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Healthy Preterm Infant Responses to Taped Maternal Voice

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This study was a repeated measures design, examining behavioral and physiologic responses of premature infants to taped maternal voice. Fourteen stable, premature infants, 31 to 34 weeks' gestation and serving as their own controls, were monitored and videotaped 4 times each day for 3 consecutive days during the first week of their life. There were no significant differences found in heart rate or oxygen saturation between study conditions. Behavioral data revealed less motor activity and more wakefulness, while hearing the maternal tape, suggesting some influence on infant state regulation. Attending behaviors were significantly greater, with more eye brightening and facial tone. Minimal distress was seen throughout the study, as indicated by stable heart rate and oxygen saturation and by the absence of behaviors such as jitteriness, loss of tone, or loss of color. The results of this preliminary study suggest that premature infants are capable of attending to tape recordings of their mother's voice. **Key words:** *infant stimulation*, *parent-infant relations*, *premature infants*

Most newborn infants are in close physical contact with their mothers, and the rhythmic stimulation of movement and intermittent speech experienced during fetal development continues after birth. The mother's regulatory role for system organization is significantly different for infants born prematurely than for term infants, because premature infants do not experience extended contact with their mothers early in life. Evidence exists that mother's voice can be an important positive stimulus for infants and for premature infants in the neonatal intensive care unit (NICU). Nevertheless, the potential for a mother's voice to offset overstimulating sensory input in the NICU and to soothe a premature infant remains a relatively unexplored area of research. The *purpose* of this study was to describe the physiological and behavioral effects of taped maternal voice on premature infants.

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Contributions from animal studies

Researchers in classical animal studies have looked at aspects of maternal behavior that promote development and decrease the detrimental effects of maternal separation. Studies of rat pups have delineated aspects of maternal behavior that modulate arousal. When synchronous social interactions were not established, or prolonged maternal deprivation occurred, these pups manifested disturbances ranging from decreased activity levels to autonomic and biochemical imbalances.[1]

In nonhuman primates, disruptions in mother-infant interaction are potent variables that cause increased hypothalamic-pituitary-adrenal activity and result in neurochemical and behavioral changes.[2,3] In studies with both monkeys and rats, decreased immune responses as well as hypothalamic-regulated functions, such as body temperature, sleep, metabolic rate, and many autonomic processes have been affected when infants are deprived of their mothers.[3]

Investigators have also demonstrated that among primates, the presence of familiar visual or auditory access to the mother, through either sound recordings or video, can ameliorate adverse biologic or behavioral responses, even when the mother herself is not available to the isolated infants.[1,3] These data suggest that providing the mother's voice on tape may support behavioral regulation in premature infants while in the NICU.

Development among human infants

Highly salient social stimuli, even in the absence of contact, increase the ability for appropriate coping responses to reduce levels of arousal and distress. Multiple factors contribute to poorer outcomes in premature infants, including gestational age at birth, medical interventions, and medical complications.[4–6] Two major factors, however, may be the loss of sensory input occurring within the womb prior to the untimely birth coupled with the types of stimulation experienced by premature infants in the NICU.[7–9]

Stimulation during fetal life

In the intrauterine environment, rhythmic stimuli are provided by maternal activity, hormonal cycles, and auditory cutaneous and kinesthetic input through the amniotic fluid and sac.[9] One of the common experiences for the fetus is the intermittent, regular exposure to the mother's voice. The maternal voice is minimally distorted and the intonation and melodic contour are identical to the external voice, factors critical for postnatal responsiveness to voice. These stimuli provide support for function and organization for the developing fetus.[10–13]

Maternal voice is heard by the fetus, although filtered by amniotic fluid and body tissue.[9] Descriptions and analysis of the spectral properties of audio recordings made from within the womb have provided information about acoustic characteristics of the intrauterine environment.[10] The maternal voice is transmitted internally with considerably less attenuation due to the low-frequency components, which are the first perceptible sounds in the developing auditory system.[11] Experience with external sounds, particularly low-frequency sounds such as the maternal voice, serves a role in enriching and facilitating function of the auditory system.

