

ORAL TOUCH IN YOUNG INFANTS: RESPONSE TO VARIATIONS OF NIPPLE CHARACTERISTICS IN THE FIRST MONTHS OF LIFE

Philippe ROCHAT *

Brown University, USA

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Newborns, and one, and four month olders, were presented for 90 sec with nipples varying in shape and in shape plus material. Pressure variations applied by the infant to the nipples were recorded. Overall activity as well as sucking and exploratory patterns of response were studied by observation of the polygraph records. Results suggest that a developmental trend exists, showing an increase in oral exploration and a decrease in sucking. Further, this age trend is influenced by the type of nipple. For the younger infants the addition of the novel material appears to be the basis of a differential response. For the older infants, global shape appears to be a relevant stimulus characteristic. These findings support the contention that there is a double function of the mouth: nutritive as well as perceptual. The tactual capacity revealed here is present within the first months of life and evolves relative to certain stimulus characteristics.

In the first months of life, general perceptual and motor organization develops rapidly as the infant extends his/her grasp upon the environment (Piaget 1936). The baby first interacts with the world predominantly through oral activity. As psychoanalytic theories have stressed (Abraham 1954; Freud 1936), the oral zone is not merely a "feeding hole" but should also be looked on as the infant's primary locus of

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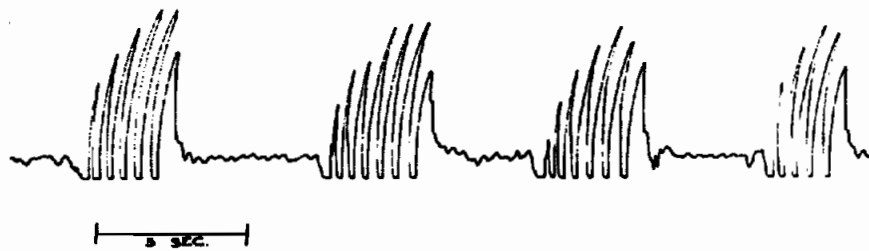
Reprints may be requested from Philippe Rochat, Department of Psychology (FPSE), Université de Genève, 1211 Geneva 4, Switzerland.

contact with caring persons, and indeed, with the surrounding world. In the field of perception, the oral zone is of great empirical interest since, along with the hands, the mouth has the highest concentration of tactile sensory receptors. Rapoport (1972), in reporting a case of an infant deprived of oral and body surface sensation whose motor development was markedly delayed, suggested that tactual perception plays an important part in the development of the infant's sensory motor organization and thus should be considered as a developmental capacity contributing to a growing knowledge of the environment. Despite the significance of this modality to early perception, little is known about the development of tactual abilities in infants.

A common measure in investigations of the sensory and perceptual capacities of the non-verbal infant is the sucking response (Kaye 1967), generally used in conditioning or habituation procedures associated with tactual (Lipsitt and Kaye 1965), visual (Siqueland and DeLucia 1969) and speech (Eimas 1975) perception. In such studies a nipple connected to a pressure transducer is placed in the infant's mouth, and a polygraphic recording of the oral response is made to document successive bursts of different frequencies and rates, with intervening periods of rest. The burst-pause pattern of sucking behaviour, illustrated in fig. 1A, is apparently reflexive in nature and has been found to have a stable temporal organization under standard no-fluid conditions. It is partially controlled, however, by incentive conditions (e.g., varying levels of sweetness) when fluid is delivered (Crook 1979; Lipsitt 1977).

The perceptual activity of the mouth and the tongue, which is the privileged organ of this tactual area because of its high sensitivity and mobility, does not always entail a sucking response. As diagrammed in fig. 1B, a distinct pattern of oral behaviour corresponding to movements and scannings of tongue and lips relative to the intra-oral stimulus is also evident in the polygraphic recordings. This apparent exploratory oral behaviour typically has been disregarded as a distinctive mode of oral-tactual response, even though it may be a more specific perceptual response compared to sucking.

Recent studies (Bryant et al. 1972; Ruff and Kohler 1978) have demonstrated an early capacity to match visual and tactual perception. These studies show an ability in infants as young as six months of age to tactually (manually) discriminate shape. Meltzoff and Borton (1979) report that infants of only 29 days can visually discriminate a previ-



B.

