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Mouthing and Grasping in Neonates: Evidence for the Early Detection of What Hard or Soft Substances Afford for Action

PHILIPPE ROCHAT

University of Massachusetts

Newborns and 2- and 3-month-old infants were presented for 3 min with a rigid or an elastic object either introduced into their mouths for mouthing or into their right hands for grasping. Each object was connected to an air pressure transducer allowing polygraphic recording of the positive pressure variations applied by the infant to the object. Results indicate that, from birth, infants haptically discriminate between the rigidity and elasticity of objects by generating different rates and patterns of responses. Furthermore, the differential haptic responding by the infant does not manifest itself in an analogous manner for the oral or the manual modality of response but is reversed relative to the two objects' properties. During the first 3 months, a developmental trend is observed wherein the infant's oral response rates and patterns begin to align themselves with her/his manual responding to either one of the two objects. Relative to a similar output of positive pressures generated orally or manually, these observations show that from birth the infant's response is both object-dependent (hard vs. soft substance) and modality-dependent (oral vs. manual condition). These results are interpreted as suggesting that early mouthing and grasping are not merely controlled by reflexive (automatic) mechanisms but rather are guided by what objects afford for functional actions.

neonates mouthing grasping affordance

Recent evidence suggests that, rather than being reflexive, early action needs to be interpreted as task-oriented, context-specific, and under some sensorimotor control (Thelen & Fogel, 1986). From birth, infant behavior appears attuned to particular aspects of the environment and oriented toward exploration, thus it is not solely reducible to the compulsive nature of reflexes (Gibson & Spelke, 1983; Spelke, 1986). Early actions such as the reproduction of facial move-

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Correspondence and requests for reprints should be sent to Philippe Rochat, Department of Psychology, University of Massachusetts, Amherst, MA 01003.

ments of a visually perceived model, prereaching patterns of arm movements toward a moving object, sucking, and stepping can be viewed as part of action systems with specific adaptative functions like communication, exploration, consumption, or locomotion (Reed, 1982, 1984). J.J. Gibson (1979) suggested that from birth, behavior is oriented toward the detection of what objects in the environment afford for action. Gibson's theory of affordances provides a new description of early behavior considered in conjunction with and in relation to the environment. Behavior is primarily considered as not occurring in an ecological vacuum (Gibson, 1982; Rochat & Reed, 1987). The present research investigates the capacity of the neonate to modulate his/her repertoire of manual and oral activities relative to objects with different affordances for hand and mouth.

Sucking and grasping are commonly assessed during the first neurobehavioral examination immediately following birth. These responses belong to the normal repertoire of sensorimotor activities displayed by the newborn. For a long time, observations have shown that prenatal behavior is related to these activities. When stimulated with a variety of mechanical and electrical stimuli, the human fetus shows contractions of all muscles and extremities (Hooker, 1938). For example, manual grasping has been observed when the palm of fetuses as young as 11 weeks of menstrual age is tactually stimulated. Moreover, sucking activity in the fetus has been reported (Hooker, 1938; Humphrey, 1970). These early observations indicate that such activities exist prior to any transaction with the world outside the womb. This might explain the inclination of neonatologists and students of infant behavior to view sucking and grasping as part of a collection of rigid reflexes or archaic automatisms (Koupernik & Dailly, 1972). In their view, the newborn is approached as a spinal individual whose behavior has the fundamental connotation of being controlled by reflexive mechanisms which become deliberate or cortically mediated later in development (Bronson, 1982; McGraw, 1943; Wyke, 1975). In Piaget's constructivist approach, early sucking and grasping are viewed as hereditary patterns of action (relexes) which are preadapted and ready to function immediately after birth (Piaget, 1952). During the first stage of sensorimotor development, sucking and grasping patterns are described as being "exercised" or "used" in the course of the first weeks. Through exercise (i.e., repetition), the neonate is presented as actively extending the range of application of these hereditary oral and manual patterns by assimilating new objects to their schema. Piaget has observed that after a few days of this exercising, there are already signs of accommodation of these patterns which the neonate alters in an apparent process of adaptation to novel situations and new objects (observations 1-5 in Piaget, 1952).