Both behavioral and electrophysiological responses to sound have been demonstrated in the fetus.[10,11] Fifer[14] postulated that the frequency level and expression of the voice, as well as repeated exposure while in the womb, allow newborns to recognize and distinguish their mother's voice from others.

Stimulation in the NICU

Normal sensory development requires stimulation during periods of rapid brain growth.[8] Neurodevelopmental processes evolve with consistent patterns of sensory input. A premature birth represents an abrupt change in experience for the infant's developing nervous system.[7,9] In the NICU, sensory stimulation is not consistent, patterned, or congruent with the types of stimulation that are required for normal neonatal development. Neonatal intensive care unit stimuli may interfere with brain development in premature infants and contribute to developmental delays.[4,5,15–17] Follow-up studies and observations of premature infants have found disturbances in interactions and delays in language development.[4,5,18,19] What is clearly missing is appropriate stimulation to prevent a prolonged interruption in sensory development of premature infants.

Developmentally supportive care has been successfully instituted in several NICUs to help protect premature infants from noxious stimuli.[7,20,21] This approach encourages noise control, dim lighting, supportive positioning, and planning care based on infant cues. Integrating appropriate stimulation, such as the maternal voice, has the potential to help infants cope with the unpredictable NICU environment.

Theoretical foundation and applications

The theoretical basis for this study is rooted in developmental science, a systems-oriented approach to human development integrating mental, biological, and behavioral systems while viewing individuals within an ongoing reciprocal process of interactions with the environment.[22,23] These interactions influence the trajectory of individual development. Developmental science recognizes the complex and dynamic state of development and the importance of change over time.[24] The premature infant is developing and differentiating into multiple subsystems that are interdependent in function, while simultaneously coping with the external environment.[22]

The auditory system is well developed and differentiated early in gestation; the functional ability of hearing has been shown as early as 24 weeks' gestation.[25,26] The critical period for language development has been reported to begin at approximately 30 weeks' gestation with exposure to sound in the womb.[26] Premature infants in the NICU have limited opportunities to hear their mother's voice. Yet, as studies with primates have suggested,[2] tape recordings of maternal voice may help foster early social responsiveness and promote attachment because the infant is reacquainted with maternal speech heard in the womb. Hearing spoken words reinforces speech, encourages vocalization, and is required for language to develop normally.[27] Responsiveness to auditory stimulation has been related to intellectual performance at 8 years of age.[4]

A few studies have investigated behavioral responses of premature infants to the human female voice, although most were combined with tactile stimulation. Infants responded to the use of motherese, or infant-directed speech, with increased visual attention.[28-31] Eckerman et al[30] studied infants from 29 to 36 weeks' gestation using 3 different protocols (quiet, talk, and talk and touch) and found that voice was an effective means to increase alertness in infants, even at early postconceptional ages. Addition of tactile stimulation, however, led to a decrease in visual attention and increasing signs of distress. In another investigation that included human voice stimulation and multimodal stimulation (the combination of tactile, visual, and vestibular stimuli), White-Traut et al[31] found that exposure to female voice increased quiet sleep and resulted in the lowest heart rate ranges. These infants were slightly older than the infants in the Eckerman et al study, and they had several forms of additional stimulation, which may account for the differences in arousal. These studies have established the preterm infant's capability for responsiveness, but all have used voice along with other forms of stimulation in their investigations. None have used mother's voice as a sole stimulus to determine its effect.

