ACTA PÆDIATRICA
NURTURING THE CHILD

Acta Pædiatrica ISSN 0803-5253

REGULAR ARTICLE

Live maternal speech and singing have beneficial effects on hospitalized preterm infants

Manuela Filippa (manuela.filippa@gmail.com)[1], Emmanuel Devouche[2,4], Cesare Arioni[3], Michel Imberty[1], Maya Gratier[1,4]

1.Université Paris Ouest Nanterre La Défense, Nanterre Cedex, France
2.Université Paris Descartes, Paris, France
3.Parini Hospital, Aosta, Italy
4.Unité de recherche de l'EPS Erasme, Paris, France

Keywords
Critical events, Infant-directed speech and singing, Maternal live voice, NICU, Premature infant, Sound environment

Correspondence
Manuela Filippa, UFR des Sciences Psychologiques et Sciences de l'Education, Université Paris Ouest Nanterre La Défense, 200 Avenue de la République, 92001 Nanterre Cedex, France.
Tel: +33 1 44 07 80 00 |
Fax: +33 1 40 97 47 29 |
Email: manuela.filippa@gmail.com

Received
29 April 2013; revised 24 June 2013; accepted 10 July 2013.

DOI:10.1111/apa.12356

ABSTRACT

Aim: To study the effects of live maternal speaking and singing on physiological parameters of preterm infants in the NICU and to test the hypothesis that vocal stimulation can have differential effects on preterm infants at a behavioural level.

Methods: Eighteen mothers spoke and sang to their medically stable preterm infants in their incubators over 6 days, between 1 and 2 pm. Heart rate (HR), oxygen saturation (OxSat), number of critical events (hypoxemia, bradycardia and apnoea) and change in behavioural state were measured.

Results: Comparisons of periods with and without maternal vocal stimulation revealed significantly greater oxygen saturation level and heart rate and significantly fewer negative critical events ($p < 0.0001$) when the mother was speaking and singing. Unexpected findings were the comparable effects of maternal talk and singing on infant physiological parameters and the differential ones on infant behavioural state.

Conclusion: A renewed connection to the mother's voice can be an important and significant experience for preterm infants. Exposure to maternal speech and singing shows significant early beneficial effects on physiological state, such as oxygen saturation levels, number of critical events and prevalence of calm alert state. These findings have implications for NICU interventions, encouraging maternal interaction with their medically stable preterm infants.

INTRODUCTION

Up until their discharge from the NICU preterm infants present some degree of medical instability. The main purpose of hospitalization is to help them attain a state of stability and integrate their physiological functions (1). Their psycho-physiological state is no longer supported by the intrauterine environment (maternal sleep/wake, hormonal and nutritional cycles), but by the NICU routines. The caregiving environment can affect infant's state organization, and individualized care as well as interactive experiences are necessary to promote healthy development for preterm infants (2,3). In the NICU, preterm infants are often exposed to a great variety and density of temporally non-contingent auditory stimuli, sounds from the equipment, monitor alarms, doors, telephones and conversations.

It is known in fact that foetuses and newborns recognize their mother's voice. By the last trimester of gestation, foetuses respond to auditory stimulation (4), memorize some characteristics of the mother's voice (5) and become familiar with the specific rhythmic organization of their mother tongue (6). Foetal heart rate changes attest to near-term foetuses' ability to discriminate intensity and frequency (7) as well as their capacity to process melodic contour in speech and music (8,9). Discriminative brain responses to sound changes can be detected as early as 28 weeks GA (10), and near-term foetuses can perceive sound streams and

Abbreviations
GA, gestational age; HR, heart rate; ID, infant directed; IDVS, infant-directed vocal stimulation; NICU, neonatal intensive care unit; OxSat, oxygen saturation.

Key notes

- Hospitalized preterm infants have less contact with their mother's voice than foetuses and full-term newborns.
- This study measured the impact of 18 mothers singing and talking to their babies in their NICU incubators.
- We believe that this is the first research to provide evidence that live maternal speech and singing are beneficial to preterm infants, increasing their oxygen saturation levels, reducing the occurrence of critical events and inducing quiet alert states.

some phonetic characteristics of the mother's language (11). Near-term foetuses prefer a speech passage, and a melody that their mothers have recited repeatedly during the later weeks of pregnancy (6,12), and they can distinguish the mother's recorded voice from that of a female stranger (13). With full-term newborns, mothers intuitively modify their vocal register, addressing them as potential partners.