Some evidence exists which indicates that the control of manual and oral activities at birth cannot merely be reduced to reflex mechanisms. Pollack (1960) studied the eventual relationship between the tonic neck reflex (TNR) and the plantar or palmar grasping response in newborns. Although able to

show a relationship between the plantar grasp response and the asymmetrical posture of the TNR, Pollack did not observe any interaction between the TNR mechanism and the *palmar* grasp. Butterworth (1986) observed in newborns that the act of bringing the hand to the mouth is neither accidental nor associated with mechanisms such as the rooting reflex or the Babkin reflex. The hands of the newborn are brought significantly more often to the mouth and for longer periods of time following tactile-gustatory stimulations of the oral zone (Rochat, Hoffmeyer, & Blass, 1987). This behavioral change, however, is observed in a lesser extent following olfactory stimulations. Newborn infants show outlines of reaching with arms and hands toward a visual target moving close to them (von Hofsten, 1982). Likewise, neonates' sucking response rate appears significantly affected by visual or auditory stimulations (Keen, 1964; Sameroff, 1967; Semb & Lipsitt, 1968) or when their posture is changed (Bullinger & Rochat, 1984). Furthermore, newborn infants differentially suck and explore nipples that vary in shape and material (Rochat, 1983). Thus, manual and oral activities at birth appear to be controlled based on sensory information issued from a coalition of modalities (Rochat, 1986). Studies of early cross-modal transfer indicate that young infants process "a-modal" information that is not specific to particular perceptual systems. Meltzoff and Borton (1979) have shown that infants as young as 1 month of age visually prefer the shape and/or texture of an object they previously explored with the mouth only.

The findings of an intersensory organization controlling action at birth as well as the evidence of a precocious capacity to perceptually discriminate and transfer information across modalities have led to renewed questions about the kind of information guiding action early in development. For example, the question remains unanswered as to whether the precocious capacity to process "a-modal" information also entails that from birth different sensory-motor systems (visual, manual, oral, etc.) are equally oriented toward the pickup of the same information specifying the environment. In the present research, we consider early manual and oral responses in relation to different objects' characteristics. In relating these responses to particular objects in the environment, we aim to discuss what determines oral and manual actions early in development. In particular, our objective is to provide evidence that functional orientations attached to different sensory-motor systems (i.e., oral and manual) determine the infant's interaction with objects in the environment from birth on. This study is a first attempt to discover the relation between early actions' functions and primitive categories of discrimination among objects in the environment.

From birth, hands and mouth are viewed as two sensory-motor systems used by the infant to pick up haptic information about objects in the environment. This view is based on the fact that both of these body parts have the highest density of tactile receptors relative to the body surface. Furthermore, both manual and oral activities appear well-organized from birth within the pre-

functional sensorimotor structures of sucking and grasping. When in contact with an object which is introduced into either the mouth or the hand, neonates generate in both cases *positive pressure* variations on this object (Rochat, 1983; Twitchell, 1965). In theory, the similar outcome of positive pressures spontaneously applied on the object either orally or manually should equally inform the neonate about the more or less rigid (or elastic) substance of an object. Gibson and Walker (1984) observed that infants as young as 1 month of age were able to extract information about the softness or rigidity of an object merely through exploration by the mouth or the hands, and were able to use this information in a subsequent visual recognition test. In line with Meltzoff and Borton (1979), oral or manual capacity of discrimination was inferred from a preferential looking test and was not directly documented at the level of oral and manual exploratory activities. There is no indication that the infants showed a differential response within the haptic modality during the pretest. The design used to assess the ability for cross-modal matching prior to 3 months of age does not allow for a comparison of tactile discriminative behavior within and between the two haptic modalities (i.e., oral and manual).

