

# Recognition of Maternal Axillary Odors by Infants

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CERNOCH, JENNIFER M., and PORTER, RICHARD H. *Recognition of Maternal Axillary Odors by Infants*. CHILD DEVELOPMENT, 1985, 56, 1593-1598. A series of 5 experiments was conducted to determine whether neonates, at approximately 2 weeks of age, can recognize their parents through axillary odors alone. Breast-feeding infants discriminated between their mother's axillary odor and odors produced by either nonparturient or unfamiliar lactating females. In contrast, breast-feeding infants displayed no evidence of recognizing the axillary odors of their father. Likewise, bottle-feeding infants appeared unable to recognize the odor of their mother when presented along with odors from a nonparturient female or an unfamiliar bottle-feeding female. Several hypotheses were presented in an attempt to account for the differential reactions to maternal odors by breast-feeding versus bottle-feeding infants. It was tentatively concluded that, while breast-feeding, infants are exposed to salient maternal odors and thereby rapidly become familiarized with their mother's unique olfactory signature.

The ability of infants to recognize their own mother is an important component in the development of mother-infant social relationships (Bowlby, 1969; Schaffer, 1971). Before they can develop a preference for, or become attached to, their mother, infants must be able to discriminate between her and other individuals; thus, individual recognition is a prerequisite for the establishment of specific social relationships. Neonates' recognition of their mothers may have the additional effect of strengthening mothers' responsiveness and attraction to their infants. According to anecdotal reports, as infants begin to respond selectively to their mother (e.g., display preferential smiling and visual orientation toward their mother and reduced crying when held by her rather than others), mothers experience increasingly positive feelings about their infants (Robson & Moss, 1970).

Although olfaction has long been suspected of playing a role in the social development of children (Brill, 1932; Kalogerakis, 1963; Peto, 1973), it is only within the last decade that the salience of odor cues for mother-infant recognition has been well documented. Several studies have now determined that breast-feeding infants can discriminate between a breast pad worn by their mother and a second pad worn by another nursing female (Macfarlane, 1975; Russell,

1976; Schaal et al., 1980). Likewise, mothers are able to recognize the odors associated with their infants (Porter, Cernoch, & McLaughlin, 1983; Russell, Mendelson, & Peeke, 1983; Schaal et al., 1980). Even mothers who gave birth by cesarean section, and therefore had only limited direct contact with their neonates prior to testing, recognized their 21-42-hour-old infants by odor cues alone (Porter et al., 1983).

The responsiveness of neonates to olfactory cues produced by mothers (and fathers) was investigated further in the present series of experiments. In particular, an attempt was made to ascertain whether breast-feeding infants differ from bottle-feeding infants in their recognition of maternal odors, and to elucidate further the range of biological odors to which infants are responsive.

## General Methods

*Subjects.*—Mothers and fathers were recruited while in the hospital where their subject infant had been born. All infants included in the following experiments were full-term (37-42 weeks gestation) and healthy, with Apgar scores ranging from 6 to 10 at 1 and 5 min after delivery.

*Apparatus.*—Each infant was tested individually in a standard hospital bassinet measuring 66 × 36 × 20 cm high. A U-

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shaped flexible metal hose was attached to the head of the bassinet so that the two ends extended inside. Large clips were fastened to each end of the hose to hold the gauze pads that served as odor stimuli.

*Testing procedures.*—In each of the experiments reported below, infants were tested for their responses to two simultaneously presented 10 × 10-cm gauze pads—one that had been worn in the underarm area of the mother (or father), and a second pad that had been worn by an unfamiliar adult. Individuals who served as sources of odor stimuli were instructed to wear one pad in each armpit for approximately 8 hours during the night preceding testing. They were also asked to follow their daily hygiene routine but to refrain from using deodorant while wearing the pads. Gauze pads were secured in the axillary region by surgical tape supplied to each odor donor and were sealed in zip-lock plastic bags after being removed. Testing followed within 11.5 hours after removal of the stimulus pads. There was no statistically reliable difference in the interval between removal of the stimulus pads and testing for parents versus unfamiliar donors in any of the following experiments.