Recordings of maternal voice have been used in intervention studies in the NICU as reported in recent review articles (14–16).

Recorded vocal stimulation affects heart rate, respiratory rate and oxygen saturation and reduces pain responses in hospitalized preterm infants (17). These studies also show that preterm infants experience fewer episodes of feeding intolerance and achieve full enteral feeds in fewer days when exposed to the recorded maternal voice. A recent study has shown that increase levels of adult language induce vocalization in preterm infants in the NICU (18). Even more recently, a randomized clinical trial intervention study showed that live singing by music therapist and parent is associated with changes in heart rate, sucking pattern, sleep pattern and behavioural state in hospitalized preterm infants (19). This study further investigates the clinical effects of exposure of preterm infants to live infant-directed maternal speech and singing. The aims of this study were to determine: (i) whether live maternal vocal stimulation would cause an increase in preterm infants' HR and oxygen saturation as well as a decrease in critical events and (ii) whether singing and speaking would be associated with more quiet alert behavioural states.

METHODS

Participants

The study was conducted in a level II NICU at the Parini Hospital (Aosta, Italy), limited to newborn infants who were more than 29 weeks' gestational age and/or weighed more than 1000 g at birth. A total of 87 infants were screened between February 2011 and September 2012: 40 were medically stable and were approached for enrolment. Clinical stability was established by the primary physician. Of these, 22 preterm infants were enrolled, including two sets of twins. Two of these were excluded because of incomplete data, and two infants were transferred to another nursery. The final sample of 18 preterm neonates consisted of eight females and 10 males who met the following inclusion criteria at the time of data collection: (i) age >29 weeks gestational age, (ii) weight >1000 g and (iii) stable medical condition (absence of mechanical ventilation, no additional oxygen, no specific pathological conditions). Mothers' mean age was 32.5 ± 4.5 years (range: 24–41 years), 15 of them were primiparous, and none of them presented any specific pathological condition or depression symptoms as assessed by the NICU psychologist. The mean gestational age of infants at birth was 31.7 ± 2 and 34.5 ± 2.9 weeks GA (range: 32–38 weeks) at testing, mean weight at birth was 1496 ± 385 (range: 920–2080 g) and 1706 ± 155 g (range: 1270–1890 g) at testing. Newborn APGAR scores were collected (6.6 ± 2 at 1 min, 8.3 ± 1 at 5 min) and at discharge, all participants had passed AABR bilateral hearing screening. The official Hospital Ethical Committee reviewed and approved the study (I.C. n. 12453), and informed consent was obtained.

Material

Video recordings of mothers and infants were made with two fixed video cameras (Sony© Handycam HDD dcr-sr30 and HDD dcr-sr58, Tokyo, Japan). The cameras were mounted at the two extremities of the incubator. Audio recordings were obtained using a Tascam linear PCM recorder (model dr-08). Video recordings were synchronized using Adobe Premiere Pro CS5 and associated with a timer using Adobe After Effects CS5 and with the clinical parameters every 10 sec using Scrivi Timer Pro created by S. Peloso, the laboratory technician, for this research study.

Procedure

Infants were tested over 6 days, in their hospital room and in their individual incubators. In the stimulus condition, mothers were asked to speak and sing to their infants continuously over a 5-min period for each type of stimulus (10 min in total). Testing was performed over three non-consecutive days (on days 2, 4 and 6), and the order of the stimuli (speaking or singing) was permuted over the three testing days. Baseline measures were collected over three non-consecutive days (on days 1, 3 and 5) over a period of 10 min each day, as well as on the three stimulus days, prior to the mother's arrival, over a period of 5 min each day. Thus, for each infant, the stimulus conditions lasted 30 min over 3 days (5 min × two stimulations × 3 days) and the baseline condition lasted 45 min over 6 days (10 min × 3 days + 5 min × 3 days), also including the 5 min prior the stimulus conditions. Recording sessions occurred midway between feeding cycles, between 1 and 2 pm, more than one hour after the first afternoon feed and more than 4 h after the last medical routine.