Only a few isolated studies examining effects of a mother's voice on premature infants have been reported, and all of these were conducted more than 20 years ago. Exposure to tape recordings of maternal voice resulted in increased muscle tone and improved responsiveness[32] and improved weight gain.[33] The heart rate of crying infants decelerated in response to their mother's voice; however, it is not clear how this was measured.[34] Because these studies were conducted long ago, the infants experienced very different medical interventions and more limited technology than premature infants cared for in the modern NICU and hence the study conclusions may not be applicable to the current population of premature infants. The studies also used variables reflecting cumulative effects over the hospitalization; the immediate behavioral responses of infants to maternal voice are unknown. For this study, the variables included heart rate, respiratory rate, oxygen saturation, infant states of arousal, activity, and observable behavior, because they have been used to quantify infant responses to stimulation in several investigations.[31,35]

PURPOSE OF THE STUDY

The purpose of this study was to explore the immediate effects of taped maternal voice on physiologic (heart rate, respiration, and oxygen saturation) and behavioral (activity, attention, state, motor, facial expression, and visceral) responses of hospitalized premature infants and examine the effects of repeated exposure to taped maternal voice over time. Because tape recorders are frequently used in the NICU, with little evidence of the safety of this practice, determining that maternal voice tapes did not cause distress for premature infants was a goal. It was also of interest to determine whether premature infants would show an orienting response to the maternal tape. Decreased body movement, a brief drop in heart rate, and a slowing in the rate of breathing often demonstrate orientation to a stimulus.[36] Changes in heart rate are the most general indicators of autonomic reactivity studied, and patterns of either acceleration or deceleration from baseline or resting are reported. In a classic work, Graham and Clifton[36] proposed that heart rate deceleration in term infants is a component of orienting or attention. Significant decreases in breathing rate and heart rate have been demonstrated in response to speech sounds among newborn infants who were 24-hours old.[24] Investigations on both 1- to 3-day-old newborn infants and fetuses as early as 26 weeks' gestation, have shown that heart rate consistently decelerates in response to tape recordings of the mother's voice.[11]

In this study, it was hypothesized that the infants would show fewer stress cues while listening to their mother's voice and that there would be physiologic changes indicating an orienting response. Providing multiple exposures to taped maternal voice was expected to result in increased attending to the voice over time and longer periods of alertness.

DESIGN AND METHODS

Using a quasi-experimental, repeated measures design, the study was conducted in 2, level II nurseries in the Greater Seattle area. Both units were equivalent to an intermediate nursery because unstable infants were transferred to level III facilities. Infants in these units were provided nursing care every 3 hours. The study nurseries had moderate activity and noise levels and overhead florescent lighting during the daytime, when the study was conducted. The usual activities of the nurseries continued throughout the data collection periods.

Participants

A convenience sample of 14 stable, premature infants was recruited for this pilot study. The preterm infants were between 2 and 5 days postbirth when the study began. Because there are no current guidelines for the use of tape recorders with preterm infants or the appropriate duration of exposure, the principle investigator used a brief recording and provided the tape on a number of occasions to help determine how much exposure to maternal voice was needed to illicit a response. Inclusion criteria for the study were: gestational age between 28 and 34 weeks, housed in incubators, not requiring ventilation, less than 1 week of age at time of entry into the study, maternal age of at least 18 years, and parental consent. Because of the potential influence on behavior and heart rate, infants with known neurological or congenital defects, exposure to cardiogenic drugs such as dopamine, or muscle relaxants, maternal history of drug use, or cranial ultrasound documentation of greater than grade II intraventicular hemorrhage were excluded.

There were 8 male infants (57%) and 6 female infants (43%) in the study. The infants ranged from 31 to 34 weeks' gestation with a mean gestational age of 33 weeks (SD = 1.0). Birth weights ranged from 1658 to 2885 g (mean = 2059 g, SD = 31.9). One infant was Hispanic and one was Asian; the rest were white. Mothers of the infants were between 21 and 41 years of age (mean = 30 years, SD = 6.0). Maternal education levels ranged from 12 to 17 years, with a mean of 13 years of schooling (SD = 2.0). The infants' fathers had 9 to 13 years of schooling, with a mean of 11 years (SD = 3.0). The clinical status of the participants was typical for infants born prematurely without significant respiratory distress. All infants were briefly in oxygen therapy, which was discontinued by the time of data collection. They all had initial intravenous therapy, which continued during the time that feeds were gradually introduced and advanced. All of the infants were housed in incubators for the duration of the study. Twelve of the 14 infants received phototherapy for hyperbilirubinemia but only 4 were receiving treatment at the start of data collection. Five of the infants received caffeine for apnea of prematurity.