Odor recognition tests were conducted in the infant's home at 12–18 days after birth. During the test session, the infant was placed in a supine position in the bassinet. Infants who were sleeping were stimulated by the experimenter or mother to an alert state with the eyes open (Stage IV; Precht & Beintema, 1964). One of the odor stimuli (gauze pads) was hung to the left and the other to the right of the infant's midline (i.e., alongside each cheek but not in direct contact with the infant). Turning the head to the left or right would bring the infant's nostrils within 1–2 cm of either of the pads. The experimenter held the infant's head centered between the two pads until a timer was activated to signal the start of the test trial. Each infant was presented with the same two odor pads on two successive 1-min trials, with a 2-min interval between the two trials. During the 2-min interval, the positions of the two pads were reversed while the infant remained in the bassinet. For each infant the position of the mother's (or father's) pad on the first trial was randomly determined. The infant's responses to the odor stimuli were videotaped throughout the two 1-min trials with a portable video recorder with the camera mounted on a tripod approximately 2 feet from the top of the bassinet. Videotapes were later analyzed by the experimenter and an observer who was blind

in regard to the individuals who had worn the stimulus pads. The amount of time that the infant was oriented to each of the stimulus pads (duration scores) was recorded from the videotapes and summed across the two trials for each pad. Orientation toward a particular pad was defined as any deviation from midline in the direction of that pad. For each stimulus pad a reliability index for the two observers was obtained by dividing the lower of the two duration scores by the greater score for that particular pad (i.e., agreed duration/agreed plus disagreed durations). Mean interobserver reliability indices obtained in this manner ranged from .92 to .97 across the five experiments presented below. The duration measures reported for each experiment are those of the blind observer.

### I. Breast-feeding Infants

As mentioned above, previous studies of infant recognition of maternal odors have focused almost exclusively on olfactory cues associated with the breast region of lactating females (Macfarlane, 1975; Russell, 1976; but see Schaal et al., 1980). To determine whether the odor of maternal breast secretions is unique in its attractiveness to breast-feeding infants, a series of experiments was conducted in which breast-feeding neonates were tested for their responses to axillary odors produced by their mothers and fathers. The major question investigated in these studies was whether breast-feeding infants can use axillary odors to recognize their parents.

#### *Experiment 1: Mother versus Nonparturient Female*

*Methods.*—Thirteen breast-feeding infants were tested as described above for their responsiveness to a gauze pad soiled with their own lactating mother's axillary odors in comparison with an axillary pad from a (unrelated, unfamiliar) nonparturient adult female (i.e., a nonlactating female with no infant of her own at the time of testing) who differed for each subject infant. Birthweights of these seven male and six female infants ranged from 3,132 to 4,040 grams, and their mean age at testing was 15.0 days. Mean ages of the stimulus mothers and nonparturient females were 27.1 and 26.1 years, respectively.

*Results.*—The results of Experiment 1 (along with those of the remaining four experiments) are summarized in Table 1. As seen on inspection of Table 1, infants spent significantly longer oriented toward their mother's axillary pad than to the pad worn by a nonparturient female. In addition, 11 of

TABLE 1  
 MEAN DURATIONS OF ORIENTATION TO THE SIMULTANEOUSLY PRESENTED OLFACTORY STIMULI IN  
 EXPERIMENTS 1-5

Experiment and Olfactory Stimuli	Mean Seconds Oriented toward Each Odor Stimulus	t Test for Correlated Samples
1 (N = 13 breast-feeding infants): Mother's axillary odor.....	62.5	2.65, df = 12, p < .05
vs. Nonparturient female's axillary odor .....	42.0	
2 (N = 16 breast-feeding infants): Mother's axillary odor.....	72.9	3.16, df = 15, p < .01
vs. Unfamiliar lactating female's axillary odor.....	37.1	
3 (N = 15 breast-feeding infants): Father's axillary odor .....	48.7	.82, df = 14, N.S.
vs. Axillary odor of unrelated adult male.....	55.7	
4 (N = 15 bottle-feeding infants): Mother's axillary odor.....	53.5	.26, df = 14, N.S.
vs. Axillary odor of unfamiliar bottle-feeding female	57.4	
5 (N = 15 bottle-feeding infants): Mother's axillary odor.....	49.3	.26, df = 14, N.S.
vs. Nonparturient female's axillary odor .....	51.3	

