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FIFER, WILLIAM PAUL

EARLY ATTACHMENT: MATERNAL VOICE PREFERENCE IN ONE- AND THREE-DAY-OLD INFANTS

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EARLY ATTACHMENT: MATERNAL VOICE PREFERENCE IN ONE- AND THREE-DAY-OLD INFANTS

by

William P. Fifer

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Anthony J DeCasper
Dissertation Adviser

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This dissertation has been approved by the following committee of the Faculty of the Graduate School at the University of North Carolina at Greensboro.

Dissertation Adviser ______________________

Committee Members ______________________

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Human newborns between thirty-four and ninety-six hours old were tested in a discrimination procedure designed to measure preference for the maternal voice. Sucking bursts initiated during one auditory stimulus resulted in presentation of a recording of the mother's voice, while sucking during another signal was followed with the voice of the previous subject's mother. Once a voice was produced it remained on for the duration of a burst. Newborns kept their mother's voice on longer than the other female's voice. In addition, the probability of responding was greatest during the signal associated with the maternal voice. Current theories of attachment do not predict this phenomenon.

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CHAPTER I

INTRODUCTION

The current literature on infant development points to a new appreciation of the perceptual and learning capabilities of the newborn. Sensorially precocial and sensitive to a variety of reinforcement contingencies, neonates are prepared to engage in the kinds of reciprocal social interactions necessary for the development of the mother-infant bond. This study investigates neonatal discrimination of and preference for mother's voice, a phenomenon which may function as a cornerstone of the attachment process.

According to modern usage, attachment processes refer to the establishment and maintenance of proximity between an infant and a conspecific, usually the natural mother (Ainsworth, 1979). Historically, students of attachment have emphasized the role of maternal behaviors in this process. More recently, however, the reciprocal nature of the mother-infant relationship has been underscored (Ainsworth, 1972; Bell, 1974; Bowlby, 1969; Brazleton, 1978; Gewirtz, 1972; Shaffer & Emerson, 1964; Sherrod, Vietz, & Friedman, 1978; Wolff, 1969). This experiment focuses on the newborn infant's role in the attachment process.

Attachment processes appear to be highly canalized. That is, the phenotypic expression of attachment will, barring significant environmental stresses and/or genetic abnormalities, inevitably develop along similar pathways or in similar stages. In a landmark work, Bowlby (1969) described the attachment process as the _sine qua non_ for infant survival. The infant's highly adaptive proximity-seeking behaviors serve not only to establish proximal interactions, e.g., the clasp reflex of rhesus monkeys or the rooting reflex of humans, but also more distal ones, e.g., eye contact, smiling or following behaviors. According to Bowlby, proximity-promoting behaviors function in three ways: (1) as orientation behaviors (rooting, visual following) to direct the infant's attention to and allow tracking of those stimuli which are most likely to emanate from humans; (2) as signaling behaviors (crying, smiling, babbling) to attract the adult into proximity with the infant; and (3) as approach behaviors (crawling, clinging, searching) to allow the child to follow and approach the mother.

Child-mother attachment is described by Bowlby and Ainsworth as developing in four phases (Bowlby, 1969; Ainsworth, 1972, 1979). The first stage is labeled the "initial preattachment phase." During this stage infants show no evidence of discriminating one person from another. Rather, the infant's repertoire of orienting and signal behaviors has been characterized as "largely reflexive" (Bowlby, 1969), "protosocial" (Newson, 1977), and reflecting mainly "thermal, reflexive, nutritive, and hormonal processes" (Cairns, 1972, p. 57). The first phase begins at birth and continues until the infant shows the ability to discriminate among individuals.

The second phase, called "attachment in the making," does not begin until the infant reaches eight to twelve weeks of age (Ainsworth, 1979; Bowlby, 1969; Eisenberg, 1979). During this phase signaling and orienting, along with proximity seeking behaviors such as visually coordinated reaching, become focused on one or a few individuals, typically the mother. Phase two is thought to last until the child is six or seven months old.

Phase three is characterized by unmistakable attachment to the primary caretaker. That is, the infant incorporates various active strategies in order to seek contact and maintain proximity. For example, the mother is used as a home base from which the infant explores his/her surroundings (Rheingold & Eckerman, 1970). During these forays the infant spends much of his/her time establishing visual or auditory contact with mother. This phase lasts well into the third year, after which time the infant becomes more skilled at adjusting his behaviors to the mother, becomes sensitive to the mother's goals and needs, and enters into what Bowlby labels the final attachment state, a partnership.

Most research on attachment has centered on the final two phases of attachment and on determining criteria for measuring the infant's attachment, e.g., latency in establishing contact, average distances from caretaker, and responses to strangers, novel environments and separation (Ainsworth & Wittig, 1969); Ainsworth, 1972; Bell, 1968; Cairns, 1977; Corter, 1977; Rheingold & Eckerman, 1970; Shaffer & Emerson, 1964). However, most research on the early stages of attachment has focused on maternal behavior. Thus, there is a gap in our understanding of the sequence of the attachment process from the infant's perspective. The need to examine the infant's early role in the attachment process has been frequently cited (Bower, 1974; Brazleton, 1978; Gerwitz, 1972; Klaus & Kennell, 1976). Ainsworth

(1972) made particular reference to the need for identifying stimuli which activate and reinforce the precursors of attachment behavior. Identification of these stimuli is emerging from recent research which shows remarkable capabilities of the newborn. Specifically, research on the sensory and perceptual capacities of the neonate indicates they are able to differentially respond to, interact with, and actively seek contact with a wide range of "maternal" stimuli.

