longitudinal study has been concluded on the emergence of reaching and its

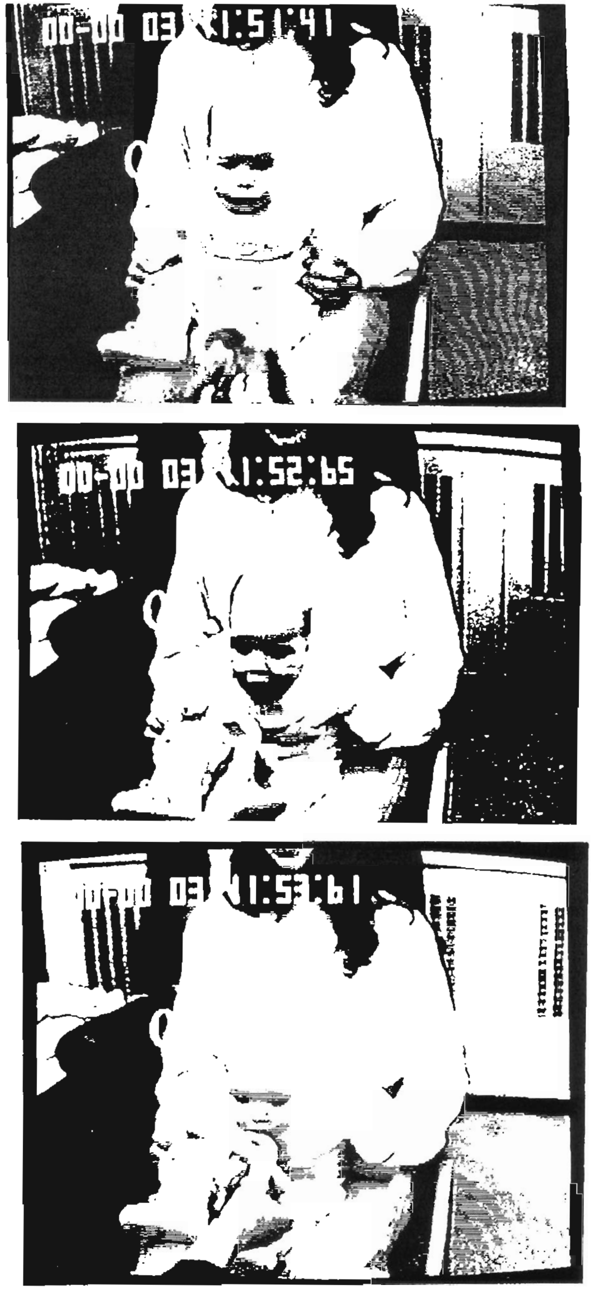

Figure 14.5. Oral capture of an object by a 4-month-old infant with both hands constrained next to her sides by her parent. In this condition, the infant is shown to lean forward with mouth open until object is finally contacted orally. The three snapshots of this action are separated by approximately one second (see the digital clock with last two digits referring to 1/100 of a second). At the bottom of each pictures, the object held by the experimenter's hand is visible (Rochat, in preparation).

relation to oral capture (Rochat, in preparation). From the time they started to reach for things placed in front of them (around three months) and until they became expert reachers (around 6 months), infants (n = 3) were filmed weekly while reaching for an object successively presented at shoulders' height, either at midline or in a left- or in a right-side presentation. The infant was seated on the parent's laps and at one point of the experiment, the parent was asked to constrain the infant's hands by holding them down by the infant's sides (see Figure 14.5). While both hands were secured, the object was presented to the infant at midline. As illustrated in the Figure 14.5, infants tended to lean forward in order to orally capture the object presented in front of them when their arms were constrained. All the tested infants showed at one time or another such a behavior in this particular condition. For two out of the three infants included in this study and prior to 5 months of age, the occurrence of such oral capture in this constrained condition was frequent, if not systematic. From 5 months on, infants usually fought to free their hands in order to grasp the object. This remarkable behavior clearly indicated that early reaching is goal-directed toward oral contact with the object. When hands are constrained and unavailable, infants use trunk movements to get the object to the mouth. It suggests that early reaching ultimately participates in action oriented toward oral capture.