the 13 infants oriented more toward their mother's pad as compared to the nonparturient female's pad, while the remaining two infants spent equal amounts of time turned toward each of the two pads. Thus, all 11 infants who displayed a preference (as defined by more time oriented toward one odor stimulus than the other) responded preferentially to their own mother's stimulus pad ( $p < .001$ ; two-tailed binomial test).

#### Experiment 2: Mother versus Unfamiliar Lactating Female

The results of the first experiment indicate that breast-feeding infants can discriminate between the axillary odors of their mother and an unfamiliar nonparturient female. These data, however, do not allow one to ascertain whether the mother's unique axillary odors are recognized by her infant, or, alternatively, whether breast-feeding infants simply prefer odors of any lactating female over those of nonparturient females. In an attempt to elucidate this issue, breast-feeding neonates were tested with olfactory cues from their mother and an unfamiliar lactating female.

*Methods.*—Sixteen breast-feeding mothers and infants (mean age = 15.0 days) partic-

ipated in this experiment. Two infants (e.g., A and B) who had been born within 72 hours of one another were tested on a given day, allowing each of these infants to be tested with odor stimuli from the same two females. Thus, the mother of infant A would serve as the unfamiliar lactating female for infant B, and infant B's mother, in turn, would be the unfamiliar breast-feeding female for infant A. Each stimulus female wore two odor pads so that a separate set of pads (mother's and unfamiliar female's) was used for each subject infant. Stimulus mothers ranged in age from 22 to 34 years, and the eight male and eight female infants weighed 2,951–4,086 grams at birth.

*Results.*—Overall, the infants oriented to their mother's axillary pad for a significantly longer time than to the unfamiliar lactating female's odor pad (see Table 1). Such preferential orientation is taken as evidence that the breast-feeding infants recognized the axillary odors of their own mother. Thirteen of the 16 infants preferred their mother's pad, while three infants oriented for a longer period to the pad soiled by the unfamiliar female ( $p < .01$ ; one-tailed binomial test).

*Experiment 3: Father versus Unfamiliar Adult Male*

Experiment 3 was conducted in an attempt to determine whether breast-feeding infants can recognize the axillary odors of family members other than their mother. Since fathers may interact frequently with their neonates, and the degree of genetic relatedness between fathers and offspring is the same as that of mothers and offspring (i.e., .50 in each instance), it was hypothesized that fathers might be the most likely class of kin (aside from the mother) to elicit an odor-based response from their neonates.

*Methods.*—Breast-feeding infants ( $N = 15$ ; eight males, seven females) were tested at a mean age of 14.6 days for their responses to simultaneously presented olfactory cues from their father and from an unfamiliar, unrelated adult male. The unfamiliar comparison males were 24–42 years of age and the birthweights of the subject infants between 2,497 and 4,812 grams. Fathers, whose ages ranged from 25 to 38 years, and comparison males were given the same set of instructions as the mothers in the previous experiment. In addition, fathers were asked to keep a daily log of the duration of direct physical contact that they had with their infant prior to the test session. Further details of the testing procedures are otherwise identical to those of the previous experiments.

*Results.*—As seen in Table 1, infants did not differ reliably in the amount of time that they oriented toward the odor pads worn by their father versus an unfamiliar adult male. Seven of the infants oriented preferentially to their father's odor, while eight infants spent longer oriented to the pad worn by an unfamiliar male. Thus, breast-feeding infants displayed no evidence of recognizing their father's axillary odor.