Vision research has demonstrated that neonates less than ten days of age can orient toward, fixate on, and follow visual stimuli (Bower, 1979; Brazleton, Scholl, & Robey, 1966; Fantz, Fagan, & Miranda, 1975; Goren, Sarty, & Wu, 1975). The newborn can focus most clearly on objects between eight to fourteen inches away (Haynes, White, & Held, 1965), which approximates the distance between mother's face and infant during feeding. These facts suggest that the infant is biased toward gaining experience with mother's face, a suggestion that is further enhanced by evidence showing that newborns will spend the most time looking at stimuli which are similar to the human eye (Fantz, 1963) and during the next several weeks develop a preference for facelike configurations (Goren et al., 1975). Eventually, the infants prefer looking at their mother's face (Bower, 1979; Carpenter, 1975).

Neonates can also differentially respond to olfactory stimuli. For example, changes in the newborn's respiration rate will habituate with repeated presentations of a chemical substance and will dishabituate with presentation of a novel olfactory stimulus (Engen & Lipsitt, 1965; Self, Horowitz, & Paden, 1972). Of special interest to this proposal are data showing that infants less than five days of age discriminate and show a preference for an odor associated with mother. Newborns will turn their head significantly more often and for longer periods of time toward a breast pad soaked with their own mother's milk rather than toward a simultaneously presented pad soaked with another woman's milk (McFarlane, 1975).

The newborn's ability to respond to vestibular and proprioceptive stimulation may also facilitate sensitivity to cues associated with mother. Neonates are most visually alert and most easily soothed in an upright position while being rocked (Korner & Grobstein, 1966; Korner & Thoman, 1970). More recent evidence points to the actual movement cues, the change to the upright position, as the critical variable in enhancing visual attentiveness (Gregg, Haffner, & Korner, 1976). In this same study infants who were sucking on a pacifier were more visually alert than those without pacifiers. In addition, infants ten days of age appear capable of using proprioceptive, in combination with other, cues for discriminating the handling and feeding style of the primary caretaker, i.e., infants showed marked distress and disruption of normal feeding patterns when multiple caretakers were substituted for the primary caretaker (Birns, Sander, Stechler, & Julia, 1972).

Several researchers have recently suggested that these sensory competencies and stimulus preferences subserve a number of developmental processes, particularly infant-mother bonding (Brazleton, 1978; DeCasper & Fifer, 1980; Eisenberg, 1976; Klaus & Kennell, 1976 ; Korner & Thoman, 1970). Early discrimination of and attachment to significant others could be served if the infant was maximally and differentially sensitive to different types of maternal stimulation. The previous discussion suggests newborns are indeed sensitive to proximal cues--odor, touch, nearby visual stimulation. However, since indices of attachment primarily consist of the infant's responses to maternal presence or absence in the auditory or visual field, a differential sensitivity in the newborn to more distal cues may more directly subserve the attachment process. Specifically, early discrimination and preference for mother's voice might serve to facilitate the development of the reciprocal interactions essential in the mother-infant bonding process.

The human newborn's auditory system appears especially useful for detecting cues potentially associated with mother. Indeed, even the fetus is capable of responding to auditory events by the final trimester of gestation and has shown gross body movement and electroencephalographic and heart rate changes to extrauterine noises (Eisenberg, 1976). Other evidence for precocious auditory competency is observed in studies showing both behavioral and electrophysiological responding to sound in preterm infants (Eisenberg, 1976; Gregg, Haffner, & Korner, 1976). Newborn infants will orient toward a sound source (Wertheimer, 1961) and, as Leventhal and Lipsitt (1964) have shown, are sensitive to the direction of the sound source. Body movement and change in respiration habituated to a tone presented from one direction and recovered when the direction of the sound source was changed.

Newborns' auditory capabilities also include a sensitivity to frequency and band width components of human speech. For example, infants less than three days old show reliable cardiac responses to a restricted band of noise but not to pure tones, demonstrating a sensitivity to band width (Turkewitz, Birch, & Cooper, 1972). Noise bands were also more effective than pure tones in eliciting muscular movement in newborns (Hutt, Hutt, Lenard, Bernuth, and Muntjewerff, 1968). Using habituation of body movement as the dependent measure, infants as young as 21 hours were observed to discriminate between signals of 200 and 1000 Hz (Leventhal & Lipsitt, 1964). A 150-Hz tone has more reliable soothing effects than does a 500-Hz tone (Birns, Blank, & Bridger, 1966). Whereas low frequency sounds are better inhibitors of infant distress, high frequencies (above 400 Hz) tend to occasion distress (Eisenberg, 1976). Hutt and Hutt (1970) reported maximal changes in newborn heart rate to frequencies within the range for human speech. Range dependent frequency effects are also observed as a function of state. For example, responding to low frequency signals is best elicited during wakefulness (Eisenberg, 1976).

Newborns can also discriminate intensity differences at birth, e.g., Bartoshuk (1964) showed heart rate change to four different tonal intensities. Newborns may also be especially sensitive to sound levels within the range of normal conversational intensities. Suzuki, Kamijo, and Kiuchi (1964) found the optimum intensity level for eliciting a change in respiration rate to be approximately 62 decibels--the average intensity of normal speech.

Infants appear to be differentially sensitive to auditory cues associated with speech and speech-like sounds (Eimas, 1975; Eisenberg, 1976). For example, cues associated with intonation and rise-and-fall time of a tone are discriminated by young infants (Morse, 1972). Condon and Sander (1974) demonstrated that newborns move in synchrony to human speech. This entrainment apparently involves a sensitivity to the prosadic features of speech, e.g., intonation, inflection, temporal patterning, in that synchrony was not demonstrated with clicks or disconnected vowel sounds. The capacity to discriminate the phonetic components of speech, which has been demonstrated in young infants (Eimas, 1975), also appears to lie within the newborn's range of capabilities (DeCasper, Butterfield, & Cairns, 1976).