One-handed reaching towards a seen object has been extensively studied (see Yonas & Granrud, 1985, for review), but unfortunately, to the exclusion of bimanual involvement. In particular, the relation between hands during reaching has not received much attention. The unimanual bias in infant reaching studies originates from the absence of systematic study of eye-hand coordination in relation to the development of postural control. Recently, infant reaching patterns were shown to be profoundly affected by the degree of postural support available (Rochat & Stacy, 1989). In particular, infants unable to sit on their own will systematically reach with both hands forward whenever they are provided with enough postural support to keep them from falling. Infants between 5 and 8 months of age were observed reaching for an object that was first presented out of reach and then slowly moved frontally along the infant's midline to within reach. The objects were colorful balls 4 cm diameter, presented at shoulder height. The infants were videotaped from overhead while reaching in four postural conditions: (a) supine, (b) prone against a board tilted 75 degrees relative to the ground, (c) seated reclined, and (d) seated upright. For the analysis, infants were divided into two groups: babies who were able to sit on their own for at least 60 seconds ("sitters," mainly 7–8-month-olds), and those who were not ("non-sitters," mainly 5–6-month-olds). Figure 14.6 shows the mean proportion of bi-manual and uni-manual reaches for each group and for each posture condition. Infants with self-seating ability (7–8-month-olds) systematically reach with one hand regardless of the postural condition. By contrast, young reachers with no self-seating ability (5–6-month-olds) show a massive tendency to reach with both hands in all postural conditions except when seated upright. This latter

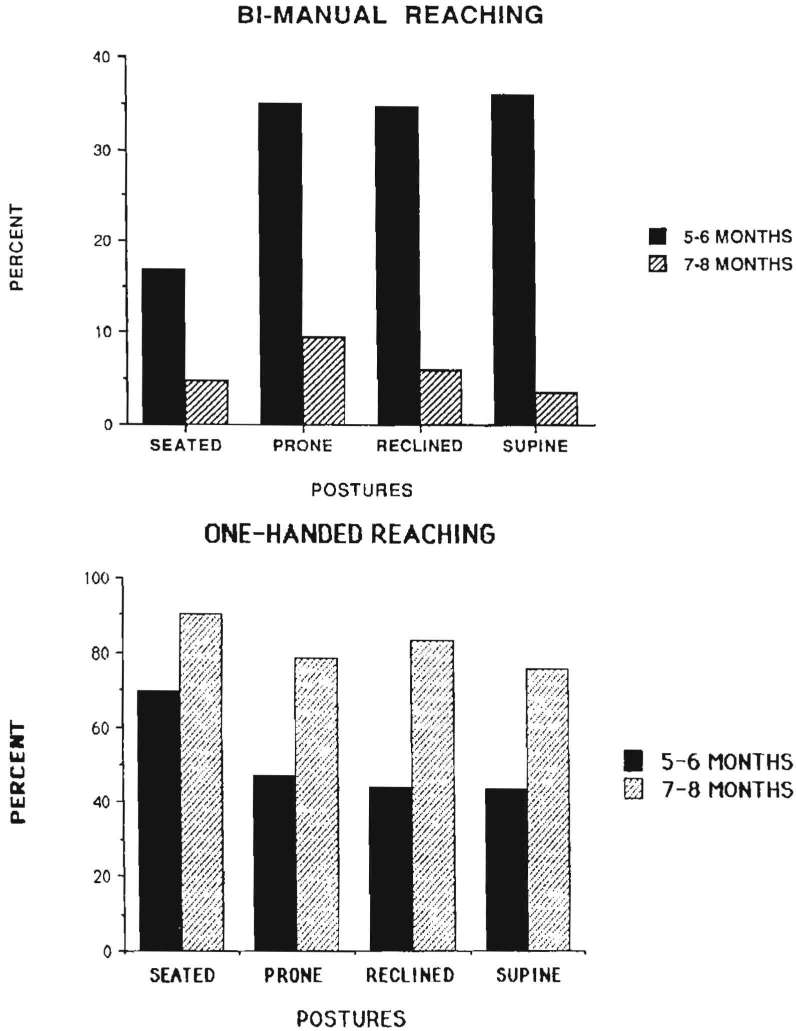

Figure 14.6. Mean proportion (%) of bimanual (figure 14.6a) and one-handed reaches (figure 14.6b) according to posture and age. This analysis included 32 infants, 18 who could not yet sit on their own (5–6-month-olds) and 14 who could sit on their own with no external support for periods longer than 60 seconds (7–8-month-olds) (Rochat & Stacy, 1989).