Intervention

The infant's mother was chosen to provide the voice stimulation, to be consistent with the infant's experience in the womb and to facilitate the establishment of the mother-infant relationship. All mothers were asked to read the same children's story to their infants, which was tape recorded to produce a 3-minute tape. The children's book was used to ensure a consistent script for the intervention and to help mothers feel at ease, because they did not have to simply talk into the recorder. Maternal voice tapes were examined for clarity prior to use.

A tape recorder (Sony model No. Wm-D3, Tokyo, Japan) located outside the incubator provided the mother's taped message. A small sponge-tipped insert earphone (Etymotic Research, Elk Grove, Illinois, No. ER-3A), which is also used for newborn hearing screening tests, was used to deliver the tape-recorded voice. Insert ear phones are calibrated in a serial coupler at a reference equivalent sound pressure level or threshold based on standards from the American National Standards Institute. A speech and hearing specialist calibrated the earphone to an average of 65 dB. This level is considered safe for infants, and is far below the sound levels that can produce hearing damage. The prosody of speech can be measured with the range of 55 to 75 dB on an A-weighted scale.[37] Numerous infant studies using recorded voice have reported protocols using decibel sound pressure levels ranging from 69 to 80 dB.[10,37–39]

Variables and their measurement

Physiologic data

Heart rate, respiratory rate, and oxygen saturation were continuously monitored and recorded by the SpaceLabs data master monitor and personal computer (model No. 90305, Redmond, Washington) and stored on computer discs. The SpaceLabs monitor automatically self-calibrated to an accuracy of within 2 beats per minute prior to each data collection period. Although physiologic data were measured continuously, the computer recorded data every 10 seconds to coincide with the interval for coding the behavioral data. This 10-second heart rate, respiratory rate, and oxygen saturation reading represented the mean over the 10-second interval. This frequency was chosen to reasonably manage the large volume of data that were generated and to avoid sudden, transient variations in the data. The physiologic data were timed-stamped and synchronized with the video recordings for concurrent analysis.

Videotaping

Video recordings of the infants were made with a mini-camera made by Toshiba (model No. IKM30AK, Torrance, California) interfaced with a high-resolution television monitor (Panasonic, model No. CT138-34) and videocassette recorder (Panasonic, model No. AG6030-P, Seattle, Washington). The camera was

Table 1. Codes for infant behavior

Category of Behavior	Examples of behavioral codes	Source
Stability	Foot clasp, hand clasp, holding on, sigh, ooh face, open face, leg bracing, flexion, grasping, hand to mouth, and smile	41
Stress	Gape face, grimace, gag, airplane, spitting up fuss, sitting on air, arching, startle, hiccup, yawn averting gaze, and finger splay	41
Attention	Eyes wide, eyes brightening, eyes toward source, sucking, stilling, head turn, visual locking, and hand to face or mouth	42
Infant state	Deep sleep, active sleep, drowsy, quiet awake, active awake, crying (1–5)	43
Activity	No facial or body movement, facial only, hand or foot only, head or extremity, mild trunk, moderate trunk, thrashing (0–6)	45

mounted at an inside corner of the incubator and remained in place for the duration of the daily data collection period, with removal at the end of each study day.

The research videotapes were transferred to vertical time-coded videotapes using the Coder 2 computer software program (Arvid Kappas, Washington).[40] All observed behaviors were coded as they occurred. An individual behavior was considered as a continuous event in the 10-second coding interval. Six major categories of behavior were observed: activity, state, stress behaviors, stability behaviors, and attentive responses.