These perceptual sensitivities undoubtedly subserve a number of auditory preferences displayed by newborns. For example, instrumental music can be distinguished from a wideband noise and the infant will actually work, i.e., alter his rate of sucking when such a change produces the music (Butterfield & Siperstein, 1972). Similar techniques show newborn preferences for vocal over instrumental music and speech over other nonspeech sounds (Eisenberg, 1976; Siperstein & Butterfield, 1973). Ashmead and Lipsitt (in preparation) demonstrated the newborn's heart rate decelerates to female voices but not to male voices. Consistent with this finding is the observation that older infants show a preference for the female over the male voice (Brazleton, 1978).

Miles and Meluish (1974) showed that the maternal voice may be an important stimulus for older infants; they demonstrated a differential sensitivity to the maternal voice in infants 20 to 30 days old. In their procedure, a six-minute contingency training period in which sucking resulted in presentation of a variety of unfamiliar voices preceded two three-minute testing periods. For a third of the infants, sucking during the first testing period produced the mother's voice. Sucking during the next period was followed by presentation of the stranger's voice. A second group experience a reverse order of testing and a third group received noncontingent voices. Amount of time spent sucking and number of sucks per minute were greater when a brief presentation of mother's voice followed initiations of sucking bursts. In a study using one-month-old infants (Mehler, Bertoncini, Bauriere, & Jassik-Gershenfeld, 1978), sucks were reinforced with either mother's or a stranger's intonated voice or either voice presented in monotone. A significant increase in sucking was only observed when mother's voice was properly intonated. Though these procedures clearly demonstrate that infants respond differentially to their mother's normal voice, the differences in responding do not necessarily indicate a preference for her voice, i.e., a differential sensitivity to a stimulus need not indicate a preference for that stimulus.

Clinical observations, e.g., André-Thomas (1966) and Hammond (1970), have suggested that newborn infants will preferentially orient to mother's voice. However, not until a recent study by DeCasper and Fifer (1980) was there any direct experimental evidence that neonates prefer their mother's voices. In their procedure, 48- to 72-hour-old infants were observed for five-minute baseline periods in which sucks on a nonnutritive nipple were recorded and the median time between sucking bursts was determined. A burst was defined by a series of sucks separated by less than two seconds. For one-half of the infants, interburst intervals (IBI) less than the baseline median were followed by a recorded presentation of their mother's voice reading a children's story. The voices, presented over stereo headphones, came on with the first suck of each burst and remained on until the burst ended. IBI's greater than the baseline median resulted in presentation of the recording of the previous subject's mother. Thus, each burst of sucking produced one voice or the other. The contingency was reversed for the remaining half of the infants, i.e., IBI's greater than baseline produced mother's voice. Eight of nine infants showing a preference preferred their mother's voice; they produced their mother's voice more often and for a longer total period of time. Four of the infants who demonstrated this preference subsequently encountered a reversal of the initial contingencies. All four newborns reversed their earlier pattern of sucking and thus again heard their own mother's voice more often and for a longer period of time. This is the first experimental evidence that newborns prefer their mother's voice and thus demonstrate attachment along the vocal dimension of stimulation.

One purpose of the present study was to systematically replicate and further investigate the neonate's preference for the maternal voice. The procedure was designed to enhance the measure of preferential responding in order to detect possible individual or group differences, and to allow observation of infants as young as one day old. DeCasper and Fifer (1980) differentially reinforced interburst intervals. A preference was shown by an increased frequency of intervals that produced the mother's voice. However, their procedure involved another direct contingency: the longer the infant sucked, the longer the voice presentation. If this contingency were effective, preference might also have been revealed by longer sucking bursts with the maternal voice. However, during baseline and reinforced sucking, there was a weak positive linear correlation between interburst intervals and succeeding burst durations (see also DeCasper & Hill, inpreparation). Although the correlation was weak, independence of interburst interval and burst duration was uncertain. The correlation may have obscured effects of the burst length presentation time relationship and/or interfered with learning the contingency, especially with younger infants. Pilot studies using the IBI contingency indicated that the one- and two-day-old infants were less likely to sustain a full 20-minute session. Further study suggested that changing from the IBI contingency might increase the time that younger infants could be tested and also facilitate acquisition of the burst during contingency.

An auditory discrimination procedure was developed in which the presence or absence of a tone signaled the availability of the different voices, but voices still remained on for the duration of a sucking burst. Because interburst intervals are nondifferentially reinforced, the duration of each burst (the amount of time each voice is maintained) may serve as an additional independent measure of preference. Thus, the likelihood of responding in the presence of each signal serves as one measure of preference and the duration of sucking bursts in the presence of each voice serves as another.

The second purpose of this study was to investigate the role of newborn experience on the attachment process; specifically, the possible effects that feeding practices may have on maternal voice preference. Benefits to health and nutrition are known to result from successful breast-feeding. Methods of feeding may also affect the early bonding process. For example, breast-feeding, as opposed to bottle-feeding, results in longer duration of feeding (Bernal & Richards, 1970), more fluid consumption (Klaus & Kennell, 1976), more crying prior to feeding (Bernal & Richards, 1970), more eye contact during feeding (Abercrombie, 1971), and more rapid development of regular feeding cycles (Lozoff, Brittenham, Trause, Kennell, & Klaus, 1977). These factors could affect both the amount and quality of vocal interactions between mother and infant and perhaps subsequent bonding.

Third, the newborn's neuronal and physiological systems rapidly adjust to requirements of the extrauterine environment (Smith & Bierman, 1973). Such changes over the first postnatal days of life have been observed to affect the newborn's patterns of sucking and sleeping and the frequency of crying and feeding (Lozoff et al., 1977; Roberts, 1977). Thus, the amount and quality of maternal contact during the early postnatal days may also be affected by changes in the infant's state and response patterns (Klaus & Kennell, 1976). The third purpose of this study then is to consider the ontogeny of preference for mother's voice by examining age differences during the first four days of life.