posture is the postural condition used in most research on early reaching, and might explain why infant reaching has been seen as predominantly a one-handed action (see the review of Yonas & Granrud, 1985). In fact, the observations shown in Figure 14.5 imply that when provided with adequate postural support,

Figure 14.7. Overhead view of a 6-month-old infant engaged in a one-handed reach for an object presented in front of him. Note that the other (left) hand is mobilized to maintain balance, preventing a lunge forward. At the time, this infant could not sit on his own and when provided with enough postural support, he tended to reach for the object with both hands forward (bimanual reach) (Rochat & Stacy, 1989).

infants will reach with both hands forward. Typically, bimanual reaches entail synergistic movements of the hands toward the object ("crabbing" motion).[1] This pattern becomes significantly less important by 7–8 months, as infants show more asymetrical use of the hands. In the seated upright condition shown in Figure 14.7, the apparent synergy of hand motion found in the younger group breaks down as the nonreaching hand is mobilized for balance and postural support.

The independent functioning of hands in 5–6-month-olds is related to the postural constraints and balance requirements of reaching. At this age, the lack of postural control constrains the infant to use one hand in reaching and the other to maintain balance and support. By contrast, the unimanual reach of the older infant was apparently guided by exploration rather than constrained by instability. At 7–8 months, change in the body's center of gravity while reaching has no apparent consequence on the reaching pattern, and the infant shows

[1] Movements of hands are synergistic because when one of the infant's is constrained, the reach is disrupted through loss of accuracy, decrease in reaching attempts, struggle, and frustration of the infant (unpublished observations).

independent functioning of hands (one-handed reach) *regardless of the postural condition*. Self-seating entails a degree of postural control which frees the infant to reach bimanually when seated upright without risking a fall. Nevertheless, these infants more often reach for and finger the object with one hand, indicating a preference and inclination for the asymetrical use of hands. It is interesting to note that this inclination also corresponds developmentally to the emergence of asymetrical use of the hands in object manipulation and exploration (i.e., fingering and object transfer from hand to hand; Ruff, 1984; Rochat, 1989).

The evolution of both reaching and manual transport of objects to the mouth strongly suggest a general developmental trend; hands first move in symetry, later in independence. There is in both cases a progression from bimanual action organized in mirror-image synergy about vertical midline, toward an asymetrical involvement of the hands. This progression, first observed in hand-mouth coordination, repeats itself within the context of a different sensorimotor integration (i.e., eye-hand coordination). The developmental progress observed in early object transport to the mouth does not appear to simply "generalize" when combined with another modality (i.e., vision). Rather, some aspects of eye-hand coordination and its development appears to be a *recapitulation* of prior progress in hand-mouth coordination. For example, a 5-month-old infant will show an asymetrical use of the hands when transporting an object to the mouth, but when reaching, will use both hands in a mirror-image synergy. In this case, the infant shows particular expertise in bringing an object to the mouth, but appears unable to integrate this expertise with vision. It is as if the infant had to relearn what he/she mastered in the context of hand-mouth coordination. In fact, the observations reported above suggest that this development is related to progress in the control of posture. The two types of action examined here, reaching and object transport to the mouth, each require different degrees of postural control. The transport of objects to the mouth generally entails only subtle changes in the body's center of gravity, while the leverage and forward motion of the limbs involved in reaching requires more powerful postural adjustments. These differing constraints and requirements might explain the observed time lag (*décalage*) in the development of what otherwise appears to be a singular action.

CONCLUSIONS

As mentioned in the introduction, the unveiling of behavioral sophistication in the neonate calls for a new conception of early behavior as well as for a reopening of developmental questions concerning the control, functional orientation, organization, and changes in infant action from birth. The observations on active touch in infancy reported above are rich in implications for the understanding of the control-variables underlying behavioral changes in infancy.