Behaviors for coding were defined according to the Individualized Developmental Care and Assessment Program that is currently used in many NICUs to provide care based on the behavior and needs of the infants.[41] The coded behaviors included indicators of stability (eg, smooth movements, relaxed face) or distress (eg, arching, finger splaying), as described by Als[41] and used in several studies.[21,22] Observable indicators of attention were adapted from Karmel Gardner and Magnano.[42] These behavioral codes are listed in Table 1. The behaviors of the infants were further clustered into 3 major categories for analysis consisting of stress, stability, and attention. Infant state was determined according to the terms defined by Brazelton and Nugent.[43] The 6 categories of state were collapsed into awake, asleep, and crying for data analysis.

The Blackburn Activity Scale for premature infants was used to define the level of activity based on gross motor movements.[44] This categorical scale was developed from multiple hours of videotaping of preterm infants and ranges from no facial or body activity to intense trunk movement (writhing or thrashing). The scale was validated by comparing time-lapsed video recordings of behavior and polygraphic state determinations on infants from 29 to 34 weeks' gestation,[45] and it has been used in other studies examining activity levels of premature infants.[44]

These activity categories, along with the behaviors defined by Als,[41] were adapted to develop a computer generated coding scheme that assigned numerical values to each defined behavior, because it was selected to quantify the observed behaviors for analysis.

Behavioral coding reliability was established by recoding a portion of the tapes (intrarater reliability) and by coding the videotapes with a second blind observer (interrater reliability). Intrarater reliability was established on 10% of the tapes randomly selected from each subject and 94% agreement was found. The Cohen's κ achieved was 0. 91. Interrater reliability was established with the second observer at 91% and a κ level of 0.81.

Procedure

With human subject's approval, the infant's nurse or the postpartum nurses informed women whose infants met the inclusion criteria about the study. If the mother indicated a desire to participate, the investigator provided a complete description of the study, and written consent was obtained. Each infant's mother read the identical children's story that was recorded in her voice on a cassette.

The principal investigator performed data collection, beginning after the first 48 hours of life (to allow the infant to adapt to the extrauterine environment), and before 7 days of age to capture premature infant behavior before significant maturation occurred. To determine the amount of exposure needed to generate a response to the taped sound, data were collected over a 3-day period and included 4 maternal voice tape exposures each day, for a total of 12 sessions for each infant. Each 9 minutes of data collection involved 3 minutes of baseline measures, followed by the 3-minute tape recording of maternal voice and 3 minutes of posttape measures. Data collection began for each session approximately 30 minutes prior to scheduled nursing care. This time frame was chosen to avoid disturbing the infant's rest, to minimize inconvenience to the nursing staff, and to capture times when the infant was most likely to be awake.

The only investigator contact with the infant involved positioning the ear probe over the infant's ear and placing him in line with the camera. The cables from the infant's cardiorespiratory monitor were switched to the study monitor for data collection. The computer was programmed to record physiologic data and was time-synchronized with the video recorder. After baseline measures were obtained, the tape recorder was turned on and then stopped after 3 minutes of play. The observation continued until 3 minutes after the maternal tape segment stopped playing. No further recording was done until the next care interval. Although intrasession intervals varied slightly with infant care needs, the average time between sessions was 3 hours. Data collection sessions were conducted for 4 consecutive times each day for 3 days.

Data analysis

Missing values in physiologic data due to infant movement or artifact, which occurred less than 2% of the time, were replaced by averaging previous and subsequent values. The data was coded several weeks after data collection by the investigator, so there was a minimal chance that bias was introduced by recognition of the infants on the videos. The coded behavioral data were transferred to ASCII files and combined with the physiologic data files for analysis. To determine the differences between infant behavioral responses, the continuous 3-minute intervals of the segments of baseline measures, maternal tape, and post-maternal tape were extracted from the data, and segment means were used for the analysis. Individual infant responses in each 10-second period were averaged for all 12 sessions so that infant patterns of responses could be visually examined. Individual curves for each infant were generated using the Lowess algorithm[39] to fit a robust, nonparametric, nonlinear regression model.