The two fixed cameras recorded, respectively, mothers' and infants' facial expressions and upper torso movements. Mothers were free to choose the content and style of their speech and singing, but they were asked to refrain from touching the infant. They were told to place their faces in front of the incubator opening so as to be as close as possible to the infant's head. The room door was kept closed in order to dampen the ambient sound level.

The sound level in the NICU room ranged from 54.6 to 60.6 dBA, and the room was for one or, rarely, for two infants. The sound level, measured in the same conditions in audio recordings, ranged from 60.6 to 71.5 dBA and from 59.3 to 71.33 dBA, respectively, for speaking and singing conditions. Decibel levels were measured at 20 cm from the infant's head and about 25 cm from the mother's head, using the Tascam audio recording device (see Material). Clinical parameter readings (HR and OxSat) were obtained every 10 sec from the video recordings (see Measures), and medically critical events were recorded automatically, based on routine hospital procedures.

Measures

Heart rate (beats per minute), oxygen saturation (%) and all critical events (hypoxemia – OxSat <80% and/or bradycardia, HR<80 bpm) were recorded automatically during the different conditions through the relevant medical apparatus and collected from video recordings of the monitors. Infant behavioural state was assessed by two trained independent raters using the Brazelton (20). Behavioural coding system and its adaptation for preterm infants by Heidelise Als (21). A behavioural state was assigned to an infant if it lasted at least 15 sec, and it was assessed every 5 min throughout the procedure. The state configurations were defined as follows: (i) deep sleep state (DS), (ii) active sleep state (AS), (iii) drowsiness state (D), (iv) quiet awake state (QA), (v) active awake state (AA) and (vi) crying state (CS).

Statistics

A repeated one-way ANOVA was conducted respectively on HR and oxygen saturation, with the condition (baseline, singing, speaking) as within subject factor. The method used to calculate the confidence interval for the proportion of critical events was the Wilson score method without continuity correction (22). An alpha level of 0.05 was used for all statistical tests. Behavioural state was analysed using both the classical chi-squared test and the Bayesian method. The Bayesian analysis of association rates was based on the local analysis of cells for which a dependency level was inductively attested with a Bayesian guarantee ≥0.95.

RESULTS

ANOVA conducted on the HR measure showed a significant difference between the three conditions (F (2,34) = 3.76, p = 0.034, η_p^2 = 0.18). Planned comparisons revealed that HR was significantly lower in the baseline condition than in singing and speaking conditions (146.3 vs. 149.7; F (1,17) = 4.52, p = 0.049, η_p^2 = 0.21), but no significant difference was found between maternal speech and maternal singing (149.5 vs. 149.8; F (1,17) < 1).

Similarly, ANOVA conducted on the oxygen saturation measure showed a significant difference between the three conditions (F (2,34) = 4.66, p = 0.016, η_p^2 = 0.22). Planned comparisons revealed that oxygen saturation was significantly lower in the baseline condition than in singing and speaking conditions (95.7 vs. 96.4; F(1,17) = 5.37, p = 0.033, η_p^2 = 0.24), but no significant difference was observed between maternal speech and maternal singing (96.4 vs. 96.4; F (1,17) < 1).

Lastly, considering that the stimulus condition lasted 30 min against 40 min for the baseline, the proportion of medically critical events appeared significantly lower during maternal speaking and singing [14.7% (10/68), 95%CI = (8.19; 25.0), p < 0.0001].

A total of 305 activity levels were coded in the entire sample: 164 during the baseline condition, 78 during the singing condition and 63 during the speaking condition. Three behavioural levels were distinguished: deep sleep, active sleep and quiet alert state, other usual states being rarely observed. A contingency analysis showed that conditions and activity levels were significantly linked (Chi^2 (4) = 35.1, p < 0.0001, *Cramer's V* = 0.24) (Table 1).

