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Preference for infant-directed speech in preterm infants

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ABSTRACT

The current study explores the effects of exposure to maternal voice on infant sucking in preterm infants. Twenty-four preterm infants averaging 35 weeks gestational age were divided randomly into two groups. A contingency between high-amplitude sucking and presentation of maternal voice was instituted for one group while the other group served as a yoked control. No significant differences were observed in sucking of the two groups, but the degree of pitch modulation of the maternal voice predicted an increase in the rate of infant sucking.

1. Introduction

Full term newborn infants show a preference for their mother's voice over an unfamiliar female voice (DeCasper & Fifer, 1980; Fifer & Moon, 1995), and they prefer infant directed speech (IDS) compared to adult directed speech (ADS; Cooper & Aslin, 1990; Fernald, 1985; Pegg, Werker, & McLeod, 1992). The prosodic exaggerations of maternal speech give it a song-like quality that infants find attractive (Fernald et al., 1989; Papousek & Hwang, 1991).

In the normal uterine environment, maternal speech provides a unique source of auditory, vibratory, and vestibular stimulation for the developing fetus. Fifer (1987) hypothesized that the frequency level, expression, and repeated exposure of the maternal voice in the womb allows the full term newborn to recognize, distinguish, and prefer their mother's voice. Preferring mother's voice and IDS is likely advantageous for bonding and survival, in regulating attention, enhancing learning of linguistic structure, and for providing for communication of emotional intent between the mother and infant.

The infants of the original studies on IDS were full term, healthy newborns who were in close physical contact with their mothers both pre- and postnatally. In contrast, the preterm infant is deprived of the evolutionarily promised womb and developmentally appropriate stimuli, including the mother's voice (Hofer, 2004), because of their early birth. Intensive care technology and treatment are necessary to reduce mortality, but these treatments disrupt the mother-child relationship (Als et al., 2004; Butler & Als, 2008). The availability and access of parents in the newborn intensive care environment varies across hospitals. Thus, studies of preterm infants responsivity to maternal voice and to IDS are limited in number (Bozzette, 2008; Krueger, Parker, Chiu, & Theriaque, 2010). At the time of birth, most preterm infants are born with an auditory system that is well developed with functional hearing from as early as 24 weeks gestational age (Amin, Orlando, Dalzell, Merle, & Guillet, 1999; Ruben, 1997). Research shows that the fetus in the last eight weeks of pregnancy responds to subtle auditory cues such as speaker gender, pitch, intensity, and musical tone (Kisilevsky & Hains, 2011; Lecanuet, Granier-Deferre, Jacquet,

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& Busnel, 1992; Lecanuet, Granier-Deferre, Jacquet, & DeCasper, 2000). Following early birth, the preterm infant responds to IDS with increased visual attention and alertness (Eckerman, Oehler, Medvin, & Hannan, 1994), and increased calmness and lowering of heart rate (White-Traut, Nelson, Silverstri, Cunningham, & Patel, 1997). In addition, tape recordings of maternal voice result in increased muscle tone and improved responsiveness (Katz, 1971), improved weight gain (Malloy, 1979), and decreased crying (Segall, 1972).

The current study investigated whether preterm infants would learn to suck a pacifier in order to hear their mother's voice. Learning has previously been described in fetuses, preterm infants, and newborns. For example, fetuses as young as 30 weeks gestation have been shown to habituate to a vibroacoustic stimulus (Dirix, Nijhuis, Jongsma, & Hornstra, 2009; Morokuma et al., 2008; van Heteren, Boekkooi, Jongsma, & Nijhuis, 2001). Twenty-eight to thirty-two week gestational age premature infants learned a contingency between behavior and pain (Goubet, Clifton, & Shah, 2001) and 33-week premature infants demonstrated instrumental learning by actively seeking contact with a comforting stimulus (Thoman & Ingersoll, 1993). Furthermore, full term infants can learn a sucking paradigm (Werner & Siqueland, 1978) and even suck to hear their mother's voice (Mehler, Bertoncini, Barriere, & Jassik-Gerschenfeld, 1978), but it is unclear whether preterm infants have that same ability

Overall, little is know about the sensitivity of the preterm infant to maternal voice and the sucking response of healthy preterm infants to a recording of their mother's voice. The current study set out to investigate whether maternal voice quality and use of IDS varied across mothers of premature infants and whether it affected their infant's responding. Previous research has shown that infants respond differently at differing ages to IDS vs ADS, whether produced by mother or another (Cooper, Abraham, Berman, & Staska, 1997). In addition, maternal voice quality and IDS varies across mothers.