RATIONALE AND EMPIRICAL QUESTIONS

The neonate's capacity to detect different affordances of an identical object for hand and mouth activities was investigated in the present study. In this perspective, the response to an object introduced either into the infant's mouth for mouthing or into the hand for grasping was assessed and compared. Manual and oral positive pressure responses were compared when applied to two objects varying in their elasticity or rigidity. Both objects were identical in shape, texture, and dimension and varied only in consistency—one was made of a rigid material and the other was made of a spongy material. Based on the following considerations, each of these two object's consistencies was regarded as defining different affordances for manual or oral action. The breast's nipple was considered as the biological prototype which provides an optimum match or affordance to sucking activities. Among other characteristics, such as its texture, temperature, shape, size, and spatial orientation relative to the oral cavity, there is evidence that the elastic constitution (suppleness) of the nipple determines its "suckability" for the young infant (Lipsitt & Kaye, 1965; Rochat, 1983). Indeed, relative to the oral modality, temperature, size, shape, and spatial orientation can be viewed as determinants of the object's "mouthability." Once inside the oral cavity, the object's flexibility (i.e., substance) should be the main determinant of whether the object is more or less "suckable" in the sense of eventually affording an oral extraction of liquid from it. Furthermore, based on the fact that the size of a "mouthable" object corresponds closely to the size of a "graspable" object for the young infant, the manual and oral responses were compared relative to the identical objects varying only in their substances. It was assumed that if the substance of the object was elastic like a nipple, the infant would respond orally in accordance to its affordance

for sucking and would manifest a differential responding when it was rigid. The comparative study of these responses within the oral and manual modalities was undertaken in order to discuss the origin of haptic discrimination in relation to the functions attached from birth to hands and mouth activities (i.e., sucking and grasping).

The rationale of this study was based on the assumption that from birth different functions dominate manual and oral activities. Manual and oral activities were viewed as the outcome of distinct action systems. The mouth of the neonate, whose dominant function is nutrition, indicates essentially sucking responses and thus belongs to the appetitive or ingestive action system. In contrast, the neonate's hands show grasping responses which appear to be guided by a "clinging" rather than nutritional function. Indeed, as much as the young infant appears, to a naive observer, as compulsively engaging in sucking on almost any physical bodies contacting the oral zone, his/her hands attempt to grip on almost anything the palms contact. Taking into account that different functions might guide early manual and oral activities, it was hypothesized that identical objects of the environment could potentially be associated with specific responses within each of these modalities. Furthermore, the different functions guiding oral and manual activities of the young infant could also potentially determine specific manifestations in the haptic discrimination of the same objects experienced either orally or manually. This would indicate that the infant's response is controlled by the object's characteristics on the basis of what they afford for functional actions. Formulated in operational terms, we tested the eventual interaction between (a) the rigid or elastic substance of an object presented to the neonate, and (b) the manual or oral modality of response to the object.

Developmental observations have shown that compared to newborns, 2- and 4-month-old infants show a significant increase in tongue and lips' scanning and a decrease in sucking in response to nonnutritive objects introduced into their mouths (Rochat, 1983). In regard to manual activities, spontaneous exploration of a novel object put in the infant's hand for grasping develops rapidly between 2 and 5 months of age. During this period, infants' manual activities evolve from "passive" holding (clinging) of the object to an active manipulation including bi-manual exploring, switching of hands, and fingering (Rochat, 1985). Based on these observations, the eventuality of a less marked differential responding according to the modality in the course of early development was assessed. Following the rationale of this study, if the nutritional function guiding oral action at birth becomes less dominant in the course of the first semester, the substance of the object should have less influence on the infant's oral response during the third and fourth months after birth. Similarly, if the clinging function of manual activity at birth becomes less dominant, the relative support for grasping provided by either one of the object's substances should have less influence on the infant's manual response by 4 months of age. In other words, if both manual and oral responses become primarily exploratory as part of a perceptual/haptic system of action, they would share the common

orientation of the system (i.e., exploration). This can be described as the orientation toward the discovery of the object's novelty and what it affords for action. In general, the widening repertoire of the infant's manual and oral activities entails the discovery of new affordances of the object. From being more or less suckable or graspable, the object would become the common source of novel interactions beyond the original functional orientation of hands and mouth activities at birth.

Three empirical questions guided the present study:

1. Do newborn infants show differential haptic responding to the rigid or elastic substance of an object?
2. If a differential haptic responding is manifested by neonates, does it manifest itself in an analogous manner within the oral and the manual modalities?
3. In the course of the first 3 months of life, what are the developmental features of manual and oral responses to rigid and elastic characteristics of an object?