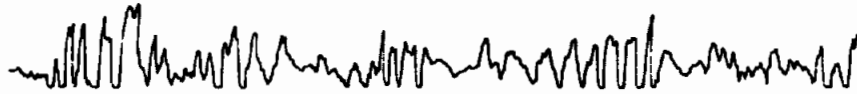


Fig. 1. A: Typical polygraphic recording of sucking responses appearing as successive bursts separated by rest periods. In the present research this pattern is defined as a minimum of three successive rhythmic positive pressures, above a 3 mm H₂O threshold (3 mm vertical displacement of the polygraph pen for a pre-established level of the display's sensitivity).

B: Typical polygraphic recording of exploratory responses to an intra-oral stimulus by the infant. In the present research this pattern is defined as a succession of irregular positive pressures above a 3 mm H₂O threshold for a continuous period exceeding one second.

ously touched oral object. These findings raise the questions of what stimulus features the infant may be responding to in tactual perception, and what features may be transferred to another modality. In the Meltzoff and Borton study the stimuli differed in shape as well as texture (pacifier with or without nubs). Using a different procedure, Lipsitt and Kaye (1965) studied the sucking rate of human newborns to different intra-oral stimuli. These authors observed that a regular nipple elicits more sucking than a tube and concluded that both contour and texture are important in optimizing the sucking response of the young infant. Taken together, these experiments suggest that tactual discrimination and cross-modal transfer exist at an early age. However, the use of a cross-modal design (i.e., the visual fixation technique as a measure of tactual discrimination) cannot precisely assess the extent to which the response measured directly reflects the influence of stimulus variation. Additionally, if tactual discrimination does indeed exist, it is not clear to what degree this is due to the development of the response during the first months of life.

Nipples that varied in material, and which ranged in shape from normal biological to eccentric, were introduced. Both sucking and exploratory responses were measured. Polygraphic recordings of differential pressure applied to the nipples allowed documentation of the relative proportions of these two patterns occurring during presentation of each stimulus.

The empirical questions of interest were: (1) Considering both sucking and exploratory behaviours, does the infant respond differentially to oral stimuli that vary in physical characteristics (here in material and shape)? and (2) If such a differential response exists, is there a developmental trend within the first months of life?

Method

Subjects

Thirty normal infants from three age groups were included in this study. In Group 1, ten neonates from a maternity hospital in Providence, RI, were tested. These infants ranged in age from 42 to 93 hr, with a mean age of 71 hr, and had an Apgar score of 8 or more. In an attempt to control for differential experience that is typically found with newborns, we included both nursing ($n = 5$) and bottle fed ($n = 5$) infants in our sample. Group 2 included ten infants from a children's orphanage in Providence, RI. They ranged in age from 10 to 54 days, and had a mean of 37 days. In Group 3, ten more infants from the orphanage were tested. They ranged in age from 62 to 302 days, and had a mean of 128 days. Sexes were approximately equally represented in all groups. All babies were tested during the third hour following last feeding. Infants in Groups 2 and 3 were bottle fed. With the exception of newborns, all infants had experienced pacifiers that were similar in shape to the bottle nipple used in the institution, and identical to the control stimulus employed in the present research.

Stimuli

Four different nipples (S1, S2, S3, S4) connected to an air pressure transducer (Grass Instruments) providing polygraphic recordings (Grass Instruments 5) were used. These intra-oral stimuli varied in shape only.

or in shape plus material, as illustrated in fig. 2. The control stimulus (S1) was a rubber nipple approximating the normal biological shape. S2, a rubber orthodontic pacifier, never experienced before by the tested infants, differed only in shape from S1. S3 and S4 were the same rubber shape as S2 but differed in that a brass element was attached to the nipple. This element (2 mm thick and 8 mm in diameter) was round for S3 and ring-shaped (also 2 mm thick and 8 mm in diameter, with a 6 mm inside diameter) for S4. These brass elements were riveted to the middle of the flat side of NUK rubber nipple, so that once in the infant's mouth the brass element faced the tongue and the curved side of the nipple was against the palate.

Thus, S3 and S4 differed from one another in shape of the attached element. Both accentuated the deviation from the normal nipple by a shape plus material novelty.