Repeated measures multivariate analysis of variance were used to evaluate the mean segment scores for each infant over the 12 sessions. Difference scores for the sample were determined from the individual mean segment score. Because no significant differences were found in either analysis, the 12 data collection sessions for each infant were averaged and combined to analyze the effects of maternal voice on the infants as a group, and dependent samples t tests were used to test differences between pairs of segments baseline to tape and baseline to posttape, using a significance level of 0.05. The study was determined to have a power of 0.8 for detecting an effect size of 0.51 of a standard deviation. In addition, the means of the first 30 seconds at the beginning of the tape were compared with those of the last 30 seconds of the baseline, using paired t tests to determine the presence of an orienting response.

RESULTS

Physiologic responses

Physiologic variables were examined for immediate change at the outset of the tape-recorded voice to determine the presence of an orienting response. Although heart rate and respiratory rate decreased in 57% of the infants, the difference between the baseline and maternal tape segments was not significant. As shown in Table 1, there were no significant differences across segments in either heart rate or oxygen saturation. The respiratory rate, however, decreased significantly from the maternal tape to the posttape segment, which may have been related to orienting to the voice. The physiologic data was cleaned by removing artifact from movement. Infant heart rates ranged from 124 to 164 beats per minute (mean = 141 beats per minute) and respiratory rates ranged from 21 to 64 breaths per minute (mean = 34 breaths per minute).

Behavioral responses

Infant behaviors were compared as segments of baseline, maternal tape, and immediate post tape. There were no significant differences in the level of stress behaviors between any study segments (Table 2). Stability behaviors, however, significantly increased from the maternal tape to the posttape segment. Although activity levels decreased during the tape, as observed by visual inspection of all sessions, they did not significantly differ across segments. Attending behavior, however, was significantly different during the assessment of values for tape than either the baseline or posttape time segments. The infants showed more attending behaviors when listening to their mother's voice. Overall, the infants were awake 71% of the time and spent only 5% of the time crying. The maternal tape may have fostered longer periods of alertness than is typical for preterm infants of this gestational age. Significantly more infants were asleep during the posttape segment than during the maternal tape. This suggests that listening to mother's voice had a soothing effect.

Patterns of responses over the 3-day intervention

The data were analyzed to determine changes in responsiveness over time. Repeated measures multivariate analysis of variance revealed no significant

Table 2. Differences in behavioral and physiologic variables across baseline, maternal tape segments and posttape segments

Variables	Baseline Mean	Baseline SD	Baseline to tape *t* test	Tape Mean	Tape SD	Tape to post tape *t* test	Posttape Mean	Posttape SD	Baseline to posttape *t* test
Heart rate (bpm)	141.80	11.00	−0.58	141.00	11.00	0.58	141.00	12.00	0.74
Respirations (no.)	35.50	4.00	−1.80[d]	35.70	4.00	−2.40[c]	35.70	4.00	−0.58
O_2 (%) saturation	97.70	1.00	0.11	97.50	1.00	−1.95	97.50	1.00	−1.90
Activity Level	2.50	7.00	0.89	2.50	8.00	−0.22	2.50	7.00	0.66
Awake percentage of time	72.20	15.00	−1.40	75.30	13.00	3.11[e]	66.70	18.00	1.40
Asleep percentage of time	22.20	16.00	−1.30	18.10	13.00	−3.95[e]	26.20	18.00	−1.10
Cry	4.80	7.00	−1.00	6.30	9.00	−0.35	4.80	7.00	0.93
Stress	0.34	0.20	0.21	0.34	0.19	−0.98	0.36	0.18	−0.43
Stability	0.51	0.19	−1.50	0.51	0.20	2.10[c]	0.45	0.19	2.20[e]
Attention	0.03	0.04	−5.60[e]	0.16	0.12	4.90[e]	0.05	0.06	−2.30[e]

