JOGNN

RESEARCH

The Effect of Maternal Presence on Premature Infant Response to Recorded Music

Trish Dearn and Helen Shoemark

Correspondence
Dr. Helen Shoemark, PhD, RMT, Murdoch Children's Research Institute, 50 Flemington Road, Parkville, Victoria 3052.
helen.shoemark@mcri.edu.au

Keywords
NICU
music
maternal presence
premature
noise
sound

ABSTRACT

Objective: To determine the effect of maternal presence on the physiological and behavioral status of the preterm infant when exposed to recorded music versus ambient sound.

Design: Repeated-measures randomized controlled trial.

Setting: Special care nursery (SCN) in a tertiary perinatal center.

Participants: Clinically stable preterm infants (22) born at > 28 weeks gestation and enrolled at > 32 weeks gestation and their mothers.

Methods: Infants were exposed to lullaby music (6 minutes of ambient sound alternating with 2x 6 minutes recorded lullaby music) at a volume within the recommended sound level for the SCN. The mothers in the experimental group were present for the first 12 minutes (baseline and first music period) whereas the mothers in the control group were absent overall.

Results: There was no discernible infant response to music and therefore no significant impact of maternal presence on infant's response to music over time. However during the mothers' presence (first 12 minutes), the infants exhibited significantly higher oxygen saturation than during their absence $p = .024$) and less time spent in quiet sleep after their departure, though this was not significant.

Conclusion: Infants may have been unable to detect the music against the ambient soundscape. Regardless of exposure to music, the infants' physiological and behavioral regulation were affected by the presence and departure of the mothers.

JOGNN, 43, 341-350; 2014. DOI: 10.1111/1552-6909.12303

Accepted January 2014

Trish Dearn, MMus, RMT, is the Clinical Director of the Early Intervention Music Therapy Clinic, Melbourne, Australia and a PhD candidate, Conservatorium of Music, University of Melbourne, Australia.

(Continued)

Trish Dearn was supported by an Australia Postgraduate Association scholarship from The University of Melbourne.
Helen Shoemark is supported by a Career Development Award Grant from the Murdoch Childrens Research Institute and the Victorian Government's Operational Infrastructure Support Program.

AWHONN

Each year in Australia approximately 8% of infants are born prematurely, that is in excess of 20,000 infants being born before age 37 weeks gestation (Laws, Li, & Sullivan, 2010). In addition to the inherent medical risks associated with premature birth, being cared for in an atypical environment puts preterm infants at increased risk of potential neuro-developmental problems (Romeo, Cioni, Palermo, Cilauro, & Romeo, 2013) and altered brain structures (Inder, Warfield, Wang, Huppi, & Volpe, 2005). The combination of the absence of the appropriate physical environment and the sudden loss of physiological and psychological support provided by the mother can be devastating to the preterm infant (Aucott, Donohue, Atkins, & Allen, 2002; White-Traut et al., 2009). The family is known to be a protective factor for infant neurodevelopment (Benzies, Magill-Evans, Hayden, & Ballantyne, 2013; Vanderveen, Bassler, Robertson, & Kirpalani, 2009); however, the mother's typical role within the mother/infant dyad can be altered by weeks of extraordinary experience in the neonatal intensive care unit (NICU) with a notable lack of opportunity for interaction due to the infant's fragility (Aagaard & Hall, 2008). A growing number of researchers are scrutinizing the consequence of hospitalization for the new mother/infant dyad (Korja et al., 2010; Newnham, Milgrom, & Skouteris, 2009) and their experiences in hospital.

Maternal Presence for Preterm Infant

Many hospitals have adopted strategies to ameliorate mother/infant separation (Chesney & Champion, 2008; Melnyk et al., 2006) and minimize

The potential of a music intervention to provide an opportunity for the mother to support her infant has only been partially realized.

