Preterm Infants Exposed to Maternal Voice

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The purpose of this pilot study was to evaluate eye movement as an additional component of behavioral observation in preterm infants exposed to maternal voice. Infants received either daily exposure to a CD recording of their mother reciting a rhyme or standard NICU care. Infants exposed to the CD recording opened their eyes by 32 weeks of age when the maternal recording was played. Infants with no prior exposure did not open their eyes when the recording was played. This suggests that inclusion of eye movement observation is warranted in future evaluations of exposure to the maternal voice in preterm infants.

INTRODUCTION

Neonatal intensive care units subject preterm infants to an array of auditory stimuli (e.g., routine incubator sounds, ICU monitoring alarms, speech sounds of health care teams) from which they are normally sheltered while still in the womb. At the same time, preterm infants in the NICU lose significant contact with their mother's voice, an auditory stimulus they would typically be exposed to if they were carried to full term.

While there is general theoretical support for the view that reduced exposure to interactions with one's mother plays a significant role in a child's growth and development (Als et al., 1979; Barnard et. al., 1987; Moon et al., 2000), very little is known about how exposure to maternal voice shapes development in the preterm infant. This may be due, in part, to the unethical nature of conducting studies that alter normal sensory events in human infants. To address this issue of altered sensory events in the NICU, Lickliter and colleagues developed an animal model that allowed them to alter sound levels and exposure to maternal voice in quail chicks.

Sleigh and Lickliter (1998) did not allow quail chicks to hear their mother's call during late prenatal development. Once hatched, they did not walk towards their mother's voice, an important early, behavioral response. Further, moving toward or approaching their mother's call was also interrupted by elevated levels of light (Foushee & Lickliter, 2002) and sound (Reynolds & Lickliter, 2002) prior to hatching. While not as extreme as the aforementioned example, preterm infants similarly lose significant contact with their mothers' voices late in prenatal development and are cared for in a hospital environment that necessitates elevated light and sound levels. Three historical studies have directly investigated the behavioral response in human preterm infants to maternal voice (Chapman, 1978, 1979; Malloy, 1979); in each, the behavioral response was limited to observations of body movement.

Chapman (1978) studied the behavioral effects of maternal voice on preterms exposed to one of three auditory scenarios: the incubator's typical auditory stimulation, the maternal voice or a taped recording of an orchestra playing Brahms's "Lullaby." Study participants were 28 to 33 post-conceptional aged infants. Chapman (1978) focused her observations on gross motor activity. She investigated upper and lower limb activity and compared right to left limb activity, as well as gender differences. While no statistical differences were found, findings suggested that exposure to both the maternal voice and music facilitated normal limb activity development (Chapman, 1978). The gross motor pattern of laterality (preference for use of one side) developed earlier in the maternal voice group, and infants did not require a 24-hour adaptation period for wearing an accelerometer (instrument used to measure gross motor limb activity), unlike those exposed to music and standard care. Chapman (1978) noted that infants exposed to music reached discharge weight faster compared to the control group, and that female preterms exhibited less motor activity than males preterms. Chapman repeated her study in 1979 using participants who were 26 to 33 weeks post-conceptional age and had the same findings.

Similarly, Malloy (1979) compared how the maternal voice, instrumental music (Brahms's "Lullaby"), and no planned auditory stimulation affected behavioral response in 27 to 33 post-conceptional aged infants. Malloy (1979) used Rosenblith's modified Graham Behavior Scale, which measures general maturation (limb activity), gross body movement to audio-visual stimuli, muscle tension, and irritability. Malloy (1979) found no significant differences in motor development among the three groups. The maternal voice and music groups were, however, a younger age at discharge than the control group (no planned auditory

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stimulation, standard care), suggesting that early exposure may have affected infant development.