METHOD

Subjects

Three groups of subjects were tested. The first group (A) consisted of 24 full-term healthy newborns (12 males, 12 females) with a postnatal age-range from 49 to 96 hours at time of testing (average age of 70 hours). All had a 1- and 5-min Apgar score greater than 8 and an average birthweight of 3186 gms. The newborns were tested at a large maternity hospital (Women and Infants Lying-In Hospital, Providence, RI) in a separated testing room run by the Child Study Center of Brown University. Half were breast-fed and half were bottle-fed 2 to 3 hours before testing. The second group (B) consisted of 20 2-month-old infants aged from 65 to 87 days with a mean age of 79 days (7 females, 13 males); 16 were breast-fed and 4 were bottle-fed an average of 1 hour before testing. The third group (C) consisted of 24 3-month-old infants aged from 99 to 152 days, with a mean age of 112 days (15 females, 9 males); 20 were breast-fed and 4 were bottle-fed an average of 1½ hours before testing. Groups B and C were tested in the infant laboratory at the University of Pennsylvania and came from primarily white middle-class families living in the Philadelphia suburbs.

In addition to the total number of 68 infants who completed testing and were used in the analysis, 2 newborns, 3 2-month-olds, and 3 3-month-olds were tested but were excluded from the sample due to poor state and rejection of the object.

Objects and Apparatus

Positive pressure variations applied to two different objects connected to an air pressure transducer (Grass Instruments) were recorded via a polygraph

(Grass Instruments 5). Both objects had an identical cylindrical shape, 5 cm in length and 1 cm in diameter. Both were covered by a thin cream-colored rubber coat (sterile finger coat) providing the same color and texture to each object. The objects weighed approximately 20 gms and varied only according to their consistency, which was either rigid ("Hard" object) or elastic ("Soft" object). The Hard object was made of a rigid hollow lucite bar and the Soft one was made of a foamy material (synthetic sponge). The rubber surface around each object was airtight to the air pressure transducer's tubing. Pressures on the external surface of the object entailed changes of pressure on the thin air cushion separating the rubber coat enveloping the object and the rigid or elastic core of it. The pressure variations were recorded on the polygraph. Compared to the Hard object, the elasticity of the Soft object caused approximately 10 times the number of large amplitude signals recorded on the polygraph for equivalent positive pressures applied to it. Thus, when the Hard object was connected to the apparatus, sensitivity of the polygraph was increased accordingly to enable between-objects comparisons. The slightest manual or oral pressure pushed the rubber coat toward the object's constituting material. Previous tests of the display with a group of adult subjects showed no indication that the rubber coat interfered with the discrimination of the two varieties of the objects' consistency.

Procedure

Each subject was seated in a 45°-inclined infant's seat facing the experimenter. Half of the infants in each age group were presented for 3 min with one object in their mouths for mouthing (Oral Condition), and the other half were presented with an object in their right hands for grasping (Manual Condition). Within the Manual and Oral conditions, half of the infants were presented with the Hard object and the other half, with the Soft one. In each condition, the object was hidden from the infant's view before and during the testing. In the Oral Condition, the experimenter touched the infant's lips with the extremity of the object until the mouth opened; the object was then inserted 4 cm inside the oral cavity. The object was never forced into the infant's mouth. While the infant was mouthing the object, the experimenter remained silent, holding gently the object at its junction with the air pressure tubing. In the Manual Condition, the experimenter held the object at its junction with the tubing and inserted it inside the infant's right hand with its extremity lying between thumb and index finger. When the baby grasped the object, the testing began. Grasping and finger pressure variations on the object were recorded. The placement of the object between index and thumb allowed for grasping and finger movements without the object dropping from the infant's hand. When the object was dropped, the experimenter placed it back in the infant's hand. Testing was discontinued if the infant began to fuss or if the infant repeatedly rejected the object by systematically dropping it or rejecting it with the tongue.

RESULTS

The frequency of positive pressure ("Squeezes") applied either orally or manually by the infant on either the Hard or the Soft object was first calculated. An individual Squeeze is 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. This threshold was determined for each infant as an individual baseline because there is a large variation in response strength among subjects. Within each age group, comparisons of individual pressure thresholds were made among all conditions. There was no evidence of systematic variations according to object or modality. Thus, threshold variations among infants reflect individual differences in response strength at the time of testing rather than being due to manipulated variables.