The potential effects of age and feeding method are, of course, confounded with other variables, particularly the amount of time spent with mother. However, with a demonstrated effect or lack of effect of these variables on voice preference and a consideration of their underlying factors would offer important information for understanding the development of attachment to the maternal voice and infant-mother bonding in general. The ultimate goal of this study, then, is to consider its implications for theories of attachment. Specifically, since the accepted views of the early stages of attachment do not predict neonatal discrimination, much less preference for the maternal voice, thorough revision of the course of attachment is needed.

CHAPTER II

METHOD

Subjects

Eight bottle-fed and eight breast-fed, full-term female neonates served as subjects. Only Caucasian infants were observed in order to control for possible effects that different fundamental frequencies might have on voice preference. Voices of white females have a higher fundamental frequency than voices of black females. Only female infants were chosen because males are unavailable for at least twelve hours following circumcisions and the scheduling of these operations is unpredictable. In order to maximize the probability of obtaining an alert healthy newborn, all infants had APGAR scores of at least eight at one and five minutes after delivery and weighed between six and eight and one-half pounds--weights which fall between the tenth and ninetieth percentiles for full-term births. The infants were in one of two age ranges at the time of testing, 24-48 hours or 73-96 hours. Informed consent was obtained from each mother and she was encouraged to observe the experimental session.

Apparatus

The neonates wore padded, calibrated earphones (Phonic Ear TDH-39-4) adjusted to fit comfortably for binaural listening. Sterilized nipples were connected to the solid state control (BRS/LVE/Colburn logic devices) recording equipment (Grass polygraph), via a Statham

P-23AA pressure transducer. A Uher 4000 monaural tape recorder was used to record mother's voice. The recordings were played through a AKAI 4000 stereo tape deck and peak intensities measured not more than 70 dB SPL at the ears.

Procedure

Following selection of the newborn and acquisition of informed consent the mother's voice was recorded while reading Dr. Seuss' And To Think I Saw It On Mulberry Street. The tape was edited to omit extraneous sound and pauses longer than one and one-half seconds and repeatedly rerecorded on one track of a stereo tape to provide 25 minutes of uninterrupted prose. The recording of the mother's voice from the just previously completed session was placed on the other track of this tape.

Sessions began two and one-half hours after either the 6 a.m., 10 a.m., or 2 p.m. feedings in order to maximize the probability of obtaining alert infants. Newborns were moved to an adjoining nursery in their own cribs and coaxed to a state of quiet alertness (Wolff, 1966). The earphones were placed securely over both ears and a non-nutritive nipple was placed in the infant's mouth. Any infant who could not be brought to this quiet, alert, eyes-open state was returned to the nursery and was brought back after the next feeding if time permitted. While one researcher monitored the recording equipment, the other, blind to the experimental condition, monitored the baby and held the nipple in place. The infant was allowed two minutes to adjust to the situation before presentation of the auditory stimuli. If the infant failed to reliably emit measurable sucks (approximately 20 mm Hg), she was returned to the nursery.

Each experimental condition began with a four-second presentation of a 400-Hz tone followed by a four-second period of silence or no tone. The tone/no-tone alternation continued until a sucking burst was initiated. Depending upon which stimulus was present when the burst began, that burst produced either the mother's voice or the voice of the previous subject's mother for as long as the burst continued. A burst was defined as a series of individual sucks separated from one another by less than two seconds. The termination of each burst was followed by the tone/no-tone sequence and each stimulus had a .50 probability of beginning the sequence.

Sessions were terminated the second time that either a one-minute period of nonresponding or crying occurred. Each session lasted at least 12 minutes but not more than 20 minutes and contained at least 100 presentations of tone or no-tone. Therefore, a "data baby" was one who met the election criteria, was in an alert state at the beginning of the session, emitted measurable sucks during the adjustment period, and completed at least 12 minutes of testing with the voices.

Experimental Conditions

One group of eight infants was from those designated as "nursing babies" in the hospital records. The majority of these infants' feedings were at the mother's breast, with supplemental bottle-feedings. These infants averaged six breast-feedings per day. The other group consisted of eight "bottle-fed" infants, who averaged four feedings per day with their mother. One-half of each group was between 24-48 hours old, and the other half was between 72-96 hours old.

For half of the infants in each subgroup the maternal voice was presented when a sucking burst began during the presentation of the 400-Hz tone and the voice continued for the duration of the burst. Sucks initiated during the periods of no tone resulted in the presentation of the other woman's voice. For the other half of the infants, sucking during the no-tone period produced their mother's voice and sucking while the tone was on produced the other voice.

CHAPTER III

RESULTS

The primary dependent variables were the percentage of signal presentations during which a sucking burst occurred and the duration of sucking bursts. The total number of signals presented to each subject was divided into thirds. Pilot studies showed this division to provide the clearest evidence of behavior change over the session. Table 1 (Table 1 and all subsequent tables may be found in Appendix A) shows these dependent variables during the first and final third of the session for each subject.

A four-way analysis of variance was performed on difference scores, the percentage of signals associated with mother's voice during which a sucking burst was emitted minus the percentage of signals associated with the other voice during which a burst occurred. The three between-group factors were Feeding (breast versus bottle), Signal (tone versus no tone), and Age (one day versus three days), and the within-group factor was Trials (first third versus final third of the session). A significant effect of trials was observed ($F(1,8) = 7.78$, $\underline{p} < .025$) but there were no other significant main effects or interactions (see Table 2).

A two-way repeated measures (ANOVA was then performed using Trials (first third versus final third) and Voice or the percentage of signals associated with each voice during which a response was emitted (mother's voice versus other voice), while collapsing across Age, Feeding, and Signal. A significant interaction of Voice x Trials was observed ($F(1,60) = 3.9$, $p < .05$) (see Table 3). As Figure 1 (Figure 1 and all subsequent figures may be found in Appendix B) shows, the probability of responding during the signal associated with the mother's voice was significantly higher during the last third of the session (Scheffe, C.V. = 85.8, $p < .05$).