Procedure

Each of the four different nipples was successively presented for 90 sec to each infant. The control nipple (S1) was presented at the beginning and end of the session to assess possible response rate change throughout

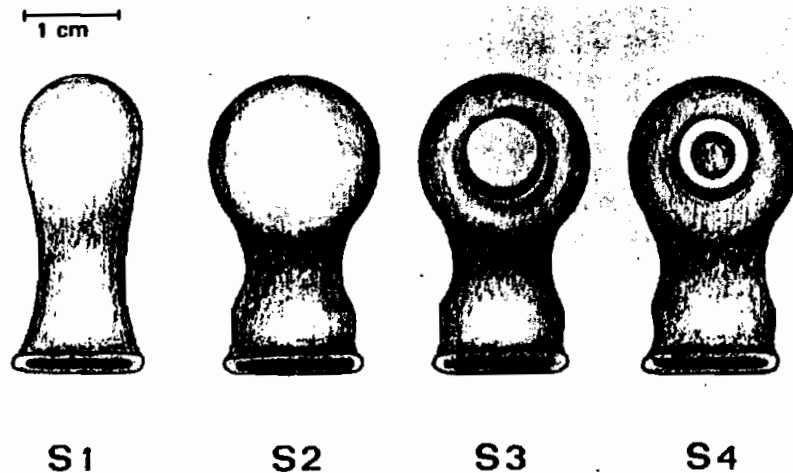


Fig. 2. The four different intra-oral stimuli: S1, the control stimulus familiar to the tested infants. S2 varying in shape only as S3 and S4 varying in shape plus material, a round and a ring shaped element made of brass being respectively attached to the novel nipple.

the testing. The order of presentation of the remaining nipples (S2, S3, and S4) was randomized among infants of each group. Time between presentation of the nipples was 15 sec. For each presentation the infant's lips were touched with the appropriate nipple until the mouth opened, then the nipple was inserted. The nipple was never forced into the baby's mouth, but was held gently during the 90 sec of testing which started with the insertion of the nipple. The experimenter always hid the nipple from the infant's view and testing was stopped when crying or fussiness appeared. Very few sessions were disrupted (1 out of 11 for Group 1, 2 out of 22 for Group 2 and 3). Before insertion, the nipple was soaked in a glass of water at room temperature to control for potential contrast of temperature between the nipples.

Results and discussion

For each 90 sec presentation of a stimulus, the percentage of overall activity as opposed to rest was calculated. This activity response was then further differentiated into sucking and exploratory patterns. First we consider the results from overall activity.

Overall activity

The threshold of an overall activity response was defined as a minimum 3 mm vertical displacement of the polygraph pen for a time longer than one sec. At a constant level of sensitivity, a 3 mm vertical displacement of the polygraph pen corresponded to 3 mm H₂O positive pressure applied to the intraoral stimulus. Fig. 3 presents the mean percentage of time that infants of different age groups exhibited the activity response for each stimulus. To insure that responding was stable throughout testing, a comparison of performance for the initial and final presentation of S1 was made. Since no differences were found at any age level, only the data for the initial presentation of S1 are considered in the analysis that follows.

A 3(age) × 4(type of nipple) mixed design analysis of variance was performed on mean percentage of overall activity. Significant main effects of age ($F_{(2,27)} = 6.258, p < 0.01$) and type of nipple ($F_{(3,81)} = 8.288, p < 0.01$) were found. These effects are qualified by a significant age by type of nipple interaction ($F_{(6,81)} = 2.699, p < 0.05$). Table 1

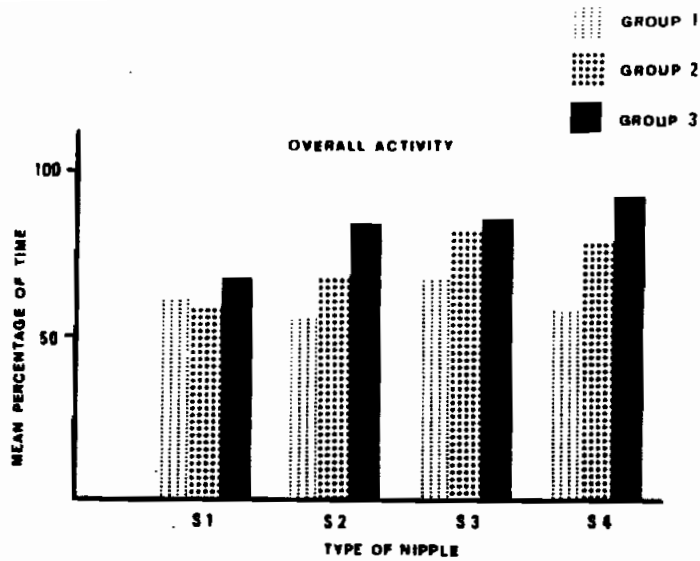


Fig. 3. Mean percentage of time (over the 90 sec presentation), infants of the 3 different age groups show overall activity response (sucking+exploratory patterns) for each of the four different intra-oral stimuli.

presents the mean percentage of overall activity for each of the stimuli at each age level.