Table 1 shows the mean frequency of Squeezes and standard deviations over the 3-min oral or manual presentation of the Hard or Soft object for each of the three age groups. Figure 1 shows a graphic representation of these results in which the mean frequency of Squeezes is plotted for each age group relative to the oral or manual modality and the two objects' substances. An overall 3(Age) × 2(Modality) × 2(Object) mixed-design analysis of variance was performed on the mean frequency of Squeezes. This analysis shows a significant main effect of Age, $F(2,56) = 10.66$, $p < .0001$, and of Modality, $F(1,56) = 11.89$, $p < .001$. Furthermore, the ANOVA shows a significant Modality by Object interaction, $F(1,56) = 8.33$, $p < .005$, and a significant Age by Modality interaction, $F(2,56) = 13.28$, $p < .0001$.

These results indicate that from birth, infants show differential haptic responding to rigid or elastic substances of an object. Furthermore, this differential responding depends on the modality, being reversed according to the oral or manual response. When grasped, the Hard object is associated with significantly more frequent Squeezes compared to the Soft object. When mouthed, the reverse tendency is observed: There were significantly more re-

TABLE 1
Mean Frequency and Standard Deviation of "Squeeze" Responses to the "Hard" and "Soft" Objects According to Age and Modality Conditions

	Manual Condition		Oral Condition	
	Hard	Soft	Hard	Soft
Newborns	37.00	3.67	89.83	135.50
SD	23.11	4.59	77.39	43.92
2 months	30.5	15.00	15.75	36.00
SD	28.5	6.29	13.81	49.54
3 months	40.00	14.00	16.67	27.83
SD	43.6	5.87	20.34	32.40

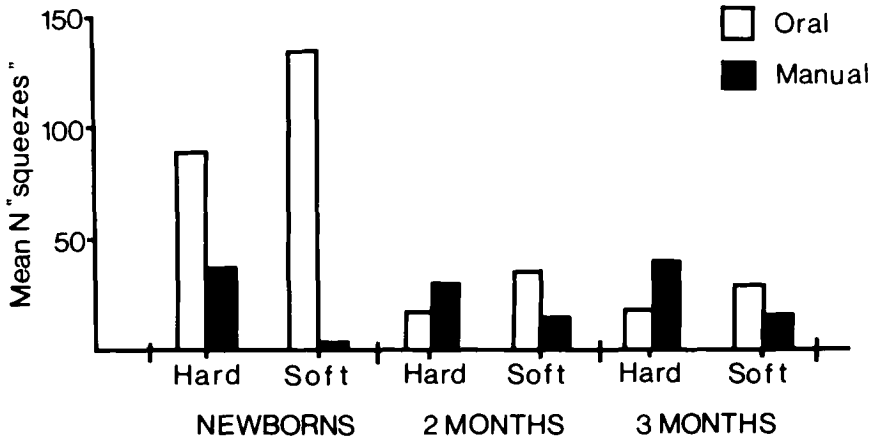

Figure 1. Mean frequency of "Squeeze" responses for the group of newborns, and 2- and 3-month-olds according to the object's substance (Hard vs. Soft) and modality condition (Oral vs. Manual).

sponses to the Soft object compared to the Hard object. A 2(Modality) × 2(Object) analysis of variance performed for each age group, separately, indicates that only newborns manifest a significant Modality by Object interaction, $F(1,20) = 4.42$, $p < .05$. It appears that the differential responding described above characterizes the newborns. However, a similar tendency is present, although attenuated, with the 2- and 3-month-olds (see Figure 1). Finally, an age trend was observed indicating that newborns manifest a significantly greater frequency of oral compared to manual responses (modality main effect, $F(1,20) = 24.15$, $p < .0001$, whereas the older infants show no significant difference in frequency of response according to the modality. At 2 and 3 months of age, infants appear to respond at a comparable frequency rate either manually or orally during object presentation.