We employed a high amplitude sucking paradigm where criterion sucks were rewarded by short voice recordings of the infant's mother. Our goal was to investigate the effects of maternal voice and voice quality on premature infant sucking and to determine if maternal speech could be used as a reinforcer to increase preterm infant sucking.

2. Methods

2.1. Participants

Twenty-four low-risk, preterm infants and their parent(s) constituted the study sample. The participants were recruited as sequential cases from the Continuing Care Unit (CCU) of Baystate Hospital in Springfield, MA, a level-III Neonatal Intensive Care Unit (NICU) with an exclusively inborn population. The institutional review boards for research with human subjects of both Baystate Hospital and University of Massachusetts Amherst approved the study protocol. The study recruitment period extended over 8 months, from July 2000 to February 2001. Infants were preselected by medical staff as healthy and without significant medical complication. Study selection infant criteria included gestational age at birth of 32–34 weeks; weight and head circumference at birth appropriate for gestational age (>5th, <95th percentile); no mechanical ventilator support; and absence of congenital or chromosomal abnormality, congenital or acquired infection, and brain lesions.

The infants were initially cared for in the NICU, but at the time of data collection all infants resided in the CCU of the hospital in open cribs. Most infants were discharged from the hospital within a week of the last day of testing. Half of the infants were randomly assigned to an experimental group ($n = 12$) and half to a control group ($n = 12$). Blocking by gender (male/female) and ethnicity (Caucasian/other) was imposed a priori. Consent was obtained soon after admission into the CCU and consenting families were immediately randomized to the experimental or control group.

Of the participants in the experimental group, seven were male and six were members of minority groups, and of the participants in the control group, six were male and five were members of minority groups. Characteristics of the sample are found in Table 1. Medical and demographic background information did not statistically differ between the two groups.

Table 1
Description of the participants.

	Experimental	Control	*t*-Test or Fisher exact test
Gestation age at birth	227 (15.3) days	228 (16.1) days	$t(22) = 0.12$, $p = .91$
Postmenstrual age at start of testing	244 (7.7) days	246 (7.2) days	$t(21) = 0.90$, $p = .38$
Birth weight	1922 (412) g	1849 (528) g	$t(21) = 0.38$, $p = .71$
Weight at start of testing	2032 (274) g	2010 (280) g	$t(22) = 0.19$, $p = .85$
Weight on day 5 of testing	2115 (274) g	2091 (244) g	$t(22) = 0.23$, $p = .82$
Apgar score 1 min[a]	6.4 (2.4)	6.6 (2.2)	$t(19) = 0.19$, $p = .85$
Apgar score 5 min[a]	7.6 (1.8)	7.9 (1.6)	$t(18) = 0.44$, $p = .67$
Vaginal/cesarean delivery	7/5	8/4	$p = 1.0$
Males/females	6/6	7/5	$p = 1.0$
Caucasian/Black/Hispanic/other	7/2/3/0	6/2/3/1	$p = 1.0$

Means with standard deviations in parentheses; *t*-test with Welch's degrees-of-freedom correction for possibly unequal variances.
[a] Two Apgar scores are missing for the experimental group.