[a]Stress, stability, and attention are clusters of observed behaviors, for example, grimacing and arching were included under stress; smiling, eyes wide, and eyes toward source were included in attention; facial tone, flexed posture, and hands to mouth were included in stability. These numbers reflect the presence of behaviors in these categories during each segment, for example, occurrence of crying.
[b]$N = 14$; [c]$P \leq .05$; [d]$P \leq .01$; [e]$P \leq .001$.

differences in responses from the first session to the last, for each these infants. Because of response variability, significant differences were not detected within individual infants across the study sessions. An illustrative individual infant curve generated by the Lowess algorithm[46] is depicted in Figure 1, which shows the activity scores over the 12 data sessions using the scale scores of 0 for asleep to 6 for thrashing movement. Although the responses of this infant over the 3 days were not the same at each session, some infants showed similar curves when the variables were plotted. Therefore, despite great variability in individual infant responses, similar recurrent patterns of behavior across infants were observed when they were examined as a group.

Videotape observation also indicated that more interest was shown by the infants toward the end of the maternal tapes, because an increase in attentive behaviors were observed. Because the time frame for analysis was limited to 3 minute, responses that occurred over longer time periods were not captured in this analysis.

PRACTICE IMPLICATIONS

The results of this pilot study indicate that premature infants are capable of attending to taped maternal voice. Tape recordings of mother's voice did not have adverse effects on this sample of premature infants, as indicated by their stable physiologic status and lack of avoidance behaviors. Indeed, the infants in this study had less overall movement and activity and displayed more stability cues during exposure to maternal voice than during the baseline period.

Behavioral responses indicating attention were significantly higher in both baseline and postmaternal tape segments, when the maternal tape was played. These findings are consistent with the results of a study, in which premature infants, 30 to 34 weeks' gestation, had longer periods of eye opening when talked to by a female adult than when the examiner was quiet.[30] Fewer body movements and increased focused attention, reflect orienting and listening to stimuli.[47] Purhonen et al[48] used event related potentials to study cerebral processing of voice and found that infants allocate more attention at processing their mother's voice than unfamiliar voices.

The normal orienting response includes an immediate decrease in heart rate to novel stimuli, followed by an increase in heart[39] and a decrease in respiratory rate. Zimmer et al[11] found that fetuses exposed to speech sounds responded with a decrease in heart rate as early as 26 weeks' gestation, depending on the baseline heart rate variability. An orienting response in the form of heart rate deceleration was not found in this study, possibly because premature infants have a predominance of neurological sympathetic activity and show less heart rate reactivity and cardiac habituation to repeated stimuli than term infants.[49] Researchers using auditory stimuli have found that premature infants required more intense stimuli and more trials than full-term infants, to elicit an orienting response.[50] The 30-second time frame to identify the heart rate response may also have been too brief for determining an orienting response, given the longer latency of premature