At a qualitative level, different patterns of positive pressures (Squeezes) applied by the infant upon the object have been further distinguished in the analysis. Due to intrinsic properties of the apparatus, Figure 2 illustrates two distinct polygraphic recordings obtained according to the relative duration of pressure applied upon the object. These two types of recordings are relative to patterns of Squeezes, whether manual (like the illustration in Figure 2) or oral. When the infant maintained his/her squeeze of the object for longer than 1 s, the pen of the polygraph, after its excursion above the one-third threshold, smoothly came down to the zero baseline. This signal was labeled as a "Clutch" pattern of response. In contrast, when the infant immediately released his/her squeeze of the object (within less than 1 s), the polygraph pen abruptly dove under the zero baseline. This signal was labeled as a "Squeeze-Release" pattern of response. This latter pattern was identified on the polygraphic chart when the pen's consecutive dive under the zero baseline was at least one third in proportion to the positive signal it followed.

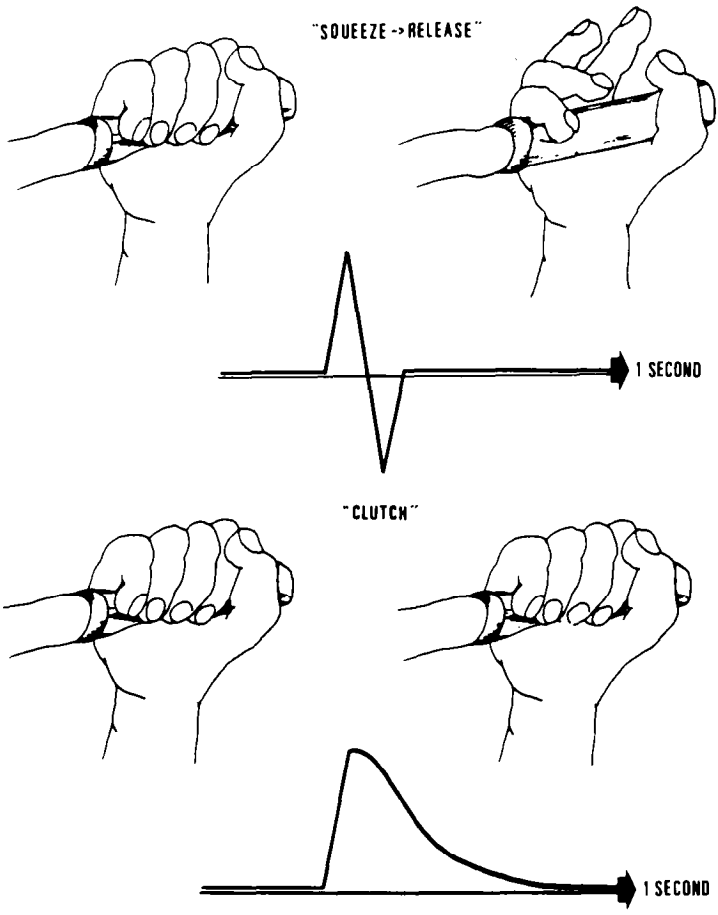

Figure 2. Illustration of the two patterns of "Squeeze" response distinguished in the analysis ("Squeeze-Release" vs. "Clutch") and their corresponding record on the polygraph over a 1-s recording period. Though the illustration shows manual responses to the object, the same distinction has been operated whether either one of the objects was presented orally to the infant.

The proportion of these two patterns of response according to age, modality, and object was assessed by calculating the frequency of Squeeze-Releases relative to the overall frequency of Squeezes (ratio of Squeeze-Releases freq./ Squeeze-Releases freq. + Clutches freq.). Table 2 shows the mean values with standard deviations of this ratio over the 3-min oral or manual presentation of the Hard or Soft object for each of the three age groups. Figure 3 shows these ratio values for each age group relative to the oral or manual modality and the hard or soft objects. A 3(Age) × 2(Modality) × 2(Object) mixed-design analysis of variance indicates a significant overall interaction between the three variables, $F(2,56) = 3.12$, $p < .05$, and a significant Modality main effect, $F(1,56) =$

TABLE 2
Mean Ratio of "Squeeze-Release" Frequency Over the Sum of "Squeeze-Release" and "Clutch" Frequencies to the "Hard" or "Soft" Object, According to Age and Modality

	Manual Condition		Oral Condition	
	Hard	Soft	Hard	Soft
Newborns	0.47	0.36	0.64	0.91
SD	0.09	0.37	0.26	0.09
2 months	0.45	0.33	0.63	0.74
SD	0.13	0.22	0.23	0.19
3 months	0.40	0.37	0.82	0.58
SD	0.09	0.16	0.19	0.33