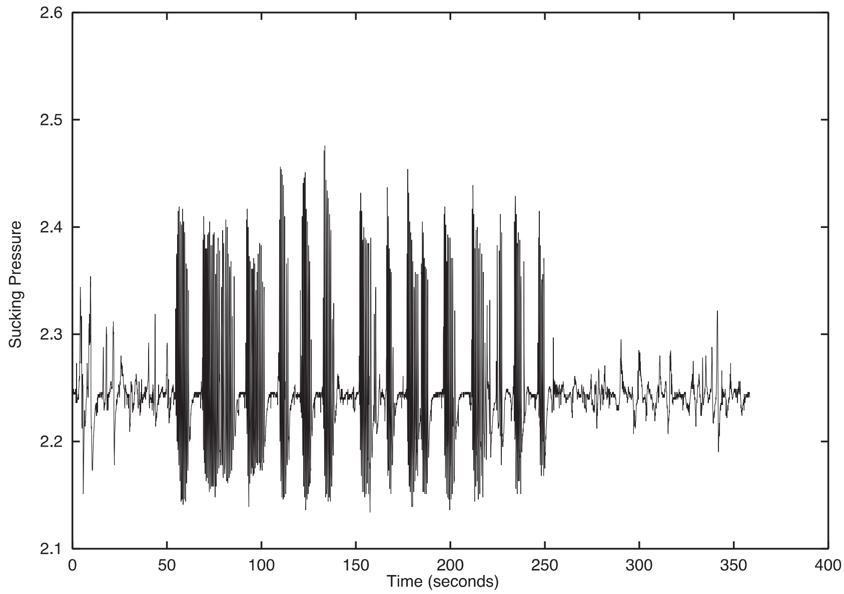

Fig. 1. An example of data from a testing session. The data show bursts of high-amplitude sucking.

2.2. Procedure

The CCU's attending physician made the initial contact with the infant's parents. The researchers then met with the infant's mother, explained the design of the experiment, obtained informed consent, and obtained a digital audio recording of the mother's voice. Given the variable visitation of mothers to the unit, maternal recordings were used to provide mother's voice. Mother's were recorded directly in the CCU while speaking to their own baby. For the recording, the mother was told to say whatever she wished in her native language and mothers were encouraged to modulate their voice to produce a recording which would gain their infant's attention. In order to have a sample of mother's voice that was clearly audible, often more than one recording was made per mother. The recording with the best audibility was used in the experiment.

Testing was timed between feedings in order to gain infant sucking response that was not influenced by hunger and at a time the infant could be aroused. Preterm infants often tire from feeding and transition into a sleep state during feeding or toward the end of a feeding. Most infants were on a caregiving schedule every 3 h and thus were tested approximately 90 min after feeding. Typically, infants were approached in a sleep state (either deep or light sleep) and were gently aroused to a quiet awake or drowsy state (Als, Lester, Tronick, & Brazelton, 1982). Infants were tested twice a day for five consecutive days. Sessions were at least 5 h apart.

A laptop computer was used to present the recording of the mother's voice, to record sucking data, and compute sucking threshold for high amplitude sucking. At the start of the session, the researchers placed two speakers to each side of the infant's head approximately seven cm away from the infant's ears. The intensity of the sound was adjusted using a sound level meter to 5 dB over the background, but no more than 60 dB. The ambient noise in the nursery was between 50 and 55 dB. A Wee-Thumbie© pacifier (Philips Healthcare) was then placed in the infant's mouth. This was the pacifier already in use in the CCU and familiar to the infant. The pacifier was connected via tubing to a pressure transducer (Omega Engineering PX-139) and a computer. Custom software written in LabVIEW (National Instruments) was used to control data acquisition, speech presentation, and calculation of threshold for high amplitude sucking. High amplitude sucking was calculated as 85% of the infants maximum sucking amplitude.

A baseline recording period of 2 min then ensued for the infant to become accustomed to the pacifier and for the threshold for high amplitude sucking to be collected. The nipple was gently held in the infant's mouth and infants were allowed to suck on the pacifier for as much or as little as they desired during this time. The mother's voice was not presented during the baseline period. After the baseline period, a test period lasting 5 min (or until the infant fell asleep) was then initiated. Fig. 1 shows a pressure recording from a testing session. For the experimental group, the recording of the mother's voice was presented once (3 s) when the infant made a criterion suck. Mother's voice was presented for each criterion suck produced. For the control group, the recording of their mother's voice was presented non-contingently, but at the same time as one of the other experimental infant's voice presentation (yoked control).

3. Results

Fig. 1 shows an example of a pressure recording from a testing session. Infants in both the experimental and control groups averaged around one to three criterion sucks per 15 s bins during the initial seconds of the baseline phase. As Fig. 2 shows, that initial burst of sucking dropped to a steady level of