Helen Shoemark, PhD, RMT, is a career development fellow, Murdoch Childrens Research Institute, Australia; Honorary Senior Fellow, Conservatorium of Music, University of Melbourne, Australia; adjunct professor, University of Queensland, Australia; and senior music therapist (neonatology), The Royal Children's Hospital Melbourne, Australia.

the potential negative impact on families, particularly on the mother/infant relationship. Most tertiary hospitals in Australia encourage the parents to be present with supportive infrastructure such as comfortable chairs, available food, facilities to express milk, and close-by or onsite accommodation. At the bedside, mothers are supported to be present with strategies such as skin-to-skin contact that allows preterm infants intermittent access to the mother's skin, smell (Schaal, Hummel, & Soussignan, 2004), voice, and touch (Gardner & Goldson, 2011; Konstandy et al., 2008), and promoting stability in the infant's physiological and behavioral status (Ludington-Hoe & Hosseini, 2005; Westrup, Kleberg, & Stjernquist, 2005). Mothers identify such experiences as a way to make a unique contribution to their infants' well-being, promoting a sense of mastery, closeness, and self-confidence in their mothering roles (Davis, Mohay, & Edwards, 2003).

Preterm Infant Response to Music

Recorded and live music are increasingly being used in NICUs and special care nurseries (SCNs) for infant self-regulation based on the evidence in the music therapy and nursing literature for the beneficial effect of music on infant status. Recorded music has been shown to reduce high arousal levels (Cassidy & Standley, 1995; Kaminski & Hall, 1996; Whipple, 2008) stabilize physiological functioning (Caine, 1991; Nagorski Johnson, 2003; Standley, 2003), increase oxygen saturation levels (Cassidy & Standley; Standley & Moore, 1995), reduce heart rate (Butt & Kisilevsky, 2000; Coleman, Pratt, Stoddard, Gerstmann, & Abel, 1997; Keith, Russell, & Weaver, 2009), and facilitate improved sleep (Olischar, Shoemark, Trudy Holton, Weninger, & Hunt, 2011).

In addition to this however, engagement in music is also being considered as a supportive opportunity for mother and infant. When combined with mother's presence during kangaroo care, music has been shown to significantly improve blood pressure and respiration (Teckenberg-Jansson, Huotilainen, Pölkki, Lipsanen, & Järvenpääf, 2011), levels of quiet sleep (Lai et al., 2006), and reduce parental anxiety (Lai et al., 2006; Teckenberg-Jansson et al., 2011). The potential of a music intervention to provide an opportunity for the mother to support her infant has only been partially realized through studies which provided parent training (Whipple, 2000), opportunity for maternal singing (Cevasco, 2008; Johnston, Filion, & Nuyt, 2007; Loewy, Stewart, Dassler, Telsey, & Homel, 2013), and kangaroo care with music (Johnston et al., 2009; Lai, et al., 2006; Teckenberg-Jansson et al., 2011). The further proposition is that mother and infant listening to music together is encompassed into the infant's existing relationship with the mother, and an association with that loving relationship is constructed. Then at times when the mother is unable to be present, the potential of the familiar music to support infant regulation may be enhanced (Shoemark & Dearn, 2008; Shoemark, 1999).

Music in the Ambient Environment of the NICU and SCN

The American Academy of Pediatrics (AAP; 1997) recommended a Leq (the logarithmic equivalent of average sound level over a specific period of time) of 45dBA (A weighted scale) for the ambient sound of the NICU. Studies to measure the environment have repeatedly demonstrated that this is a very conservative sound level and difficult to achieve (Busch-Vishniac, West, Hunter, Orellana, & Chivukula, 2005; Byers, Lowman, & Waugh, 2006; Lasky & Williams, 2009). Alongside this, recommendations for the volume at which recorded music should be played in the NICU have varied from 55dBA (Standley, 2000) to 65dBA (75 dBC) (Standley, 2012), to Philbin's (2000) recommendation that the sound intensity of the music needs to be context driven (incubator or open cot; ventilation or proximity to nursing station). Premature infants do not have the same auditory discrimination ability as term newborns (de Regnier, 2008), and therefore it is reasonable to expect that premature infants would require more sound level intensity to detect music from the ambient sound than adults do (Werner, 2007).