In this concluding section, four major points will be highlighted. First, it is argued that, in order to adequately capture the origin of developmental changes, there is a necessity to consider early behavior in relation to its functional orientation. Second, the mouth (i.e., oral capture) is presented as the primary organizer of infants' active touch such as reaching and object manipulation. Third, it is suggested that a main observable feature of early development is the change in relative dominance of various action systems. Finally, the central role of posture (i.e., postural control) is emphasized as a variable controlling active touch in infancy, and early action development in general.

REASONS FOR A FUNCTIONAL TAXONOMY OF ACTION FROM BIRTH

Hand-mouth coordination in neonates further demonstrates that early behavior can potentially integrate different sensorimotor systems. It is not merely reducible to a collection of isolated responses, but rather, is best described as integral part of overall actions or action systems. Neonates are active rather than responsive. They engage in various activities that are, as rudimentary as they might appear, oriented toward the environment: They orient to sound, track visual targets, imitate, learn, suck, look, and grasp preferentially. All these activities are behavioral patterns attuned to particular events, objects and, in general, to environmental resources. Within this perspective, an important task for any student of infancy is to provide an inventory of the environmental resources that guide infant action from birth. These resources are basic categories within which infants operate and develop. Based on our observations, for example, neonates suck preferentially on an elastic nipple and show more grasping activities on a rigid object. They are sensitive to and guided by what these objects afford for the particular action system that is engaged (i.e., sucking or grasping). To make sense of early behavior, there is a need to interpret the precocious preferences and differential responding of the neonate in relation to the environment. Considering that behavior is oriented from birth and that it corresponds to actions rather than reflex responses, it is necessary to consider early behavior in the context of the adaptive function it serves and for which it develops. That is, to describe the young infant's behavior without an explanation of the environmental circumstances in which the behaviors are found, or an understanding of the larger behavioral action network within which isolated behaviors occur, is clearly incomplete. The necessity of a *contextualization* of infant behavior is dictated by the type of observations reported here and by other empirical evidence now accumulating in the infancy literature. In general, the apparent fact that neonates do not respond in a vacuum but act in a resourceful environment provides grounds for a functional taxonomy of action from birth.

At the beginning of the chapter, neonates were reported to respond differentially to intraoral objects varying in texture, shape, and material. The more excentric the nipple is from its biological shape and substance (i.e., the more its physical characteristics deviate from a rubber nipple approximating the breast), the more it will be associated with exploratory rather than sucking activities. From birth infants appear to be oriented toward the nutritional potential of the nipple, and in general, toward what objects afford for action. This simple observation provides another illustration that neonates are interacting with a resourceful environment furnished with objects having particular affordances.

ACTIVE TOUCH IN INFANCY: THE IMPORTANCE OF ORAL CONTACT

A common feature to the observations compiled in this chapter is the importance of the mouth as a haptic system, and in general, the importance of oral contact early in development. From birth, the mouth is more than a feeding device. When novel objects are introduced into the mouth, in addition to sucking, infants show increased patterns of exploratory mouthing, including lipping, gumming, and tonguing (see also Pêcheux, Lepecq & Salzarulo, 1988), and also chewing when introduced to solid food (Sheppard & Mysak, 1984). Prior to the emergence of fine manipulation such as fingering around 4–5 months, the mouth is indeed the privileged instrument of haptic exploration (Rochat, 1989).

Analogous to the distinction between perceptual and grasping functions of the hands introduced by Hatwell (1987) in her account of the early development of manual behavior, it is heuristically meaningful to distinguish between oral exploration and oral *capture* to account for the early development of oral/haptic behavior. Oral capture refers to all the actions participating to the approach phase of the object (including hands) prior to contact with the mouth. Indeed, prior to any oral exploration, the mouth needs to be brought into contact with the object to be explored. This preliminary phase includes orientation (i.e., rooting) but also approach or transport of the object to the mouth.