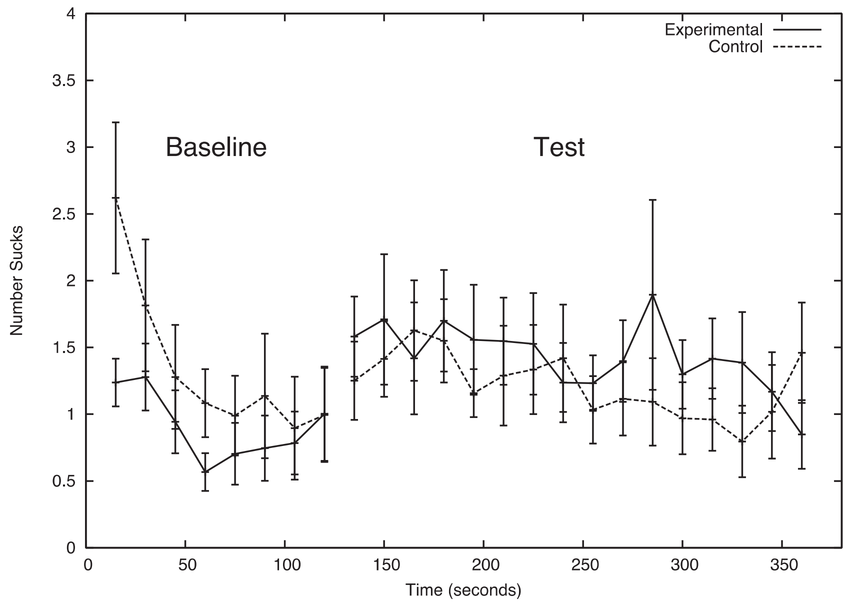

Fig. 2. The number of criterion sucks per 15 s bin during baseline and testing by study group (experimental verse control). Means are shown with standard error bars.

about one criterion suck per bin during the baseline period. An analysis of variance for the last minute of the baseline period showed no effect of group, $F(1, 22) = 0.22$, $p = .64$, time, $F(3, 66) = 0.35$, $p = .79$, nor of group interacting with time, $F(3, 66) = 0.47$, $p = .70$.

In order to compare the short-term effect of the introduction of the maternal voice, sucking was compared during the first minute of the test period with the last minute of the baseline period. Analysis of variance showed an effect of test period (baseline vs. test), $F(1, 22) = 11.50$, $p = .003$, but no effect of experimental group, $F(1, 22) = 0.005$, $p = .944$, time, nor any interaction of the variables. An analysis of variance of the entire 240 s test period showed no effect of group, $F(1, 22) = 0.337$, $p = .57$, of time, $F(15, 330) = 1.170$, $p = .29$, nor a group by time interaction, $F(15, 330) = 1.011$, $p = .44$. We investigated the change in sucking during the test period using linear and quadratic orthogonal polynomials. The quadratic term was not significant, but the linear term was significant, $F(1, 380) = 5.497$, $p = .02$, with a non-significant group source, $F(1, 380) = 3.245$, $p = .07$.

In terms of maternal voice presentation, even with encouragement, mothers varied substantially in the quality of their speech with some mothers providing well-modulated samples and other mothers providing relatively flat speech samples. The range of modulation of pitch and the standard deviation of speech frequency was obtained for each sample using Praat (Boersma & Weenink, 2013). Fig. 3 shows the range of voice inflection as a scatter plot of the features from the 24 speech samples. K-means analysis with three centers resulted in the classification shown in the figure, with centers for the three clusters given by the asterisks. Speech samples were classified as high ($n = 9$), moderate ($n = 7$) or low pitch modulation ($n = 8$). Fig. 4 shows representative examples of pitch contours classified as high (left) and low pitch modulation (right).

Fig. 5 shows the infant sucking behavior during test for these three groups of infants. Analysis of variance showed that infants significantly differed by voice grouping, $F(2, 21) = 4.077$, $p = .03$, with increased sucking with highly modulated voice recording. Analysis of variance by time was not significant and neither was time by group, $F(15, 315) = 1.18$, $p = .28$, $F(30, 315) = 1.124$, $p = .30$.

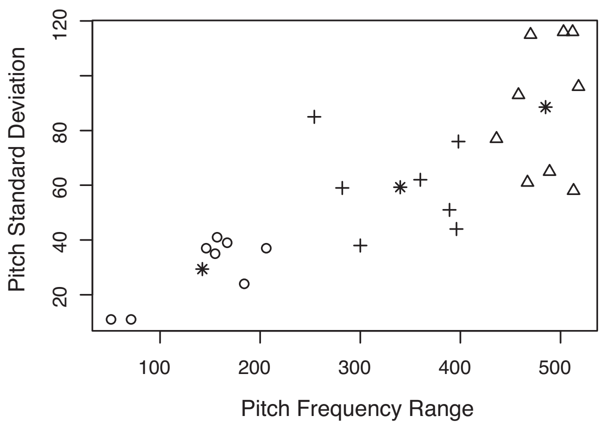

Fig. 3. Pitch features of maternal voices used in the current study. Samples were divided into three groups using k-means clustering, with the centers of the three clusters given by the asterisks. Circles show low pitch variability recordings, triangles show high pitch recordings, and crosses show moderate pitch recordings.