Tukey tests (Kirk 1968: 88-90) of the interaction revealed that significant differences in overall activity were apparent only between S2 and S3 for Group 1 ($p < 0.05$) whereas Group 2 showed differences between S1 and S3, and S2 and S3 ($p < 0.01$ and $p < 0.05$, respectively). In Group 3 a difference in overall activity between S1 and S3 ($p < 0.01$) as well as between S1 and S2 ($p < 0.01$) was found.

Table 1

Mean percentage (over the 90 sec presentation) of overall activity for each of the four different intra-oral stimuli at each age level.

Age groups	Stimuli			
	S1	S2	S3	S4
1 (Newborn)	61.5	55.2	67.2	57.9
2 (1 month)	58.5	67.1	81.2	78.3
3 (4 month)	67.3	84.3	85	92.3

In this experiment the sucking pattern of response (SUCT) corresponds operationally to three or more rhythmic pressures above the activity threshold (3 mm H₂O). In order to be considered part of a sucking pattern, individual pressures could not differ by more than one third amplitude from the preceding one. On the other hand, the exploratory pattern of response (EXPL) was considered as a succession of irregular pressures above the activity threshold for periods longer than one sec.

In order to have a measure of sucking as an activity, the proportion of sucking relative to overall activity (SUCT + EXPL) was calculated. This ratio (SUCT/SUCT + EXPL) gives an indication not only of sucking but also regarding the proportion of exploratory responses relative to overall activity. Since these responses are related in this fashion, only the sucking ratio was analyzed.

Fig. 4 presents the mean SUCT/SUCT + EXPL ratios for each age group and each type of nipple. Again, in order to insure that responding was stable throughout testing, a comparison of the mean ratios of the initial and final presentation of S1 was made. Since no differences

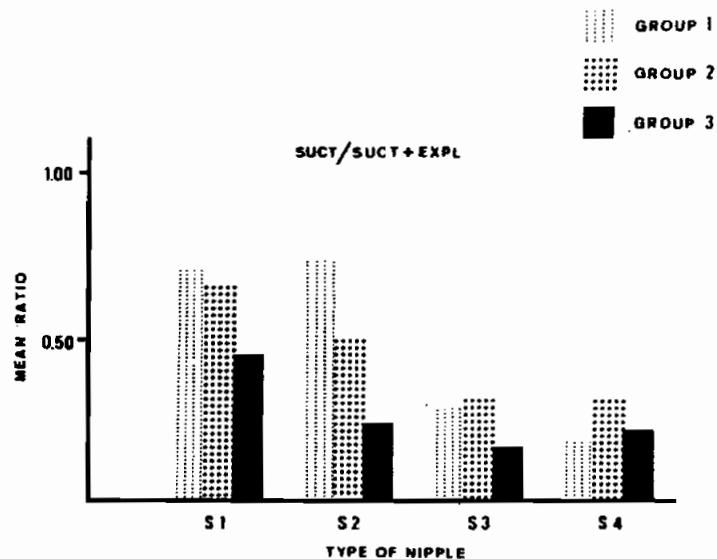


Fig. 4. Mean SUCT/SUCT + EXPL ratios for each of the 3 age groups and the four different intra-oral stimuli.

were found at any age level, only the data for the initial presentation of S1 are considered in the analysis that follows.

A 3(age) × 4(type of nipple) mixed design analysis of variance was performed on the mean SUCT/SUCT + EXPL ratios. This analysis revealed a main effect of type of nipple ($F_{(3,81)} = 30.966, p < 0.01$). The nipple effect is qualified by a significant interaction with age ($F_{(6,81)} = 4.380, p < 0.01$). Table 2 presents the mean ratios for each of the stimuli at each age level. Tukey tests of the interaction revealed that significant differences for the mean ratios in Group 1 were apparent between S1 and S3, as well as between S2 and S3 ($p < 0.01$). Group 2 showed significant differences between S1 and S3 ($p < 0.01$), S2 and S3 ($p < 0.05$), and S1 and S2 ($p < 0.05$). Finally, for Group 3, significant differences were only apparent between S1 and S3, and S1 and S2 ($p < 0.01$).

These results strengthen the contention made in earlier studies (e.g., Lipsitt and Kaye 1965) that from birth, infants manifest differentiated responses to intra-oral stimuli that vary in physical characteristics. In this study differential responding was found when nipples varied only in global shape (S1 vs S2), as well as when they varied in shape plus attached material (S1 vs S3, S4). Further, the present findings clearly indicate a developmental trend of increased overall activity. The age trend appears to be influenced by type of nipple. Thus, for young infants (Group 1 and 2) changes in shape produced when a novel material is attached to the nipple (S2 vs S3) are salient. One month olds also increase overall activity when nipples differ in both global shape plus attached material (S1 vs S3). Taken together, these findings suggest that a common basis for increased overall activity found with younger

Table 2
Mean SUCT/SUCT + EXPL ratios for each of the four different intra-oral stimuli at each age level.