Oral capture may be the earliest, and is certainly the clearest case of goal-oriented (oral) behavior. This was strongly suggested by observations of the neonate's mouth opening in apparent anticipation of hand-mouth contact (see also Butterworth & Hopkins, 1988). The general impetus of the young infant for oral contact is expressed in action patterns that integrate multiple sensorimotor systems, some of which are already manifest hours after birth and possibly by the end of prenatal life. Considering the importance of oral capture in early development, it is surprising that students of infancy have paid so little attention to it. Excepting the work of Connolly (1973) on the development of spoon use in early self-feeding activities, there is, as noted by Valsiner (1987), a lack of empirical investigations of oral capture in infancy. Early reaching behavior (von Hofsten, 1979, 1982; Yonas & Granrud, 1985) has been essentially studied as an expression of eye-hand coordination, even though Bruner pointed out long ago that the mouth often serves as the "*tertium quid*" or third element between vision and the hand, consisting in the actual *terminus* of early guided reaching activity (Bruner, 1969, p. 227). For example, when both hands are constrained, young infants often lean their trunk forward with mouth wide open to orally capture and contact the object presented in front of them. These observations, reported and illustrated in Figure 14.5 of this chapter, clearly support the idea of a link between the emergence of reaching and the oral capture of an object. In particular, they suggest that early reaching might be goal-directed toward oral contact and exploration of the object.

Reaching does not appear to be geared toward manual/haptic contact per se, but rather toward grasping of the object for its transport to the mouth. Again, this observation emphasizes the importance of the mouth as part of a perceptual/haptic system which emerges prior to the development of fine manual activities (i.e., fingering) around 6-months of age (Rochat, 1989). It also underlines the role of the mouth in canalizing early manual action.

Potentially, the mouth plays an important role in organizing manual behavior, guiding primitive grasping, and the transport of objects. The role of vision and its coordination with the hands is, of course, important but needs to be seen as originally serving the basic goal of oral capture. Early eye-hand coordination is an integral part of this oriented action and cannot be dissociated from what appears to be its third and dominating link: the mouth. Other evidence corroborates this link between hand-mouth and eye-hand coordination early in development. Observations presented in this chapter show that there is an isomorphism in the developmental progression of these coordinations emerging in succession during the first 6-months. The morphological changes of reaching behavior between 5 and 8 months seems to recapitulate those observed in the transport of objects to the mouth between 3 and 5 months. In general, infants are bimanually engaged, and become essentially one-handed in performing these actions. Questions remain as to what mechanisms underly this progression. Clearly, change in the control of overall body posture seems to be an important factor of this phenomenon. Note that other questions remain concerning the underlying motives of the young infant as he or she systematically brings things into oral contact. For example, are the motives unchanged between 2 and 9 months when the frequency of object transport to the mouth is reported to decline (Ruff, 1984; McCall, 1974)? The observations reported in this chapter suggest that these motives are different, and that this difference originates from the relative dominance of developing action systems together with changes in the dynamic of their interaction.

EARLY DEVELOPMENT AND THE INTERACTION BETWEEN ACTION SYSTEMS

If the mouth appears to dominate active touch during the first months of life, the expression of this dominance changes. In general, the observations reported above indicate that the mouth is primarily dominated by a nutritive function at birth, even though neonates' oral action is not merely reduced to sucking but also includes active mouthing that has been identified above as haptic exploration. Between birth and four months, manifestation of nonnutritive sucking decreases significantly as oral exploration increases. Although both sucking and exploration coexist, the developmental trend is toward an expanding repertoire of oral action in which exploration appears to progressively take over from nutrition as a major determinant of oral behavior. Another sign of this takeover is the reported observation that hand-mouth coordination at birth appears to be an integral part of the feeding system and is re-oriented toward object exploration starting at 2–3 months. At birth, sucrose stimulation elicits hand transport to the mouth and sucking. By two months, this does not seem to be the case anymore, and by three months hand-mouth coordination is mainly observed when an object is placed in the infant's hand for grasping. As already discussed, by 4–5 months hand-mouth coordination is essentially the terminal action of visually guided reaching. Eventually, the exploratory function of the mouth is delegated to the hands as they become instrumental for fine haptic exploration under visual supervision (Rochat, 1989).