The majority of studies using recorded music with premature infants in a NICU have used a volume level that does not account for the AAP recommendations and do not give important acoustic details for replication such as the sound level response time (slow or fast) or the weighting in the A scale (weighted for human hearing) or the C scale (weighted for environmental measurement). Music has been presented via free field speakers, headphones, and a speaker pillow, and the sound itself measured at various distances from the infant's head to the speaker (Cassidy & Ditty, 1998; Standley & Walworth, 2010). In two studies, researchers attempted to stay within the AAP guidelines for ambient sound of 45dBA but then went on to add music as a stimulus above that level causing the cumulative sound level to be above the recommended levels (Arnon et al., 2006; Neal & Lindeke, 2008).

The aim of this study therefore was to examine whether the presence of the mother at the bedside would influence the infant's physiological and behavioral status on first exposure to recorded music presented within the AAP guidelines for NICU auditory environment. Specifically the hypothesis was that the presence of the mother would influence the infant's physiological and behavioral response to recorded music.

Method

The study was conducted in a 69-bed open plan design SCN colocated with the NICU at Mercy Hospital for Women, Melbourne Australia. The ethical aspects of this research project were approved by the Mercy Health Human Research Ethics Committee and in accordance with the National Statement on Ethical Conduct in Human Research (National Health and Medical Research Council, the Australian Research Council, & the Australian Vice-Chancellors' Committee, 2013).

A randomized controlled trial design with repeated measures allowed for comparison both between groups and within groups. For the purposes of this study, 25 infants in each group, were needed to detect a 10% reduction in resting heart rate (HR) (13 beats per minute [BPM]) with a power 80% (beta – 0.2) at a significance level of 0.5% ($p < .05$) and a change in mean oxygen saturation of approximately 3% with similar power and significance levels.

Infants were eligible if they had been born at >28 weeks gestation and were 32 weeks or more at study commencement (to account for auditory processing maturity) (Jardri et al., 2008; Morlet et al., 1995), were medically stable (no current oxygen support and no complicating medical diagnosis), and still connected to cardio-respiratory monitoring. Infants with known neurological impairments and previous exposure to recorded music were excluded. Mothers needed to be able to speak sufficient English to read participant information and consent for the study. Participants were assigned to groups using blocked randomization in sealed sequential numbered envelopes held by the ward clerk.

Infants displayed significantly higher oxygen saturation when the mothers were present.

The music stimulus was the first 6 minutes of Brahms' Lullaby (*Music for Dreaming* CD, Track 1). Copyright clearance to use this recording was covered in the principal researcher's copyright license. The music was selected by the researchers to provide a stimulus with consistent musical features. The music arrangement features a stable, consistent rhythm. The tempo of the music was 60 BPM equating to half time of the lower safe resting heart rate (120 BPM) of the preterm infant (Gardner & Hernandez, 2011). The timbre of the music consisted of a melody played on flute accompanied by an ensemble of strings and harp. The principle tune was within a small frequency range of one octave (349.23 Hz to 698.46 Hz) which is within the range of 32- to 36-week-old premature infant hearing (Gray & Philbin, 2004; Kellam & Bhatia, 2008). A wordless melody was chosen because language is culturally specific and not universal in nature (Gilad & Arnon, 2010). Infants in both groups received the same recorded music intervention.

Data were collected in one 30-minute period. In the experimental group, mothers were present for the first 12 minutes of the 30 minute data collection (6 minutes without music; 6 minutes with music) and then asked to leave (see Table 1 for data collection protocol).