Taking into account the findings discussed above, we hypothesized that given a history of four weeks' exposure to maternal voice (using a low decibel level, CD recording), preterm infants would respond with positive behavioral changes (body movement). To this we added the observation of whether the eyes opened, thinking that the infants would more easily recognize their mother's voice and thereby reach an attentive state if given a history (4 weeks) of hearing a CD recording of their mothers speaking a rhyme. We believed that the addition of this observation was essential when studying preterm infant behavioral development because infants "tend to orient visually to an attended sound source" (Kemler Nelson, Jusczyk, Mandel, Myers, Turk & Gerken, 1995, p. 111). Full term infants are physically capable and mature enough to "learn to maintain a response (e.g., a head-turn) when motivating stimulation is contingent on their behavior" (Kemler Nelson *et al*, 1995, p. 111). Preterm infants, on the other hand, are physiologically immature which renders them incapable of turning their heads to attend to sources of sound. Therefore, eye opening is perhaps an immature attending response. Thus, the purpose of this pilot study was to evaluate eye movement as a component of behavioral observation in preterm infants exposed to maternal voice. The study compared the behavioral effects in preterm infants of daily exposure to a CD recording of mothers reciting a nursery rhyme, to that of infants receiving standard NICU care.

MATERIALS AND METHODS

Subjects and Setting. Infants in this study participated in a larger study entitled *Heart Rate Variability and Learning in the Premature*. Following parental informed consent, a convenience sample of 38 infants (admitted to a NICU in the Southeast) were randomly assigned to 1 of 2 groups. Infants either listened to a nursery rhyme recited by their mother twice a day, from 28 to 32 weeks postmenstrual age (Group 1) or did not hear the CD recording (Group 2). The target age for admission was 27 to 28 postmenstrual weeks of age. Inclusion criteria consisted of 1) confirmation of age by Ballard scoring and 2) English as the parental native language. Exclusion criteria consisted of the following: 1) abnormal head ultrasound, 2) sensorineural hearing loss, 3) confirmed prenatally transmitted viral/bacterial infections, or 4) cardiac abnormalities.

Four low-risk preterm infants from the larger study participated in this methodological pilot study. Two infants (Set A) were randomly assigned to Group 1 and heard the CD recording from 28 to 32 post-menstrual weeks. Two infants (Set B) were assigned to Group 2 and did not hear the CD recording. Both sets were tested at 32 weeks of age: Set A, using the same CD recording of their mother reciting the rhyme and Set B, using the prerecorded (but never played) recording of their mother reciting the same rhyme.

Nursery rhyme. A CD recording of one nursery rhyme was used in this study. The untitled rhyme (Simon & Schuster, 1985) was nine lines long, took approximately 15 seconds to recite and was not a common verse, making it unlikely that the infants would be spontaneously exposed to it. Recordings of the rhyme were made by asking the mother to use "motherese," a method of speaking that emphasizes greater changes in pitch and slower speech (Kaplin et al., 1995). To do this, we asked mothers to practice reciting the rhyme once before creating the recording and to imagine holding their infants in their arms while reciting the rhyme. Although the effect of this speaking method on the fetus (and preterm infant) is unknown, newborns have been shown to systematically prefer human speech with the characteristics of "motherese" (Kaplin et al., 1995).

CD recordings consisted of three separate recitations of the same rhyme, each lasting approximately 15 seconds, for a total of 45 seconds. The 45-second recording was presented twice a day over a 12.5-cm speaker positioned 20 cm from the infant's ear. Overall stimulus intensity was 50 to 55 dB (M=53.9; SD=2.35) with background NICU sound levels just prior to initiation of the stimulus ranging between 48.6 to 69.2 dB (M=57.90; SD=4.01), using the A-scale on a Bruel-Kjaer (220SLM) sound level meter. The decibel level for presentation of the stimulus (50 to 55 dB) was chosen to maintain the decibel level just below that of human speech (58 to 60 dB) and to stay within recommended sound levels for the preterm infant (Graven, 2000; Gray, 2000).