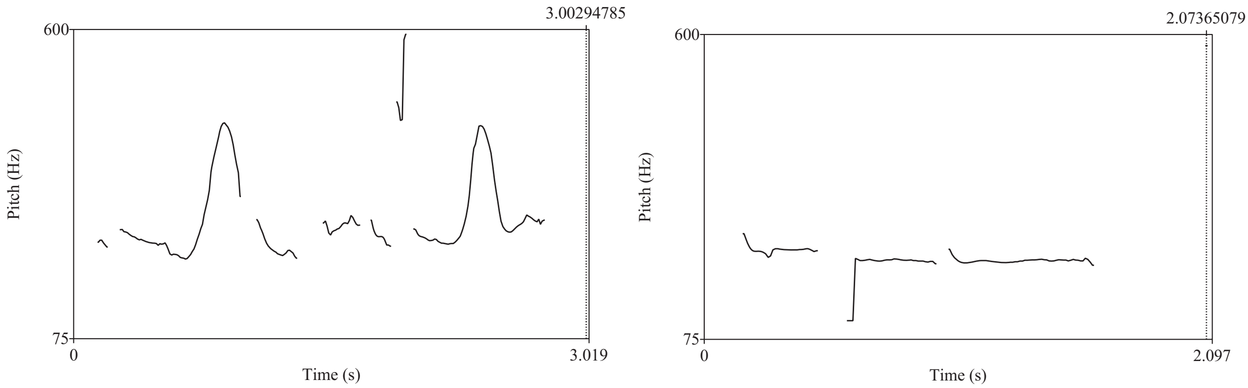

Fig. 4. Pitch contours of voice recordings of high and low pitch variability. (A) Speech of high variability, "Good morning Joseph, it's Mommy, how are we today?" (B) Speech of low pitch variability, "Get up Izen, get up Izen." Pitch analysis by Praat (Boersma & Weenink, 2013).

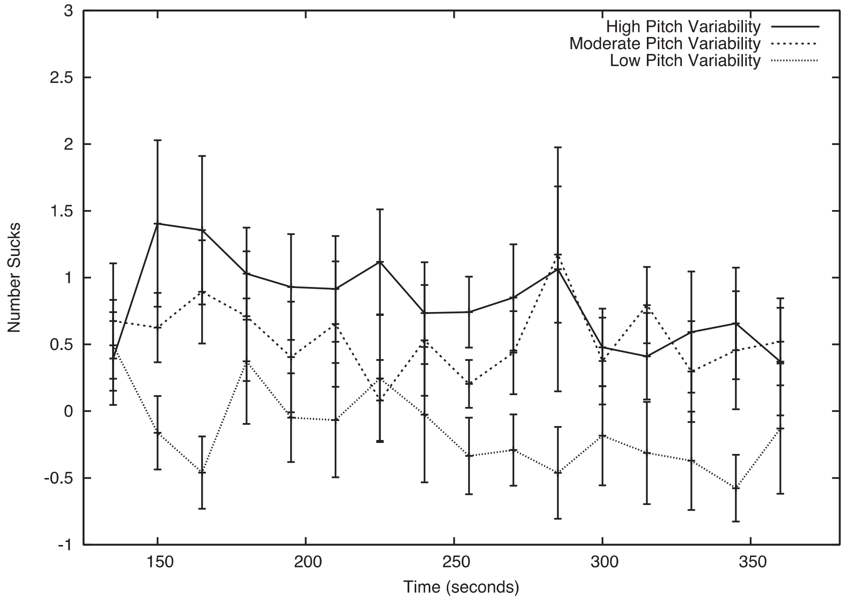

Fig. 5. Change in sucking during testing relative to baseline for infants with high, moderate, and low pitch variability.

As a follow-up to the group analysis of Fig. 5 we used principal component analysis to reduce the dimension of the pitch data shown in Fig. 3. The first component in the principal component analysis accounted for 98.7% of the variance of the data. We then correlated the scores on this dimension with the change in sucking between the baseline and testing periods of the experiment. The data were significantly correlated, $r(22) = .52$, $p = .008$.