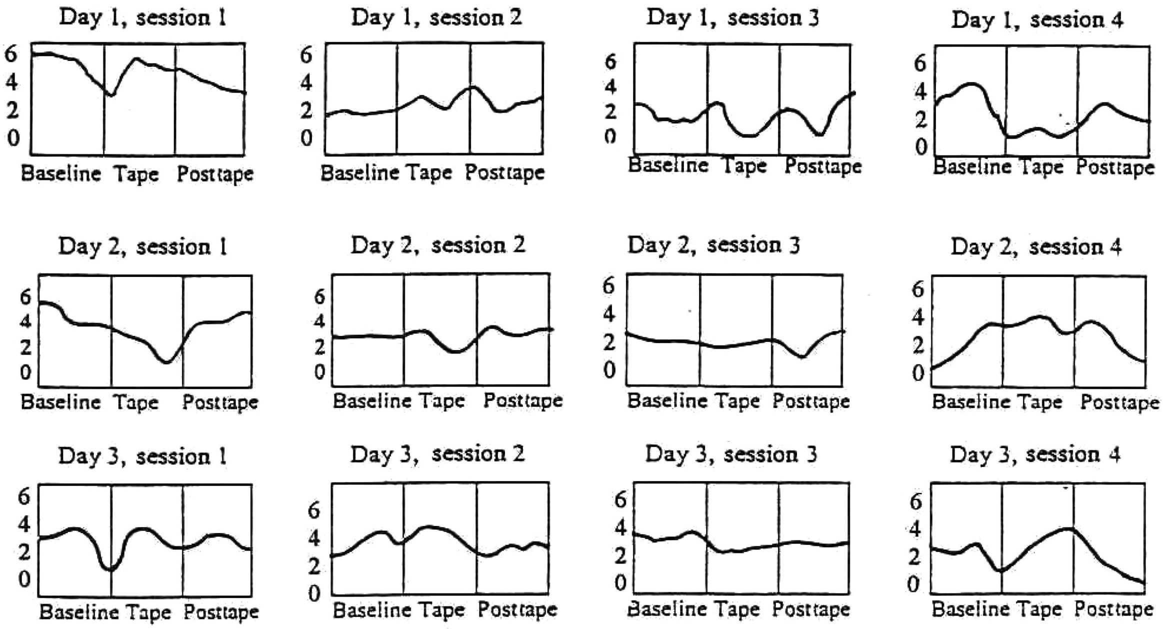

Figure 1. Individual infant curve generated by the Lowess algorithm for infant activity.

infant responses to stimulation. However, the respiratory component of the orienting response, or slowing of respirations, was present while listening to the mother's voice.

Infant behavioral and physiological responses to taped maternal voice varied among the data collection sessions, but systematic change over the 3 days was not found. The study infants displayed neither habituation to the stimulus nor an increase in responsiveness from the first tape exposure to the last. The 3 days of exposure to maternal voice may have been too short a period to measure evidence of learning, which is generally more delayed than in full-term infants. Although there was no increase in the amount of responsiveness of the infants over time, attentive responses were repeatedly obtained. Thoman and Ingersoll[51] used a breathing teddy bear as a stimulus for premature infants for several weeks during hospitalization. The infants actively sought contact with the breathing bear, showing that with enough exposure, premature infants are capable of instrumental learning. Thus, there may be improved carryover of responses, if taped maternal voice was presented to premature infants for a longer period of time. Further, the delay of several hours between the last session on day 1 and the first session of the next may have helped make each day a novel experience. In addition, infants began to show behaviors indicating attention about halfway through the tape, which suggests that 3-minute tapes may not be long enough.

Issues of time can be further explored. First, because we collected data just prior to feeding, some of the infants were getting hungry and probably had limited energy available for a sensory stimulus. Perhaps using the period after feeding would be more effective. Second, we do not know the optimal amount, timing (ie, optimal gestational age), or duration for providing stimuli for premature infants, and we have limited data on infant responses or boundaries of tolerance. Both issues can be clarified with additional studies.

These study data were reduced to use segment means for comparison. This may have masked some of the effect of the maternal tape. Because data reduction resulted in the loss of information, time series analysis could be applied in a future study to utilize all the data collected and to determine the effect of time on infant responses. Use of mixed general linear models would also provide information on individual infant trajectories of responsiveness.[52]

Despite limitations, this study indicates that listening to their mother's voice was not distressing for the premature infants and increased periods of alertness. Intermittent exposure to maternal voice during hospitalization may help prevent the developmental problems experienced by premature infants, particularly because hospitalization limits the contact these infants have with their mothers. The study intervention thus has the potential to facilitate infant responsiveness and should be further refined and tested with additional premature infants.

There are clear indications in this research that providing experiences that will support normal development, to premature newborns, are needed to help prevent deficits and facilitate normal social integration.[53] When dimensions of maternal voice are further studied and a dose response is identified, interventions can be developed to coincide with components of developmentally supportive care for preterm infants.

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