Table 1 Behavioural states in response to infant-directed vocal stimulation (IDVS)

	DS (%)	AS (%)	QA (%)	Total (%)	Total N
NS	46**	50	4°°	100	164
Singing	19°°	64	17	100	78
Speaking	19°	60	21*	100	63
Mean	34	56	10	100	305

The use of the symbol '*' points association rates significantly higher than 20%, and the symbol '°' association rates significantly lower than 10%. The use of '*' or '°' indicates cells for which the association rate is inductively attested with a Bayesian guarantee of 0.95, and '**' or '°°' with a Bayesian guarantee of 0.99.

The analysis of the association rates revealed that the proportion of DS was significantly higher in the baseline condition and lower in both stimulus conditions. Moreover, the proportion of QA appeared to be significantly higher in the speaking condition and lower in the baseline condition. Although it tended to be lower in the baseline condition, AS was not discriminating enough to significantly distinguish between the three conditions.

DISCUSSION

Social interaction based on vocal stimulation is now at the heart of new approaches in NICU interventions (20,23). Our data examining the specific effects of live maternal speech and singing on hospitalized preterm infants reveal that live maternal vocal stimulation has beneficial effects on infants: the significant decrease in critical events and the increase in oxygen saturation are valid indicators of a better quality of life for preterm infants in the NICU. In this study, increased HR, together with an increase in the proportion of quiet alert state, was associated with live vocal stimulation. This finding contrasts with those from studies using recorded vocal stimulation, which report a decreased HR after exposure to recorded sound (24), often interpreted as indexing the soothing effect it has on infants. Our heart rate findings are consistent with recent studies showing foetal HR increase in response to the mother's voice (13) and in response to familiar or unfamiliar melodies (25). In addition, we observed behavioural effects of maternal voice on preterm infants, supported by the increase and stability of quiet alert states, commonly considered as a positive state that can, in the long term, improve the quality of bonding between the mother and the preterm infant (26). The live vocal relationship between a mother and her preterm infant during the first weeks of life in the NICU has been overlooked in current research, and recent meta-analysis studies demonstrate that little research investigates the significance of the loss of exposure to maternal voice for the preterm infant (27). What is left unanswered is the question of what is a developmentally appropriate stimulation for very preterm infants. What this study adds to the debate is that a

meaningful and relational-based maternal vocal stimulation can positively activate the infant's state avoiding or dampening the risks of non-contingent overstimulation.

An unexpected finding was that no difference between the speaking and singing stimulation conditions emerged with respect to infant physiological parameters. However, preterm infants' reactions to singing and speaking did not completely overlap as their behavioural reactions show that the quiet alert state is more often induced by maternal speaking, whereas maternal singing tends to maintain the infant in an active sleep state. Further analyses should be performed on the acoustic qualities of maternal speaking and singing styles to preterm infants in order to explain their differential effects.

CONCLUSIONS

This study provides evidence that hospitalized preterm infants draw benefits from a renewed connection to their mother's voice. Preterm infants' behavioural state was shown to change from a deep sleep state to active sleep and quiet alert states when mothers spoke or sang. In addition, higher levels of the quiet alert state were associated with speaking as opposed to singing. These findings demonstrate the powerful effects of parental involvement in NICU care and have implications for intervention programmes encouraging live maternal vocal stimulation with medically stable preterm infants during hospitalization.

ACKNOWLEDGMENTS

This research was supported by a Research Grant from the European Social Fund. We wish to thank Gianni Nuti, the Aosta Musical Institute, the medical and administrative staff of Parini Hospital, Aosta; the mothers and their infants for making this study possible. We also thank M Dondi and S Trehub for their helpful comments on drafts of the manuscript, Stefano Peloso for his technical support and G. Filippa for help with statistical analysis.

FUNDING SOURCE

All phases of this study were supported by a grant from the European Social Fund, ESF 2007–2013.