Behavioral Coding. Behavioral counts were obtained from videotaped recordings of the infants. Specific behaviors coded were: 1) eyes open or closed, 2) mouth movement present or not, and 3) body movement present or not. Mouth movement was measured because Standley (2003) had demonstrated differences in this behavior based on exposure to music in preterm infants from 24 to 40 weeks post-menstrual age. Three research assistants were trained to >95% agreement with a training videotape that demonstrated the behaviors to be coded. Once trained to >95%, intra- and inter-rater reliability were maintained at >85% agreement.

Procedure. Recordings were presented over a 12.5-cm speaker positioned 20 cm from the infants' ears. Overall stimulus intensity was 50-55 dB, using the A-scale of a Bruel-Kjaer (220SLM) sound level meter. Recordings were played while the infants remained in their assigned incubator beds, and were initiated at least 15 minutes following a meal and once the infant was determined to be in an active sleep state of the sleep-wake cycle.

Criteria established by Thoman (1990) for use with preterm infants were employed to control for differences in

behavior secondary to sleep-wake state. Subjects were determined to be in an active sleep state if: 1) respirations were irregular, 2) no body movement was present, and 3) eyes were closed. Interrater reliability in state detection was maintained at > 90% agreement.

A Sony Hi-8 Digital Camera was used to videotape subjects' behavioral responses at approximately the same time of day for each infant (between 10 AM-12 PM) before, during, and after the CD recording of the rhyme was played. Videotaping occurred at the same time of day to control for potential circadian influences on heart rate patterns and movements (Arduini et al., 1986). Film clips of the 15-seconds before, during, and after presentation of the rhyme were then created. These video clips were then cut into 5-second segments with the audio removed in preparation for coding the behavioral responses. The 5-second segments were then randomized prior to behavioral coding to ensure that no bias would affect the observations.

Researchers viewed the video segments and recorded the occurrence of three behaviors for each 5-second clip. Behavior coded included whether the eyes were open or closed, the presence or absence of mouthing movements and the presence or absence of body movements. Movement of the mouth or cheek was considered a mouthing movement, and any sustained physical movement of the body (head, arm, fingers, leg, torso, etc.) was considered a body movement. Twitches and spasms were not considered body movements in this pilot study.

RESULTS

No consistent changes in body movement were noted based on exposure to maternal voice for either Set A or B infants. Mouthing movements were not noted during the 5-second segments of behavioral observation for Set A or Set B infants.

The infants exposed to a CD recording of their mother reciting a nursery rhyme (Set A), however, opened their eyes when the same CD recording of the rhyme was played. The infants (Set B) who were not exposed on a daily basis to the CD recording of their mother reciting a rhyme did not open their eyes when the rhyme was played. Subject 025 (a Set B infant) had his eyes open before the rhyme, and closed his eyes when the rhyme was begun.

DISCUSSION

A comparison of behavioral responding given a history of exposure to maternal voice (Set A) and no history of exposure (Set B) revealed one finding of note. Infants given a 4-week history of listening to a CD recording of their mother reciting a rhyme opened their eyes in response to hearing the CD recording. Infants not exposed to a regular recording did not open their eyes when their mother recited the rhyme.

This pilot study adds to historical studies investigating exposure to maternal voice (Chapman, 1978, 1979; Malloy, 1979) by suggesting the need to add the behavioral observation of eye movement to studies investigating exposure to maternal voice. Eye movement (opening) following repeated exposure to hearing the maternal voice may be a crucial first step toward establishing an important maternal-newborn interaction or eye contact between the mother and infant. Repeated exposure to hearing their mother speaking a rhyme resulted in only those infants opening their eyes when the maternal recording was played. The occurrence of increased body movement was not detected and no difference in mouthing movements based on exposure to maternal voice was noted.

The small sample used in this pilot study does not allow for statistical significance to be established, and thus it cannot confirm or oppose the former research performed within this field. Pilot findings do, however, suggest an important methodological change to investigations of the behavioral response to maternal voice in the preterm infant (Perry, 2001).