An identical series of analyses was performed on the burst duration data. The four-way ANOVA on the difference scores, mean burst duration with mother's voice minus mean burst duration with the non-maternal voice, revealed a significant interaction of Age x Trials ($F(1,8) = 7.64$, $p < .05$) (see Table 4). Post hoc analysis showed the only significant difference was between the one-day-old and three-day-old infants during the first third of the session (Sheffé, C.V. = 12.3, $p < .025$) (see Figure 2). That is, during the initial third, one-day-old infants had significantly greater burst duration differences in favor of mother's voice than did three-day-old infants. The differences disappeared by the end of the session.

Collapsing across the nonsignificant variables of Feeding and Signal, a repeated measures ANOVA on the burst durations was performed with the between-group factor of Age and the within-subject factors of Trials (first third versus final third) and Voice (mother versus other). A significant main effect of Voice and a significant interaction of Voice x Age was superseded by a significant triple interaction of Trials by Voice by Age ($F(1,14) = 7.06$, $p < .02$) (see Table 5). Post hoc analyses showed three comparisons to be significant. One-day-old infants showed greater burst durations with mother's voice during both the initial third and the final third of the session. Three-day-old infants showed significantly longer duration with mother's voice only in the final third of the session (Sheffe, C.V. = 0.89, $p < .01$) (see Figure 3).

Analyses of individual subject data (see Table 1) for both sets of dependent measures give the following additional information. During the final third of the session, 13 of 16 infants responded more often during the signal associated with their mother's voice ($p < .011$ by the binomial test). During the same period 15 of 16 infants showed longer burst durations during presentation of mother's voice ($p < .001$). Additionally, the three infants who responded less to the signal preceding mother (Subjects 2, 5, 16) were the infants who showed the three greatest burst duration differences in favor of mother. This observation suggests the possibility of a strong negative correlation between the two dependent measures, but after eliminating the data of these three infants, there was a negligible correlation between burst duration differences and signal responding differences ($r = .06$). A final analysis was performed to see if mother's voices stimulated longer sucking bursts during initial exposures. Burst durations occurring with the first five presentations of each voice did not differ.

CHAPTER IV

DISCUSSION

The newborns' preference for their mother's voices was confirmed; the infants responded more often to the signal associated with her voice and further, they produced her voice for longer durations. The procedure used in the study allowed infants as young as one day old to demonstrate this preference. There was no effect of feeding method or postnatal age on either dependent measure during the final third of the session. However, data from the first third of the session suggest an age difference in the acquisition of differential burst durations.

The auditory discrimination procedure used in this study allowed the use of burst duration as a dependent measure, the effects of the correlation between IBI and succeeding burst durations (DeCasper & Fifer, 1980; DeCasper & Hill, in preparation) were minimized by allowing more variation in the duration of sucking bursts associated with each voice. The procedure was quite effective in this regard. In general, burst durations which produced and maintained the maternal voice were longer than those which produced and maintained the nonmaternal voice. Moreover, several observations suggest that the burst duration/voice duration contingency which maintained the voice, appeared to be acquired more readily than did discriminated responding which produced the voice. First, burst durations did not differ through the first five presentations of each voice, but by the end of the first third of the session, the durations were significantly longer with the mother's voice.

There was no evidence of discriminated responding at this time. Second, no infant ever showed average burst durations in favor of the other voice and the three infants who had the longest mean burst durations in favor of mother's voice were those who gave no evidence of learning the auditory discrimination. Third, baseline behavior was not systematically recorded, but examination of the records suggested that burst durations were generally longer during the experimental phase of the session than during the two-minute adjustment period. Thus, the response to the burst duration/voice duration contingency seems to have been an increase in burst durations independently of whose voice was presented.

Thus, observations indicate that the burst duration contingency was acquired more readily than discriminated responding, but the younger infants account for much of the difference. There are at least two possible explanations. Perhaps more experience with a nutritive nipple with the three-day-old infants, i.e., more experience with nutritive reinforcers (water or formula), interfered with learning to suck on the nonnutritive nipple for auditory consequences. Another possible explanation may center on the fact that the infants' network of sampled voices has expanded. This may in turn effect either the discriminability or initial reinforcability of the voices.

One final observation can be made regarding the burst duration measure. The general increase in burst durations during the experimental phase over those during the two-minute adaptation period suggest female voices in general may be reinforcing. There was no increase in maternal-voice burst durations over the session, but there was a significant decrease in burst durations associated with the other voice. Perhaps the infants had first, and quickly, learned to keep both voices on as long as possible and then learned to shorten the presentation of the other woman's voice.

Preference for the maternal voice was also shown by the acquisition of an auditory discrimination. Infants of both ages learned to suck more frequently in the presence of the discriminative stimulus that signaled their mother's voice. The data provide the earliest evidence, in terms of postnatal age, of learning in an operant discrimination paradigm. In only one other study have infants under two months of age learned to differentially respond to different discriminative stimuli, i.e., stimuli which then set occasion for different environmental consequences of behavior. Siqueland and Lipsitt (1966) used a buzzer and tone as positive and negative stimuli with five-day-old infants. When the positive stimulus, a tone plus tactile stimulation applied to the cheek, was presented, head turns were reinforced with a dextrose solution. When the negative stimulus, a buzzer paired with the tactile stimulus, occurred, head turning resulted in no reinforcement. There was clear discrimination of the stimulus compound, but there was no evidence of a discrimination involving only auditory stimuli.

The present procedure placed more demands on the infant than did the Siqueland and Lipsitt procedure. The newborns in this study were required to differentially respond to the discriminative signals without simultaneous presentations of eliciting stimuli, i.e., the nipple was always in the infant's mouth and there was no other response-eliciting stimulus paired with the signal. The contingencies also required differential responding without a negative or neutral consequence as in the Siqueland and Lipsitt study, i.e., the nonmaternal voice which followed the "other" signal was presumably reinforcing, though less so than mother's voice. Successful discrimination learning under these contingencies indicates the presence of a mechanism available for acquiring associations between environmental events and also suggests that newborns are even more competent learners than is usually believed (Hulsebus, 1972; Sameroff, 1972).