The fathers' logs revealed that the total amount of physical contact between father and infant prior to testing ranged from .5 through 59 hours across the 15 participating fathers. The amount of father-infant contact did not correlate significantly with the time that the infants spent oriented toward their father's odor during the olfactory preference test ( $r = .03$ ). Likewise, there was no significant correlation between the difference in time oriented toward the father's pad versus the comparison male's pad and the amount of physical contact that the infants had with their fathers ( $r = -.05$ ).

## II. Bottle-feeding Infants

In the previous experiments, only breast-feeding infants were tested for recognition of

olfactory cues produced by their mothers and fathers. The question arises, therefore, whether bottle-feeding infants would respond in a similar manner as breast-feeding infants to parental odors. In particular, will bottle-feeding infants also display evidence of recognizing their mother's axillary odors? The final two experiments (4 and 5) were designed to address this question.

*Experiment 4: Mothers versus Unfamiliar Bottle-feeding Females*

*Methods.*—A total of 15 infants (seven males and eight females) participated in Experiment 4. These bottle-feeding infants were individually tested for their responses to an odor pad worn by their own mother and a second pad soiled by an unfamiliar female who was also bottle-feeding her own infant. Two infants who had been born within 72 hours of one another were scheduled for testing on a given day. As for Experiment 2, this allowed each of the paired infants to be tested with odor stimuli from the mothers of those same two infants. Each stimulus female wore two odor pads so that a separate set of pads was used for each subject infant.

The stimulus mothers ranged in age from 17 to 37 years and the birthweights of infants from 2,769 to 4,540 grams. The mean age of infants at the time of testing was 15.2 days. Further procedural details are otherwise identical to those presented above for the experiments with breast-feeding infants.

*Results.*—The mean duration of orientation to the mother's odor pad (across all 15 infants) did not differ reliably from the mean time oriented to the pad worn by an unfamiliar bottle-feeding female (see Table 1). Likewise, the number of infants who preferred the mother's pad was not significantly different from the number who preferred the comparison female's pad; nine of the infants spent more time oriented toward their mother's pad than to the unfamiliar female's pad, while the remaining six infants oriented preferentially to the odor pad of the unfamiliar female.

*Experiment 5: Bottle-feeding Mothers versus Nonparturient Females*

It is possible (albeit unlikely) that recently parturient females who do not breast-feed their infants and therefore cease lactating nevertheless produce somewhat similar odor cues as a function of physiological changes (metabolic or endocrinal) associated with birth-giving. Accordingly, the lack of differential responsiveness by the infants in Experiment 4 to odor cues from their mother as compared to an unfamiliar bottle-feeding female may reflect, in part, the difficulty of this

discrimination task. In an attempt to test this hypothesis, bottle-feeding infants were tested for their responses to olfactory cues from their own mother and from an unfamiliar *nonparturient* female.

**Methods.**—Fifteen bottle-feeding infants (eight males and seven females) were each tested with two odor pads, one soiled by their own mother and a second that had been soiled by an unfamiliar nonparturient female. Birthweights of infants ranged from 2,270 to 3,949 grams, and mean ages of mothers and comparison females were 24.5 and 27.0 years, respectively. The mean age of infants at the time of testing was 14.7 days.

**Results.**—No reliable differences were found between the mean durations of orientation to olfactory cues from the bottle-feeding infant's mother versus an unfamiliar nonparturient female (Table 1). Preferences for the mother's odor pad over the unfamiliar female's pad were displayed by eight infants; however, the remaining seven infants oriented preferentially to the pad soiled by an unfamiliar female.

#### Discussion

Maternal odors emanating from the breast region are not unique in their attractiveness to breast-feeding infants. Rather (as seen in Experiments 1 and 2), at 12–18 days after birth, breast-feeding infants also orient preferentially to axillary odors produced by their mother in comparison to such odors from either unfamiliar nonparturient females or unfamiliar breast-feeding females. These latter data indicate that breast-feeding infants do not simply respond indiscriminately to axillary odors from lactating females but can recognize the characteristic olfactory signature of their own mother.