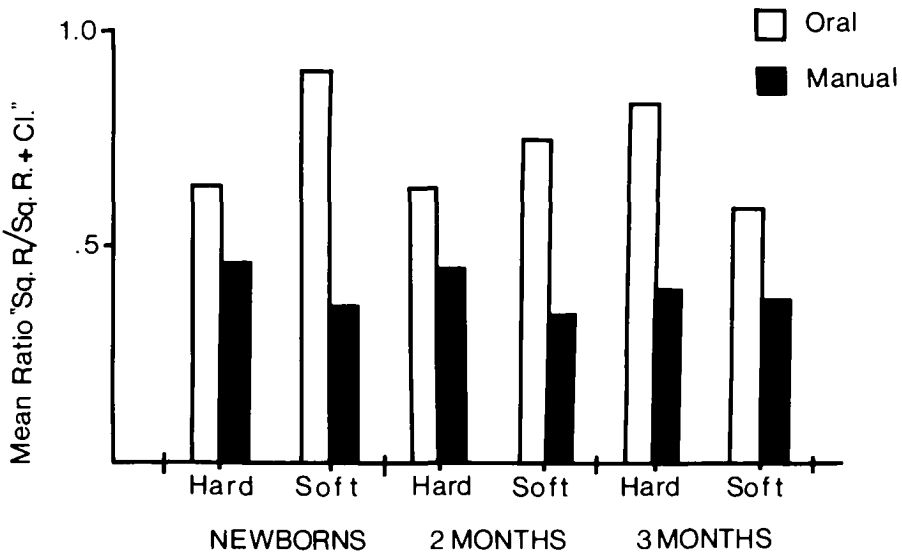

Figure 3. Mean ratio of the two patterns of "squeeze" response ("Squeeze-Release"/"Squeeze-Release"+"Clutch") for the group of newborns, and 2- and 3-month-olds according to the object's substance (Hard vs. Soft) and modality condition (Oral vs. Manual).

37.01, $p < .00001$. At all ages and for both objects, the proportion of Squeeze-Release patterns of response is significantly higher within the oral modality, the Clutch pattern being a prominent when the object is grasped. Considered separately, the group of newborns showed a close-to-significant Modality by Object interaction, $F(1,20) = 3.76$, $p < .06$. At birth, infants tend to manifest more responses of a Squeeze-Release pattern when mouthing the Soft object compared to the Hard one. When grasping, they tend to show the reverse. For this age group, the results show a similar trend as those obtained with the responses' frequency analysis. There was no significant Modality by Object inter-

action for the group of 2- and 3-month-old infants considered separately, $F(1,16) = 2.25$ and $F(1,20) = 1.53$, respectively. Figure 3 illustrates this developmental trend, showing that, compared to the neonates, the Modality by Object interaction is less marked at 2 months and disappears by 3 months of age. Indeed, the older group indicates a reversal in responding to the two objects within the oral modality when compared to the younger groups. At 3 months, the infant appears to match, orally, the ratio of manual patterns shown at the youngest age (higher proportion of Squeeze-Releases to the Hard object and more Clutches to the Soft).

DISCUSSION

The present findings suggest that early mouthing and grasping are related to the object they are applied to. In particular, we observed that rigidity of an object affects the frequency and pattern of oral and manual actions at birth. Neonates' mouthing and grasping, being *Object-Dependent,* suggests that these activities are not merely under the control of reflexive mechanisms. Indeed, they do not present themselves as triggered by any kind of stimulation, but are rather actively modulated according to the object's characteristics. Answering the first empirical question guiding this study, these results indicate that neonates generate differential haptic responding to either rigid or elastic substances of an object. The behavioral differences observed at birth cannot be solely explained by the variety of physical resistances offered by the rigid or elastic consistency of the object. It could be argued that the Hard or Soft object provides different feedback to automatic mouthing and grasping—the activity "self-triggering" itself once engaged and until it dies out. According to this reasoning, the rigid object should provide more stimulation and thus be associated with more oral or manual responding. Our findings of an interaction between Object and Modality contradict this assumption. If the prediction seems correct regarding the manual response of the young infant, we observe the *opposite* within the oral condition. When mouthing the object, the Soft substance is associated with more frequent Squeezes and an increase in the ratio of Squeeze-Release patterns of action. When grasping it, there are less frequent Squeezes and a trend toward more Clutch patterns. This interaction shows that the differential haptic responding of the neonate is both *Object-* and *Modality-Dependent.*