4. Discussion

The results of the current paper show that premature infants are sensitive to maternal voice, that presentations of the maternal voice increases nonnutritive sucking, and that the amount of sucking evoked depends on the quality of the mother's speech. Furthermore, regardless of whether maternal voice was provided contingent or non-contingent on infant high amplitude sucking, infants increased their bursts of high amplitude sucking at the presentation of maternal voice. If the maternal voice show high pitch variability, the effect was greater. Overall, the effects of maternal speech strongly depended on the quality of the maternal speech. Speech that conformed to the features of IDS had strong effects, but speech that was flat in tonal quality and resembled ADS had weak or no effect on infant sucking.

The current results and study design do not provide support for high amplitude sucking increasing with short segments of recorded maternal speech at 34–35 weeks postmenstrual age. The latter failure of infants to show significant instrumental conditioning, might represent a true limitation of 34–35 week postmenstrual infants, or it might reflect a non-optimal conditioning paradigm or possibly a confounding factor of prematurity and exposure to maternal speech.

Interestingly, Cooper et al. (1997) found that 1-month-olds born full term did not show a preference for maternal IDS verse ADS; however, they did show a preference for the IDS as long as it was not maternal. Also, 4-month-olds showed a preference for maternal IDS over maternal ADS. Thus, full term infants appear to integrate their recognition of mother's voice with their attention to exaggerated prosody in the first weeks and months after birth. The current study found that preterm infants around 35 weeks gestational age preferred maternal speech with more inflection and more like IDS than the speech with less inflection and more like ADS. This poses the possibility that these preterm infants are responding as an infant with little experience with their mother's voice. The preterm infants likely had less experience with maternal speech both prenatally and postnatally compared to full-terms given their early birth and need for ICU care. So the lack of evidence for instrumental conditioning in the experimental group could be attributable to less experience with maternal speech, and the more robust learning in the infants that were listening to "higher quality" and more inflected IDS aligns with Cooper et al.'s findings where infants preferred IDS in the non-maternal group. The present results leave the question of whether the effects of voice were due to a highly inflected female voice or a highly inflected maternal voice as infants were only exposed to their own mother's voice. Maternal voice by itself was not sufficient to increase sucking, but the results do not speak to the question of whether maternal voice was necessary for the effects. An experiment with a non-maternal, inflected voice condition would be needed to answer the latter question. It would certainly be supportive of mother's presence in the NICU if infants preferred their mother's voice and mother's voice increased infant sucking. At this time, it appears that speaking to the premature infant in inflected speech is likely to be more engaging that with uninflected or ADS.

A limitation of the study, which could have contributed to the lack of evidence for infant learning of contingency, is the testing of infants at a possibly non-optimal state. Infants were approached between their feedings to minimize the effects of sucking for nutritive value, a procedure that meant that infants were tested when they were most sleepy. Increased understanding of infant state and feeding ability at time of testing would have been beneficial in finding a more appropriate time for testing. More robust infants with intact oral motor skills may have a stronger ability to learn a task requiring an oral motor skill if presented when they were awake, alert, and interested in sucking, possibly prior to feeding.

A concern and consistent problem with auditory studies in the hospital is that of the ambient sound (Philbin, 2000). The NICU is often characterized by loud unpredictable noise from extraneious sources such as alarms, ventilators, phones, and staff conversation. The American Academy of Pediatrics (1997) determined the safe sound levels in the NICU should not exceed a level of 45 dB. We measured the ambient sound level at the time of testing and the maternal voice recording was set 5 dB above a background of about 50–55 dB. This procedure was largely successful in setting the speech stimulus at an appropriate level for the infant to hear over the background noise but we could not prevent the occurrence of rare loud sounds and the already high level of background noise. It is likely that in the NICU and CCN distinguishing mother's voice from background can be challenging.

Another area of opportunity for future research surround the use in this study of a recorded maternal voice as opposed to a live maternal voice or even more supportive, mother's holding their infants during testing. In the study CCN, as like most NICUs, maternal presence at the bedside was variable. It is possible that a live voice would be more rewarding than a recorded voice which may have lead to habituation or disinterest over time.