In contrast with the breast-feeding infants, bottle-feeding infants displayed no evidence of recognizing their mother's axillary odors; that is, they did not differ in their responses to maternal axillary odors and odors from unfamiliar bottle-feeding females (Experiment 4) or from nonparturient females (Experiment 5). It should be pointed out that lack of an overt preference for the maternal odor does not necessarily imply that these infants were unable to recognize that stimulus. Although discriminative responsiveness is an indication of recognition, stimulus preferences and recognition cannot be equated. There are several logically possible explanations for the differences in responsiveness to maternal axillary odors observed between breast-feeding and bottle-feeding infants. Although unlikely, the perceptual capabilities of

bottle- and breast-feeding infants may differ. Accordingly, breast-feeding infants may be more sensitive to olfactory cues (i.e., have a lower detection threshold than bottle-feeding infants for odor stimuli) and therefore better able to discern or recognize their mother's characteristic body odor. Alternatively, chemical signals emitted by breast-feeding females may differ, either qualitatively or quantitatively, from those produced by nonlactating (e.g., bottle-feeding) females. Therefore, discrimination between pads soiled by lactating versus nonlactating females could be based on stimulus strength alone. The difference in odors among lactating females might also be greater than that among nonlactating females. In several nonhuman species, lactating females are known to produce chemical signals (maternal pheromone) that are uniquely attractive to suckling young (Breen & Leshner, 1977; Leon, 1974; Porter & Doane, 1976). Human infants may similarly be responsive to odors that are specifically associated with lactation and learn rapidly to recognize such signals produced by their own mother.

Perhaps the most parsimonious hypothesis to explain the discrimination of maternal axillary odors by breast-feeding, but not bottle-feeding, infants concerns the differential mother-infant interactions between these two groups of infants. During the recurring bouts of breast-feeding, infants' nostrils are maintained within close physical proximity of the mother's bare skin for prolonged periods of time. Bottle-feeding infants, in comparison, are not necessarily routinely exposed to their mother's bare skin to the same extent as are breast-feeding infants. These two groups of infants, therefore, are quite likely to differ markedly in their degree of exposure to body odors produced by their mothers, especially if such olfactory signals are best perceived when in close contact with the mother's body surface. Such differential exposure to salient maternal odors might be sufficient to account for the pattern of results reported above. In addition, fathers would be somewhat similar to bottle-feeding mothers in having relatively limited direct skin-to-skin (or skin-to-nostril) contact with their infants. Therefore, as seen in Experiment 3, even breast-feeding infants show no evidence of recognizing paternal axillary odors.

The current emphasis on olfactory recognition does not imply that other sensory modalities are of minimal importance for maternal recognition by neonates. As early as the third day after birth, infants respond discriminatively to their mother's voice (DeCasper & Fifer, 1980; see also Mehler, Berton-

cini, Barriere, & Jassik-Gerschenfeld, 1978, and Mills & Melhuish, 1974). Similar to the above results with odor stimuli, however, neonates displayed no evidence of discriminating between the voices of their father and another male within the first 3 days postpartum (DeCasper & Prescott, 1984).

The developmental time course of visual recognition of the mother's face is somewhat ambiguous. When tested with photographs of females' faces, 3-month-old infants recognize their mother's face (Barrera & Maurer, 1981). More recent experiments revealed that 22-93-hour-old infants respond preferentially to the silent live face of their mother over faces of unfamiliar nonparturient women (Field, Cohen, Garcia, & Greenberg, 1984). As pointed out by the authors, however, the testing procedures did not rule out the possibility that the infants were actually responding to odors associated with the stimulus faces rather than their visual appearance. The results of the present series of experiments offer further support for the conclusion that the infants tested by Field et al. may have discriminated their mother's face by olfactory cues.

Given the importance of mutual mother-infant recognition for the development of early social relationships, it would be adaptive for infants to be able to discriminate their mother by cues across several sensory modalities. Breast-feeding infants have been found to recognize their mother by her breast odor or, as seen above, her axillary odor alone. As research on human olfaction progresses, the potential influence of biological odors on the mediation of social behavior in our own species becomes increasingly evident.

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