The maternal voice preference shown by infants as young as one day old is significant for several reasons. First, at this writing, these data constitute the only evidence that infants less than 48 hours old discriminate or prefer any "maternal" stimulus. The prevailing view of attachment maintains that discrimination of mother from another person does not occur during the first attachment phase (Ainsworth, 1979; Bowlby, 1966). The absence of observable differential signaling or orienting to mother has been taken as evidence for inability to discriminate. In fact, the presumed inability to differentiate between humans is the defining characteristic of the phase. This study when taken with other newborn research indicates a clear need to revise the current theory of attachment.

One revision could take the form of eliminating phase one, "orientation and signals without discrimination of figure." This would entail advancing the onset of phase two, "attachment in the making," by 8-12 weeks. However, the only substantive distinction between phase two and phase three, "unmistakable attachment," is the presence of locomotion in seeking and maintaining proximity (Ainsworth, 1978). Retaining this one-phase division for the entire first three years of attachment development seems superfluous. However, if the emphasis is directed toward changes in the development of more advanced attachment phenotypes, such as differential motor responding to attachment figures, perhaps the original four-phase division is useful. That is, though the timetable is in error regarding the onset of attachment behaviors per se, i.e., the discrimination and preference for maternal stimulation, the developmental course of more differentiated and/or complex ways of demonstrating attachment is well documented and accurately described within the phase division offered by Bowlby and Ainsworth.

Cairns' (1979) synthesis of social learning and psychobiological approaches to social development suggests another way to revise traditional theories of attachment. For Cairns, the relevant data for understanding social phenomena, like attachment, is the behavioral interaction that evolves between the maturing organism and caretaker. The developmentalist's task is to explain how the infant's behavior comes to be organized around distinctive features of the primary caretaker. As both the response systems and sensory apparatus change, the events which will elicit and maintain attachment behaviors, e.g., signaling, orienting, and proximity seeking, will also change. Within this framework, the present results are not anomalies, but rather are major keys to understanding the early interaction process. Specifically, early preference for mother's voice directs our attention toward how the infant initially organizes his/her attachment behaviors around the distinctive, vocal features of the caretaker, and how this preference could facilitate later discrimination of other "maternal" features as well, e.g., by association of maternal access through discrimination learning of the type demonstrated in this study.

This newborn capability may also have implications for the study of receptive language development. Horowitz (1975) suggests that exploration along the length of the developmental ladder for auditory discrimination abilities may be a fruitful direction for research into receptive language. The newborn's special competencies with speech sounds discussed earlier and ability to discriminate the maternal voice demonstrated in this study, suggest that the neonatal segment of the ladder may provide an especially fruitful area for language research. In addition, early discrimination of mother's voice may directly influence later language development. Not only could differential attention by the newborn serve to elicit and maintain maternal vocal responding, but an early predisposition for the mother's voice may subserve later discrimination of other characteristics of human speech. That is, early development of a well-formed schema for mother's voice may then facilitate later interaction with more complex features of human language.

The demonstration that one-day-old newborns discriminate and prefer their mother's voices directs our attention to even earlier stages in development of attachment. Prenatal experiences may function as precursors for later postnatal attachment. As previously mentioned, the auditory apparatus is functional during the seventh month of gestation and the fetus is capable of responding to sounds outside the womb (Eisenberg, 1976). Although little data exist regarding the significance on intrauterine auditory experience in humans, the maternal voice may be one of the most frequently heard sounds. Research with sheep indicates that conversationsl sounds near the ewe can be heard within the amniotic sac (Armitage, Baldwin, & Vince, 1980) and prenatal auditory input has been shown to play a crucial role for attachment in some species of birds (Gottlieb, 1971). The relatively brief amount of time spent with mother postnatally, typically under two hours for the one-day-old infants in this study, also suggests that prenatal auditory experience may affect development of voice preference. Thus, human studies designed to investigate the relative effects of postnatal and prenatal auditory events are important. One such study could entail observation of infants with no opportunity for postnatal interaction with mother, e.g., infants put up for adoption. Another could examine postnatal responses to distinct sounds presented during pregnancy.

Finally, the newborn's preference for the maternal voice may also have implications for neonatal hospitalization. Disturbance of mother-to-infant bonding has been frequently observed following extended separations of mother and newborn (Kennell, Voos, & Klaus, 1979; Klaus & Kennell, 1976; Lipsitt, 1979). Low levels of response contingent sensory stimulation and decreased opportunity for caretaker-infant interactions are factors implicated in retarding the behavioral reciprocity characteristic of a normal caretaker-infant relationship (Lipsitt, 1979). Though the preference for mother's voice is present shortly after birth, the maintenance of this preference may well require continued interaction with the voice during the newborn period. The absence of this experience may adversely affect attachment to other distinctive features of the mother and subsequent development of reciprocal responding by the mother. Providing an opportunity for hospitalized infants to interact with their mother's voice might supplement existing procedures designed to diminish the adverse effects suffered by ill, premature, and low birth-weight infants.

The picture of the newborn as a passive helpless recipient of environmental stimulation is no longer accurate. More questions than answers remain in the exploration of the newborn's social, perceptual, and learning capabilities, but we are beginning to allow the newborn to answer these questions.