Clinical implications. Preterm infants lose significant contact with their mothers' voices late in prenatal development and are cared for in a hospital environment that necessitates elevated light and sound levels. All this happens due to the need for prolonged hospitalization and the daily care provided within the NICU. Thus, they are not only deprived of the protective properties of the womb, but of a possibly critical aspect for normal development—*the mother's voice*. Taken together with the fact that these infants are at increased risk for developmental delay (Bhutta et al., 2002; Colvin et al., 2004; Inder et al., 2005; Perlman, 2001; Therien, 2004), this suggests the need for further investigation of the relationship between preterm infants' early altered sensory experiences and developmental outcomes.

Potentially beneficial psychological effects from exposure to maternal voice have been suggested by Latva and colleagues (2004), who described a correlation between parental visits during NICU care and emotional/behavioral development 7 to 8 years later. Moreover, there is substantial literature documenting positive developmental and long-term outcomes from interventions in which interactions between the mother and her preterm infant were encouraged (Als et al., 1986; Als et al., 2003; Als, 2004; Ashbaugh et al., 1999; Forcada-Guex et al., 2004; Muller-Nix et al., 2004). While none of these studies specifically examined exposure to maternal voice and the initiation of eye contact, taken together with the finding of this study, they underscore the need for further investigations of the relationship between exposure to voice and developmental outcomes.

Literature Cited

Als, H., Lester, B., & Brazelton, T. (1979). Dynamics of the behavioral organization of the premature infant: A theoretical perspective. In T. M. Field, A. M. Sostek, S. Goldberg, & H. H. Shuman (Eds.), *Infants Born at Risk* (pp. 173-192). Medical and Scientific Books: New York.

Als, H., Lawhon, G., Brown, E., Gibes, R., Duggy, F., & McAnulty, G. (1986). Individualized behavioral and environmental care for the very low birth weight preterm infant at high risk for bronchopulmonary dysplasia: Neonatal intensive care unit and developmental outcome. *Pediatrics, 78*(6), 1123-32.

Als, H., Gilkerson, L., Duffy, F., McAnulty, G., Buehler, D., & Vandenberg, K. (2003). A three-center, randomized, controlled trial of individualized developmental care for very low birth weight preterm infants: Medical, neurodevelopmental, parenting, and caregiving effects. *Journal of Development and Behavior in Pediatrics, 25*(3), 224-5.

Als, H. (2004). Developmental care in the newborn intensive care unit. *Current Opinion in Pediatrics, 10*(2), 138-142.

Arduini, D., Rizzo, G., Giorlandino, C., Valensise, H., Dell'Acqua, S., & Romanini, C. (1986). The development of fetal behavioural states: A longitudinal study *Prenatal Diagnosis, 6*, 117-124.

Ashbaugh, J. B., Leick-Rude, M. K., & Kilbride, H. W. (1999). Developmental care teams in the neonatal intensive care unit: Survey on current status. *Journal of Perinatology, 19*(1), 48-52.

Barnard, K., Hammond, Sumner, G., Kang, R., Johnson-Crowley, N., Snyder, C., Spietz, A., Blackburn, S., Brandt, P. & Magyary, D. (1987). Helping parents with preterm infants: Field test of a protocol. *Early Child Development and Care, 27*(2), 256-290.

Bhutta, A.T., Cleves, M. A., Casey, P. H., Cradock, M. M., & Anand, K. J. (2002). Cognitive and behavioral outcomes of school-aged children who were born preterms: A meta-analysis. *JAMA, 288*(20), 2542-3.

Chapman, J. S. (1978). The relationship between auditory stimulation and gross motor activity of short-gestation infants. *Research in Nursing and Health, 1(1)*, 29-36.

Chapman, J. S. (1979). Influence of varied stimuli on development of motor patterns in the premature infant. *Birth Defects: Original Article Series, 15(7)*, 61-80.