As an aside, there are a number of studies which have attempted to use the mother's voice as an intervention technique with variable success (Krueger et al., 2010). Regardless, the effects of maternal presence and maternal speech are likely clinically important. Both preterm and full term infants grow and develop most advantageous when in close proximity with their mothers and when hearing their mothers voice. This study does not have the power or scope to look at mother's voice as an intervention technique but further research is warranted. Most of the infants of this study (20 of 24) had just made the transition from gavage feeding to breast and bottle feeding. This transition involves a changing role of sucking for the preterm infant. In gavage feeding, sucking is unrelated to food ingestion, but in breast and bottle feeding, sucking is integral to obtaining nutrition. Others have proposed interventions to accelerate this transition (Als, 1981; Barlow, Finan, Lee, & Chu, 2008; Fucile, McFarland, Gisel, & Lau, 2012; Poore, Zimmerman, Barlow, Wang, & Gu, 2008). The current results suggest that preterm infants increased their sucking at the presentation of a highly inflected maternal voice. It would be helpful to examine if the presence of mother's live voice, engaged in IDS, increased infant sucking and thus increased infant ability to feed. Using maternal IDS during initial bottle or breast feeding might enhance the transition for preterm infants from gavage to oral feeding. And most importantly, promoting maternal presence and family centered care should remain integal in the NICU.

Author note

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References

Als, H. (1981). *Manual for the naturalistic observation of the newborn (preterm and fullterm) (Tech. Rep.).* Boston, MA.

Als, H., Duffy, F. H., McAnulty, G. B., Rivkin, M. J., Vajapeyam, S., Mulkern, R. V., et al. (2004). Early experience alters brain function and structure. *Pediatrics: 113.*, 846–857.

Als, H., Lester, B. M., Tronick, E., & Brazelton, T. B. (1982). Manual for the Assessment of Preterm Infants' Behavior (APIB). In H. E. Fitzgerald, B. M. Lester, & M. W. Yogman (Series Eds.) &, *Theory and research in behavioral pediatrics : Vol. 1.* (Vol. 1) (pp. 65–132). New York: Plenum Press.

American Academy of Pediatrics, & Committee on Environmental Health. (1997). Noise: A hazard for the fetus and newborn. *Pediatrics: 100.*, 724–727.

Amin, S. B., Orlando, M. S., Dalzell, L. E., Merle, K. S., & Guillet, R. (1999). Morphological changes in serial auditory brain stem responses in 24 to 32 weeks' gestational age infants during the first week of life. *Early Hearing: 20.*, 410–418.

Barlow, S. M., Finan, D. S., Lee, J., & Chu, S. (2008). Synthetic orocutaneous stimulation entrains preterm infants with feeding difficulties to suck. *Journal of Perinatology: 28.*, 541–548.