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APPENDIX A

TABLES

TABLE 1

Mean Burst Durations and Percent of Signals Responded to for Each Infant During the First and Final Thirds of the Session

				First Third				Final Third			
				$\bar{x}$ Burst Duration (sec)		% Signal Response		$\bar{x}$ Burst Duration (sec)		% Signal Response	
Subject	Feeding Method	Age Group in Days[a]	Signal	Mother	Other	Mother	Other	Mother	Other	Mother	Other
1	Breast	1(45)	Tone	9.7	7.7	90	50	9.6	7.8	77	66
2	Breast	1(36)	Tone	16.9	9.7	50	59	11.7	9.5	43	52
3	Breast	1(42)	No tone	11.5	10.8	63	85	9.7	7.8	68	63
4	Breast	1(39)	No tone	9.2	6.9	71	47	8.7	7.5	65	52
5	Breast	3(73)	Tone	8.8	9.3	62	59	12.6	9.4	38	54
6	Breast	3(96)	Tone	8.6	8.5	61	73	7.2	7.2	56	33
7	Breast	3(85)	No tone	8.5	9.8	65	43	9.2	8.0	72	57
8	Breast	3(90)	No tone	7.5	12.0	61	78	8.8	8.3	60	47
9	Bottle	1(41)	Tone	9.7	8.0	81	89	6.2	5.1	70	50
10	Bottle	1(34)	Tone	5.9	6.5	50	60	9.8	9.0	75	47

				First Third				Final Third			
				$\bar{x}$ Burst Duration (sec)		% Signal Response		$\bar{x}$ Burst Duration (sec)		% Signal Response	
Subject	Feeding Method	Age Group in Days[a]	Signal	Mother	Other	Mother	Other	Mother	Other	Mother	Other
11	Bottle	1(41)	No tone	10.6	8.1	60	50	10.0	9.1	100	61
12	Bottle	1(35)	No tone	6.7	5.7	46	64	7.4	6.6	50	40
13	Bottle	3(86)	Tone	7.6	6.5	66	82	6.5	5.6	88	77
14	Bottle	3(93)	Tone	8.6	6.7	36	55	7.8	6.3	95	62
15	Bottle	3(72)	No tone	9.1	9.5	94	90	12.4	11.4	81	75
16	Bottle	3(86)	No tone	9.6	10.3	58	70	10.1	8.1	55	58

a = Age in testing in hours

TABLE 2

ANOVA Results for Percent of Signal

Responses Difference Scores

Source of Variance	Degrees of Freedom	MS	F	p
Feeding	1	2.6	.006	NS
Signal	1	11.3	.03	NS
Age	1	247.6	.56	NS
Feeding x Signal	1	19.5	.04	NS
Feeding x Age	1	62.8	.14	NS
Age x Signal	1	16.5	.03	NS
Feeding x Signal x Age	1	166.9	.37	NS
Subject/Feeding x Signal x Age	8	443.9	-	$< .025$
Trials	1	1785.1	7.78	NS
Trials x Feeding	1	1092.7	4.76	NS
Trials x Signal	1	19.5	0.08	NS
Trials x Age	1	11.2	0.05	NS
Trials x Feeding x Signal	1	520.0	2.27	NS
Trials x Feeding x Age	1	226.3	0.99	NS
Trials x Age x Signal	1	290.0	1.27	NS
Trials x Feeding x Signal x Age	1	13.8	0.06	NS
Trials x Subject/Feeding x Signal x Age	8	229.5		

TABLE 3

Repeated Measures ANOVA for Percent of Signal Responses

Source of Variance	Degrees of Freedom	MS	F	p
Voice	1	394.7	1.71	NS
Trials	1	102.5	0.45	NS
Voice x Trials	1	892.8	3.87	< 0.05
Subjects/Voice x Trials	60	230.0		

TABLE 4

ANOVA Results for Burst Durations Difference Scores

Source of Variance	Degrees of Freedom	MS	F	p
Feeding	1	.11	0.05	NS
Signal	1	2.09	1.02	NS
Age	1	13.65	6.69	$< .05$
Feeding x Signal	1	5.69	2.78	NS
Feeding x Age	1	11.16	5.47	NS
Age x Signal	1	0.69	0.33	NS
Feeding x Signal x Age	1	1.33	0.65	NS
Subject/Feeding x Signal x Age	8	2.04	1.03	NS
Trials	1	1.95	1.03	NS
Trials x Feeding	1	0.23	0.12	NS
Trials x Signal	1	3.44	1.84	NS
Trials x Age	1	14.4	7.64	$< .025$
Trials x Feeding x Signal	1	1.33	0.70	NS
Trials x Feeding x Age	1	4.74	2.50	NS
Trials x Age x Signal	1	1.39	0.74	NS
Trials x Feeding x Signal x Age	1	1.86	0.98	NS
Trials x Subject/Feeding x Signal x Age	8	15.11		

TABLE 5

Repeated Measures ANOVA for Burst Duration Scores

Source of Variance	Degrees of Freedom	MS	F	p
Age	1	0.04	0.004	NS
Subject/Age	14	9.7	-	
Trials	1	1.9	0.55	NS
Voice	1	16.7	10.84	$< .005$
Trials x Voice	1	0.9	0.99	NS
Trials x Age	1	0.7	0.7	NS
Trials x Subject/Age	14	3.42	-	
Voice x Age	1	6.86	6.82	< 0.03
Voice x Subject/Age	14	1.54	-	
Trials x Voice x Age	1	7.1	7.06	< 0.02
Trials x Voice x Subject/Age	14	1.006		

APPENDIX B

FIGURES

Figure 1

The Mean Percent of Signals Associated With the Maternal Voice and the Other Voice That Were Responded to During the First and Final Third of the Session