By the end of the first 6 months, infants tend to bring a grasped object first in the field of view for visual inspection rather than to the mouth for oral contact—a reverse of earlier tendencies (Rochat, 1989). With the increasing importance of the hands as perceptual instruments, the haptic potential of the mouth appears to progressively reintegrate the feeding system it originally differentiated from, as it controls the processing of solid food. The emergence of chewing (Sheppard & Mysak, 1984) illustrates this progression toward a specialization of oral exploration within the context of solid food processing. The mouth evolves as a multifunctional, multipurpose device serving communication and nutrition, as well as the vital task of determining what is edible and ingestible.

THE CENTRAL ROLE OF POSTURAL CONTROL IN EARLY ACTION DEVELOPMENT

The dynamic of the interaction between action systems provides a rich description of the development of active touch in infancy. Nevertheless, it does not account for the mechanisms responsible for this development as it does not specifically point to the variables controlling these changes. As a final note, a restatement is given to the central role of postural control in the early development of action in general, and active touch in particular.

As mentioned above, functional reorientation of oral action and changes in the status of the mouth parallel and interact with progress in the development of the hands as fine haptic systems. This development itself parallels and interacts with changes in the control of posture. Indeed, the basic prerequisite of hand use, as in reaching, object manipulation and exploration, is the freeing or *liberation* of the hands from constraints of postural maintenance. For example, when infants are unstable while sitting on their own and are not provided with adequate body support, hands are mobilized for the maintenance of posture and cannot be engaged in exploratory activities. As back and neck muscles take over the control of posture, hands are free to manipulate and explore. Meanwhile, the oral/haptic potential of the mouth develops within the specialized function of food processing (i.e., emergence of chewing).

A remarkable demonstration of the importance of posture and its control in the emergence of sensorimotor skills early in development are the observations of Grenier (1980, 1981) and Amiel-Tison (1985) on the role of posture on motor behavior and level of attention in neonates. By holding the neonate's head firmly in the axis of its trunk while sitting, Grenier reported precocious visuomotor coordination with the infant showing reaching patterns toward an object lying on a table in front of him. According to Grenier, the apparent sensorimotor clumsiness and the obligatory responses of the neonates are linked to poor neck control. When experimentally provided with adequate postural support to remedy their "neck impotence," neonates reveal striking sensorimotor aptitudes.

In conclusion, we would like to suggest that the development of behavior and attention in infancy must be viewed in the context of the interactions between systems, rather than *isolates*. In particular, within the realm of sensorimotor development, evidence suggest that posture and its relative control plays a central role in the development of active touch in infancy. Unlike the vast majority of existing research, future studies should focus more on the role of posture as a potential control variable of early perceptual and motor development.

FINAL NOTE; THE NEONATE AS AN ACTIVE EXPLORER

One of the major methodological and empirical breakthroughs in infancy research has been the demonstration that young infants manifest systematic preferences for certain stimulus configurations over others (Fantz, 1963). Infants, and even neonates, were shown to manifest habituation or "boredom" for certain familiar displays, showing dishabituation or recovery of interest for new ones. Important experimental paradigms originated from the discovery of habituation, dishabituation and preference phenomena. The preferential looking paradigm, for example, has been instrumental to the recent unveiling of infant cognition (Spelke, 1985).

The discovery of these phenomena also drastically changed common conceptions of the neonate as a helpless individual bombarded by undifferentiated stimulation. Babies started to be regarded as active explorers whose behavior is oriented toward selected aspects of the environment. Extensive empirical evidence now demonstrates that from birth infants are actors in a resourceful environment (Eimas, 1982; Gibson & Spelke, 1983). Furthermore, the characterization of the neonate's repertoire of behaviors as a collection of unrelated reflexes (Wyke, 1975; Bronson, 1982; Piaget, 1952) no longer holds in view of recent research progress.

The view presented in this chapter indicates that the newborn and young infant is also an active participant in their oral-manual haptic exploration of the environment. Moreover, assessment of oral-manual behaviors during the early months of life is greatly facilitated by studying the action systems in which they reside. From this perspective it is possible to assess not only what stimuli elicit a response from the infant, but also a broader picture of the dynamic interaction between the infant's action systems and affordances presented in the environment.

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