Boersma, P., & Weenink, D. (2013). *Praat: Doing phonetics by computer [Computer program]. Version 5.3.53.* , retrieved from http://www.praat.org
Bozzette, M. (2008). Patterns of early communication between preterm infants and their mothers. *Early Childhood Services: 2.*, 21–31.
Butler, S., & Als, H. (2008). Individualized developmental care improves the lives of infants born preterm. *Acta Pediatrica: 97.*, 1173–1175.
Cooper, R. P., Abraham, J., Berman, S., & Staska, M. (1997). The development of infants' preference for motherese. *Infant Behavior & Development: 20.*, 477–488.
Cooper, R. P., & Aslin, R. N. (1990). Preference for infant-directed speech in the first month after birth. *Child Development: 61.*, 1584–1595.
DeCasper, A. J., & Fifer, W. P. (1980). Of human bonding: Newborns prefer their mothers' voices. *Science: 208.*, 1174–1176.
Dirix, C. E., Nijhuis, J. G., Jongsma, H. W., & Hornstra, G. (2009). Aspects of fetal learning and memory. *Child Development: 80.*, 1251–1258.
Eckerman, C. O., Oehler, J. M., Medvin, M. B., & Hannan, T. E. (1994). Premature newborns as social partners before term age. *Infant Behavior & Development: 17.*, 55–70.
Fernald, A. (1985). Four-month-old infants prefer to listen to motherese. *Infant Behavior & Development: 8.*, 181–195.
Fernald, A., Taeschner, T., Dunn, J., Panousek, M., de Boysson-Bardies, B., & Fukui, I. (1989). A cross-language study of prosodic modifications in mothers' and fathers' speech to preverbal infants. *Journal of Child Language: 16.*, 477–501.
Fifer, W. P. (1987). Neonatal preference for mother's voice. In N. A. Krasnegor, E. M. Blass, M. A. Hofer, & W. P. Smotherman (Eds.), *Perinatal development: A psychobiological perspective* (pp. 111–122). New York: Academic Press.
Fifer, W. P., & Moon, C. (1995). The effects of fetal experience with sound. In J. P. Lecanuet, N. A. Krasnegor, W. P. Fifer, & W. P. Smotherman (Eds.), *Fetal behavior: A psychobiological perspective* (pp. 351–366). Hillsdale, NJ: Erlbaum.
Fucile, S., McFarland, D. H., Gisel, E. G., & Lau, C. (2012). Early Human Development. *Early Human Development: 88.*, 345–350.
Goubet, N., Clifton, R. K., & Shah, B. (2001). Learning about pain in preterm newborns. *Journal of Developmental & Behavioral Pediatrics: 22.*, 418–424.
Hofer, M. A. (2004). The emerging neurobiology of attachment and separation: How parents shape their infant's brain and behavior. In S. W. Coates, & J. L. Rosenthal (Eds.), *September 11 – 'when the bough broke', attachment theory, psychobiology, and social policy: An integrated approach to trauma*. New York: Analytic Press.
Katz, V. (1971). Auditory stimulation and developmental behavior of the premature infant. *Nursing Research: 20.*, 196–201.
Kisilevsky, B. S., & Hains, S. M. J. (2011). Onset and maturation of fetal heart rate response to the mother's voice over late gestation. *Developmental Science: 14.*, 214–223.
Krueger, C., Parker, L., Chiu, S.-H., & Theriaque, D. (2010). Maternal voice and short-term outcomes in preterm infants. *Developmental Psychobiology: 52.*, 205–212.
Lecanuet, J. P., Granier-Deferre, C., Jacquet, A. Y., & Busnel, M.-C. (1992). Decelerative cardiac responsiveness to acoustical stimulation in the near term fetus. *Quarterly Journal of Experimental Psychology: 44.*, 279–303.
Lecanuet, J. P., Granier-Deferre, C., Jacquet, A. Y., & DeCasper, A. J. (2000). Fetal discrimination of low-pitched musical notes. *Developmental Psychobiology: 36.*, 29–39.
Malloy, G. B. (1979). The relationship between maternal and musical auditory stimulation and the developmental behavior of premature infants. *Birth Defects Original Article Service: 15.*, 81–89.
Mehler, J., Bertoncini, J., Barriere, M., & Jassik-Gerschenfeld, D. (1978). Infant recognition of mother's voice. *Perception: 7.*, 491–497.
Morokuma, S., Doria, V., Ierullo, A., Kinukawa, N., Fukushima, K., Nakano, H., et al. (2008). Developmental change in fetal response to repeated low-intensity sound. *Developmental Science: 11.*, 47–52.
Papousek, M., & Hwang, S-F. C. (1991). Tone and intonation in Mandarin babytalk to presyllabic infants: Comparison with registers of adult conversation and foreign language instruction. *Applied Psycholinguistics: 12.*, 481–504.
Pegg, J. E., Werker, J. F., & McLeod, P. J. (1992). Preference for infant-directed over adultdirected speech: Evidence from 7-week-old infants. *Infant Behavior & Development: 15.*, 325–345.
Philbin, M. K. (2000). The influence of auditory experience on the behavior of preterm newborns. *Journal of Perinatology: 20.*, S77–S87.
Poore, M., Zimmerman, E., Barlow, S. M., Wang, J., & Gu, F. (2008). Patterned orocutaneous therapy improves sucking and oral feeding in preterm infants. *Acta Paediatrica: 97.*, 920–927.
Ruben, R. J. (1997). A time frame of critical/sensitive periods of language development. *Acta Oto-laryngololgica: 117.*, 202–205.
Segall, M. E. (1972). Cardiac responsivity to auditory stimulation in premature infants. *Nursing Research: 21.*, 15–19.
Thoman, E. B., & Ingersoll, E. W. (1993). Learning in premature infants. *Developmental Psychology: 29.*, 692–700.
van Heteren, C. F., Boekkooi, P. F., Jongsma, H. W., & Nijhuis, J. G. (2001). Fetal habituation to vibroacoustic stimulation in relation to fetal states and fetal heart rate parameters. *Early Human Development: 61.*, 135–145.
Werner, J., & Siqueland, E. (1978). Visual recognition memory in the preterm infant. *Infant Behavior & Development: 1.*, 79–94.
White-Traut, R. C., Nelson, M. N., Silvestri, J. M., Cunningham, N., & Patel, M. (1997). Responses of preterm infants to unimodal and multimodal sensory intervention. *Pediatric Nursing: 23.*, 169–193.