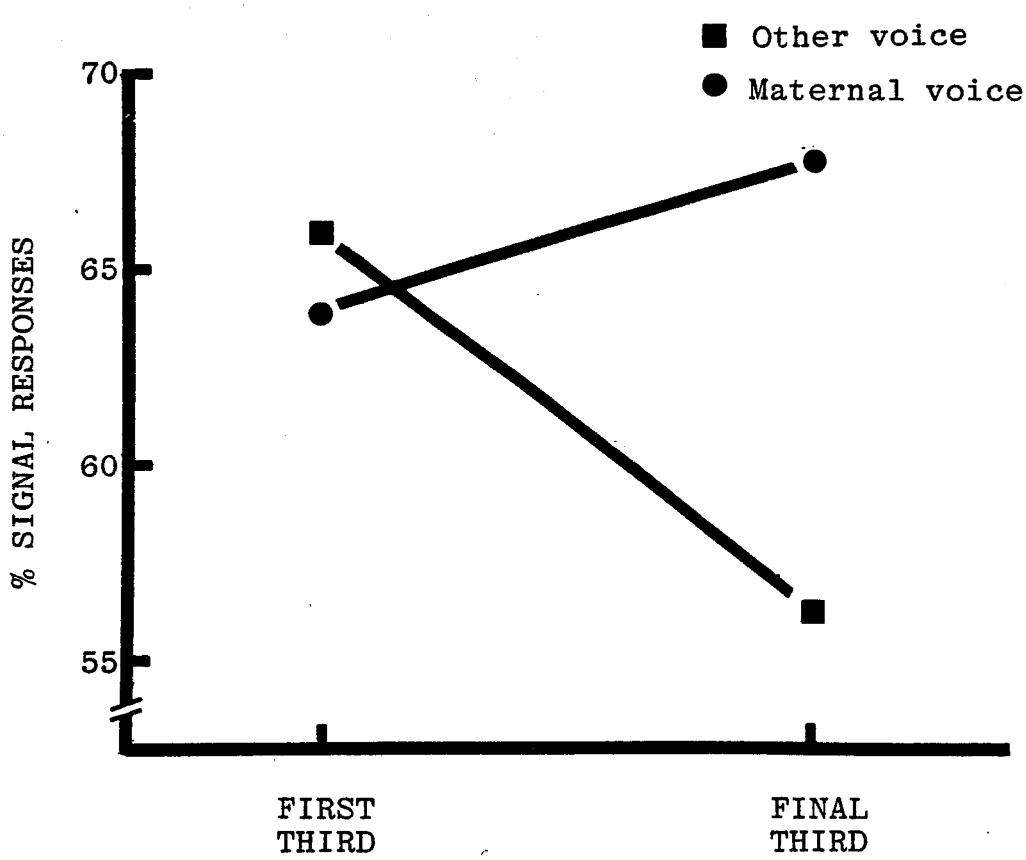

Figure 2

The Average Difference Scores in Seconds of Burst Durations Associated With Mother's Voice Minus Durations With the Other Voice for the First and Final Thirds of the Session

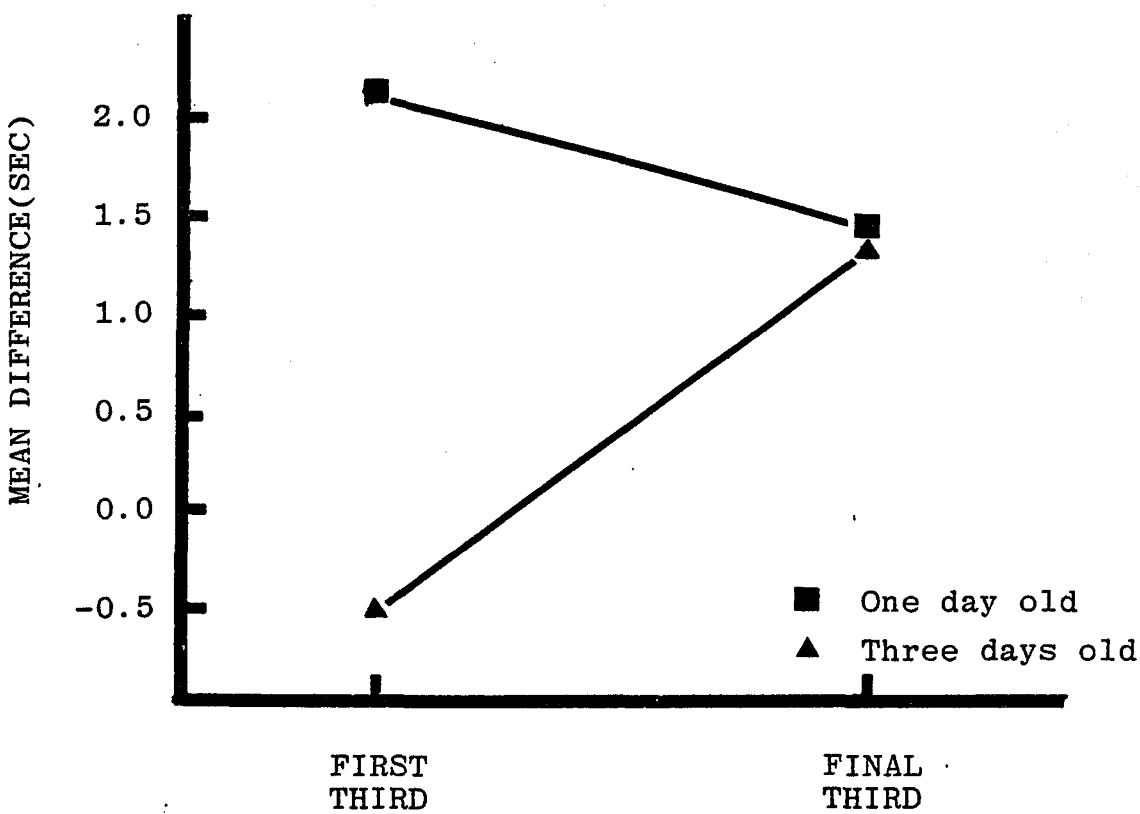

Figure 3

The Average Burst Durations in Seconds Associated With the Maternal and the Other Voice for One-Day-Old and Three-Day-Old Infants During the First and Final Third of the Session