Relative to the second empirical question, neonates do not manifest analogous responding whether grasping or mouthing either the Soft or the Hard object. Again, this latter observation calls for an interpretation beyond physiological mechanisms such as reflexes. Indeed, the infant's response, as measured here quantitatively and qualitatively, appears neither automatic nor rigid. Rather, the infant's response is controlled both by the object's characteristics (Hard or Soft substance) and the sensory-motor system involved (Oral or Manual action system). The finding of an interaction between the kind of object presented to

the infant and the modality of his/her response suggests that from birth infants actively modulate their haptic responding as opposed to merely reacting to nonspecific tactile stimuli.

In order to make sense of the fact that the neonate interacts differently with an object grasped or mouthed, it is necessary to interpret these results in light of (a) the functions attached to hands and mouth activities at birth, and (b) the object's characteristics defined in relation to these functions. From a general point of view, these results suggest that from birth the function attached to a modality influences the nature of the infant's discriminative response. In this view, Gibson's concept of "affordances" (1979) offers a meaningful descriptive tool to define objects in the environment in behavioral terms, that is, in terms of what they afford for functional actions within the particular oral or manual system of action. At the beginning of life, objects appear to be differentiated based on their suckability with respect to the mouth and graspability with respect to hands. In the oral condition, results show that the Soft object is associated with more frequent Squeezes and that these responses are more often followed, within less than a second, by a consecutive antagonistic releasing action (Squeeze-Release pattern). This pattern of positive pressure variations corresponds to the individual sucking response applied on a rubber nipple introduced in the baby's mouth (Rochat, 1983). The higher frequency of Squeezes with a pattern corresponding to sucking indicates that the Soft object is detected by the neonate as more suckable compared to the Hard object. The opposite trend observed in the manual condition indicates that within this modality the two substances are not discriminated on the same grounds. Compared to the Soft one, it appears that the Hard object is discriminated on the grounds that it provides more support for grasping activities and too much rigidity for clutching.

The results obtained with the group of newborns show that from birth, the infant's discriminative responses depend on the functional orientation of the action system involved. Moreover, they support the idea of an early detection of what objects afford for functional actions.

From the perspective of early development, the infant's responding to the two objects' substances appears less modality-dependent. Compared to the newborns, the 2- and 3-month-old infants respond to the two objects at a significantly more comparable rate of Squeezes within the oral and the manual modality. More precisely, results show that with age, there is a progressive alignment of oral response frequency over manual, with the frequency of the latter remaining stable at all ages. These results suggest that the developmental trend observed is based on a change within the oral modality. The nutritional function of the mouth might be less dominant by 3 months when the infant is less engaged in sucking responses. This would be consistent with other findings in which a general increase of oral exploration and decrease of sucking in response to various nonnutritive objects were observed in infants within the same age range (Rochat, 1983). Further support for this interpretation is provided

by the ratio of the two patterns of response. At 3 months, there is no longer evidence of a Modality by Object interaction. Within the Oral condition, older infants generate more Squeeze-Release responses to the Hard object and fewer to the Soft. Considering that the Squeeze-Release pattern of response corresponds to sucking, this result suggests that by 3 months of age, the suckability of the elastic or rigid substance no longer determines the differential oral responding to the two objects. From the less dominant nutritional function of the oral system (less sucking) emerges new interactions with the object and new grounds for discrimination. This apparent change of function within an action system corresponds to behavioral changes in which the infant becomes differently oriented toward objects in the environment and eventually generates opposite responses toward the same object. The present findings indicate that functional reorganization and change of orientation appear as key concepts in the interpretation of how the young infant discovers new environmental resources. More research dealing with infant behavior in relation to the discovery of environmental resources will greatly contribute to a better understanding of early development and provide a more complete account of what is responsible for behavioral changes in infancy.

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