Age groups	Stimuli			
	S1	S2	S3	S4
1 (Newborn)	0.706	0.741	0.293	0.194
2 (1 month)	0.656	0.500	0.316	0.317
3 (4 month)	0.456	0.245	0.176	0.231

infants is the addition of a novel material. It may be that the increased activity reported for Group 2 with S3 as opposed to S1 indicates that these infants are beginning to be more sensitive to global shape changes. These appears to be the case for older infants (Group 3). Older infants show an increase in activity for nipples that differ only in global shape (S1 vs S2). Thus, global shape appears to be an important stimulus characteristic for older infants while novel material is significant for younger infants. One month olds appear to be in a transitional stage.

Overall activity is a combination of sucking and exploratory response patterns. An examination of fig. 4 reveals that although overall activity generally increased as nipples differed from the control, the sucking component of this activity (as measured by the ratio $SUCT/SUCT + EXPL$) actually decreased. Specifically, this means that the increase in overall activity found in this data corresponds to a decrease in sucking and an increase in exploration.

These results support the view that in addition to the nutritive function of oral activity, as revealed by the pattern of sucking response, there exists a distinctly perceptual function of the mouth, inherent in the exploratory response. The functions of the mouth are both nutritive as well as perceptual. The importance of the latter, revealed by a decrease in the nutritive sucking response and increase of exploratory activity, appears to gain within the first months of life.

In conclusion, the stimulus variation introduced in this study showed that a global change of shape produced either by a change of overall shape or through the addition of a novel element, resulted in differential responding but local changes in shape of the attached element did not. Future studies may help to clarify the issue of whether the local shape discriminations are indeed possible for the young infant in his/her tactual capacity.

References

- Abraham, K., 1954. 'The influence of oral eroticism on character formation'. In: Selected papers on psychoanalysis. New York: Basic Books.
- Bryant, P.E., P. Jones, V. Claxton and G.M. Perkins, 1972. Recognition of shapes across modalities by infants. *Nature* 240, 303-304.
- Crook, C.K., 1979. 'The organization and control of infants sucking'. In: L.P. Lipsitt and C.C. Spiker (eds.), *Advances in child development and behavior*, Vol. 14. New York: Academic Press.

- Eimas, P.D., 1975. Auditory and phonetic coding of the cues for speech: discrimination of the (r-l) distinction by young infants. *Perception & Psychophysics* 18, 341-347.
- Freud, S., 1936. 'Three contributions to a theory of sex'. In: A.A. Brill (ed.), *The basic writings of Sigmund Freud*. New York: Modern Library.
- Kaye, H., 1967. 'Infant sucking behavior and its modification'. In: L.P. Lipsitt and C.C. Spiker (eds.), *Advances in child development and behavior*, Vol. 3. New York: Academic Press.
- Kirk, R.E., 1968. *Experimental design: procedure for the behavioral sciences*. Brooks/Cole.
- Lipsitt, L.P., 1977. 'Taste in human neonates: its effect on sucking and heart rate'. In: Weiffenbach (ed.), *Taste and development: the genesis of sweet preference*. U.S. Dept. of Health, Education and Welfare.
- Lipsitt, L.P. and H. Kaye, 1965. Change in neonatal response to optimizing and non-optimizing sucking stimulation. *Psychonomic Science* 2, 221-222.
- Meltzoff, A.N. and R.W. Borton, 1979. Intermodal matching by human neonates. *Nature* 282, 403-404.
- Piaget, J., 1936. *La naissance de l'intelligence chez l'enfant*. (1st ed.) Neuchâtel/Paris. Delachaux et Niestlé.
- Rapoport, J.L., 1972. 'Normal psychological development in the absence of oral and body surface sensation: a case report'. In: J.F. Bosma (ed.), *Third symposium on oral sensation and perception: the mouth of the infant*. Springfield, IL: Charles C. Thomas.
- Ruff, H.A. and C.J. Kohler, 1978. Tactual-visual transfer in six-month-old infants. *Infant Behavior and Development* 1, 259-264.
- Siqueland, E.R. and C.A. DeLucia, 1969. Visual reinforcement of non-nutritive sucking in human infants. *Science* 165, 1144-1146.