Colvin, M., McGuire, W., & Fowlie, P.W. (2004). Neurodevelopmental outcomes after preterm birth. *British Medical Journal, 329*(7479), 1390-3.

Forcada-Guex, M., Pierrehumbert, B., Borghini, A., Moessinger, A., & Muller-Nix, C. (2006). Early dyadic patterns of mother-infant interactions and outcomes of prematurity at 18 months. *Pediatrics, 118*(1), e107-14.

Foushee, R. D., & Lickliter, R. (2002). Early visual experience affects postnatal auditory responsiveness in bobwhite quail (Colinus virginianus). *Journal of Comparative Psychology, 116*(4), 369-380.

Graven, S.N. (2000). Sound and the developing infant in the NICU: conclusions and recommendations for care. *Journal of Perinatology, 20(8)*, 88-93.

Gray, L. (2002). Properties of sound. *Journal of Perinatology, 20(8), 6-11.*
Inder, T. E., Warfield, S. K., Wang, H., Huppi, P. S., & Volpe, J. J. (2005). Abnormal cerebral structure is present at term in premature infants. *Pediatrics, 115*(2), 286-94.

Kaplin, P., Goldstein, M., Huckeby, E., & Cooper, R. (1995). Habituation, sensitization, and infants' responses to motherese speech. *Developmental Psychobiology, 28*, 45-57.

Kemler Nelson, D.G., Juscyzk, P.W., Mandel, D.R., Myers, J., Turk, A., & Gerken, L. (1995). The headturn preference procedure for testing auditory perception. *Infant Behavior and Development, 18*, 111.

Latva, R., Lehtonen, L., Salmelin, R. K., & Tamminen, T. (2004). Visiting less than every day: A marker for later behavioral problems in Finnish preterm infants. *Archives of Pediatric Adolescent Medicine, 158(12)*, 1153-1157.

Malloy, G. B. (1979). The relationship between maternal and musical auditory stimulation and the developmental behavior of premature infants. *Birth Defects: Original Article Series 15(7)*, 81-89.

Moon, C., & Fifer, W. (2000). Evidence of transnatal auditory learning. *Journal of Perinatology, 20(8)*, 37-44.

Muller-Nix, C., Forcada-Guex, M., Pierrehumbert, B., Jaunin, L., Borghini, A., & Ansermet, F. (2004). Prematurity, maternal stress and mother-child interactions. *Early Human Development, 79*(2), 145-58

Perlman, J. M. (2001). Neurobehavioral deficits in premature graduates of intensive care potential and neonatal risk factors. *Pediatrics, 108*(6), 1339-48.

Perry, S. (2001). Appropriate use of pilot studies. *Journal of Nursing Scholarship, 33*(2), 107.

Reynolds, G., & Lickliter, R. (2002). Effects of prenatal sensory stimulation on heart rate and behavioral measures of arousal in bobwhite quail embryos. *Developmental Psychobiology, 41*(2), 112-122.

Simon & Schuster. (1985). *Opposites: Nursery rhyme concept books.* New York, New York: Little Simon Publishing.

Sleigh, M. J., & Lickliter, R. (1998). Timing of presentation of prenatal auditory stimulation alters auditory and visual responsiveness in bobwhite quail chicks (Colinus virginianus). *Journal of Comparative Psychology, 112*(2), 153-160.

Standley, J. M. (2003). The effect of music-reinforced nonnutritive sucking on feeding rate of premature infants. *Journal of Pediatric Nursing, 18(3)*, 169-173.

Therein, J.M., Worwa, C.T., Mattia, F.R., & deReregnier, R.A. (2003). Altered pathways for auditory discrimination and recognition memory in preterm infants. *Developmental Medicine and Child Neurology, 46(12)*, 816-824.

Thoman, E. (1990). Sleeping and waking states in infancy: A functional perspective. *Neuroscience and Behavior Reviews*, 93-107.