References

1. Als H. Reading the premature infant. In: E Goldson, editor. *Nurturing the premature infant*. New York, NY: Oxford University Press, 1999.
2. Als H. Advances in the understanding and care of the preterm infant. In: Lester BM, Sparrow JD, editors. *Nurturing children and families: building on the legacy of T. Berry Brazelton*. Oxford: Wiley-Blackwell, 2010
3. Als H, Duffy FH, McAnulty GB, Rivkin MJ, Vajapeyam S, Mulkern RV, et al. Early experience alters brain function and structure. *Pediatrics* 2004; 113: 846–57.
4. Lecanuet J, Schaal B. Fetal sensory competencies. *Eur J Obstet Gynecol Reprod Biol* 1996; 68: 1–23.
5. DeCasper AJ, Fifer WP. Of human bonding: newborns prefer their mothers' voices. *Science* 1980; 208: 1174–6.
6. DeCasper AJ, Spence MJ. Prenatal maternal speech influences newborns' perception of speech sounds. *Infant Behav Dev* 1986; 9: 135–50.
7. Lecanuet JP, Granier-Deferre C, Jacquet AY, DeCasper AJ. Fetal discrimination of low–pitched musical notes. *Dev Psychobiol* 2000; 36: 29–39.
8. Mastropieri D, Turkewitz G. Prenatal experience and neonatal responsiveness to vocal expressions of emotion. *Dev Psychobiol* 1999; 35: 204–14.
9. Hepper PG. An examination of fetal learning before and after birth. *Irish J Psychol* 1991; 12: 95–107.
10. Draganova R, Eswaran H, Murphy P, Lowery CL, Preissl H. Serial magnetoencephalographic study of fetal and newborn auditory discriminative evoked responses. *Early Hum Dev* 2007; 83: 199–207.
11. Granier-Deferre C, Ribeiro A, Jacquet AY, Bassereau S. Near-term fetuses process temporal features of speech. *Dev Sci* 2011; 14: 336–52.
12. Moon C, Lagercrantz H, Kuhl PK. Language experienced in utero affects vowel perception after birth: a two-country study. *Acta Paediatr* 2013; 102: 156–60.
13. Kisilevsky B, Hains SML, Lee K, et al. Effects of experience on fetal voice recognition. *Psychol Sci* 2003; 14: 220–4.
14. Hodges AL, Wilson LL. Preterm infant responses to music: an integrative literary review. *Southern Online J Nurs Res* 1990; 10: 120–5.
15. Krueger C. Maternal voice and short-term outcomes in preterm infants. *Dev Psychobiol* 2010; 52: 205–12.
16. Standley J. A meta-analysis of the efficacy of music therapy for premature infants. *J Pediatr Nurs* 2002; 17: 107–13.
17. Doheny L, Hurwitz S, Insoft R, Ringer S, Lahav A. Exposure to biological maternal sounds improves cardiorespiratory regulation in extremely preterm infants. *J Matern-Fetal and Neonat Med* 2012; 25: 1591–4.
18. Caskey M, Stephens B, Tucker R, Vohr B. Importance of parent talk on the development of preterm infant vocalizations. *Pediatrics* 2011; 128: 910–16.
19. Loewy J, Stewart K, Dassler A-M, Telsey A, Homel P. The effects of music therapy on vital signs, feeding and sleep in premature infants. *Pediatrics* 2013; 131: 902–18.
20. Brazelton TB. *Clinics in developmental medicine: neonatal behavioral assessment scale (NBAS)*. Philadelphia: Lippincott, 1983.
21. Als H. Developmental care in the newborn intensive care unit. *Curr Opin Pediatr* 2004; 10: 138–42.
22. Newcombe RG. Two-sided confidence intervals for the single proportion: comparison of seven methods. *Stat Med* 1998; 17: 857–72.
23. Malloch S, Shoemark H, Črnčec R, et al. Music therapy with hospitalised infants – the art and science of intersubjectivity. *Infant Ment Health J* 2012; 33: 386–99.
24. Standley JM. Music therapy research in the NICU: an updated meta-analysis. *Neonat Netw* 2012; 31: 311–16.
25. Granier-Deferre C, Bassereau S, Ribeiro A, Jacquet A, DeCasper A. A melodic contour repeatedly experienced by human near-term fetuses elicits a profound cardiac reaction one month after birth. *PLoS ONE* 2011; 6: e17304.
26. Als H, Lawhon G, Duffy FH, McAnulty G, Gibes-Grossman R, Blickman JG. Individualized developmental care for the very low-birth-weight preterm infant. Medical and neurofunctional effects. *JAMA* 1994; 272: 853–8.
27. Krueger C. Exposure to maternal voice in preterm infants: a review. *Adv Neonatal Care* 2010; 10: 13–18.