Intervention

The music source (IRiver E30 MP3 player) was located on a bench behind the infant's bed, with the attached microspeakers (Sony SRS-P7) placed in the cot 30 cm from the infant's head (Cassidy & Ditty, 1998). The music stimulus was faded in to prevent startling the participant (Cassidy, 2009). A minimicrophone (Bruel & Kjaer Half Inch Microphone Type 4950) was suspended through the small opening in the top of the incubator, or for infants in open beds it was mounted on a small tripod as close as possible to the infant's ear. This was connected by a lead to the sound level meter (Bruel & Kjaer 2250 Light) that was held by the researcher for data collection to prevent any interference from vibration. Sound-level data were logged continuously through the data collection period (A weighted scale, slow response).

Table 1: Data Collection Protocol

Period in minutes	Experimental	Control	Music – No Music
00.00 – 05.59	Mother present	Mother absent	No Music 1
06.00 – 11.59			Music 1
12.00 – 17.59	Mother absent		No Music 2
18.00 – 23.59			Music 2
24.00 – 29.59			No Music 3

Music was presented in an ambient environment maintained within the recommended standards for NICU of an hourly L_{eq} of 45dBA (slow response), with an L_{10} (the equivalent of the average sound level for 10% of the specified time) of 50dBA (slow) and an L_{max} (maximum sound level) of 65dBA (slow) (White, 2012). Data collection did not commence until the ambient L_{eq} was less than 50dBA, allowing for music to be played up to 6dBA louder without going above the recommended L_{max}.

Prior to set up for data collection, control group mothers were asked to leave as had previously been explained to them. Equipment set-up and ambient sound level monitoring took 10 minutes and provided a buffer period after the control group mothers left to diminish the effect of their presence. Just prior to data collection, the experimental group mothers were instructed to "touch and speak to your baby as you would normally do when nurturing him/her." Both researchers stood within one meter of the infant's cot with a full view of the infant's face, monitors, and the infant/mother pair.

Data Analysis

A restricted maximum likelihood (REML) model was used to analyze the continuous data (mean HR, oxygen saturation [SpO_2], and behavioral state). This model fits a different mean for each group at each time and takes into account the fact that there were repeated measures for each infant over time. Because of the exploratory nature of the study, no further corrections were used.

The order in which the infant behavior data was coded was randomized prior to coding to compensate for the lack of blinded data collection. The infant behavior data was coded into six categories derived from Thoman's (1990) primary states taxonomy: quiet sleep, active sleep, drowsy, alert inactive, awake active, and fuss/cry. Behavior was initially coded independently by the two researchers prior to establishing consensus coding to confirm the data for analysis. From a total of 1339 recorded infant behaviors, the majority were in the quiet sleep category (QS) and as this was the desirable behavior, all nonsleep behaviors were classified as not QS, and analyzed in binary fashion against QS. The maternal behavior data was categorized in four nonmutually exclusive interactive and care-giving behaviors: uninvolved (looking but not talking, touching or interacting), talking, touching, interacting (looking, talking, and touching) (Holditch-Davis, Cox, Miles, & Belyea, 2003).

A secondary analysis examined the relationship of exposure variables and infant status. Continuous data were assessed using Pearson's correlation; binary variables were tested with a *t* test; and position was tested with ANOVA. The stratifying variables of gestational age at birth (GAB), postconception age (PCA) at commencement of study, Apgar 5-minute score, birth weight, and level of Caffeine Citrate were tested for significant correlation with the outcomes measures. The categorical variables of gender, position, ventilation, 15 + days of ventilation, and use of Caffeine Citrate were analyzed for significant association with outcome measures(Grenier, Bigsby, Vergara, & Lester, 2003; Sakatani, Chen, Lichty, Zuo, & Wang, 1999; Soloveychik, Bin-Nun, Lonchev, Sriram, & Meadow, 2009; White-Traut et al., 2009). An ANOVA was used to test for significant associations between HR and infant position in bed. Infants were positioned in prone, side-lying, or supine.

Results

Data were collected December 2009 to May 2010 (see Figure 1 for Participant Flow Diagram). Of 86 eligible infants, 24 infants were randomly assigned to the experimental (n = 10) and control group (n = 12) with the data of two infants excluded from the analysis as they were belatedly found

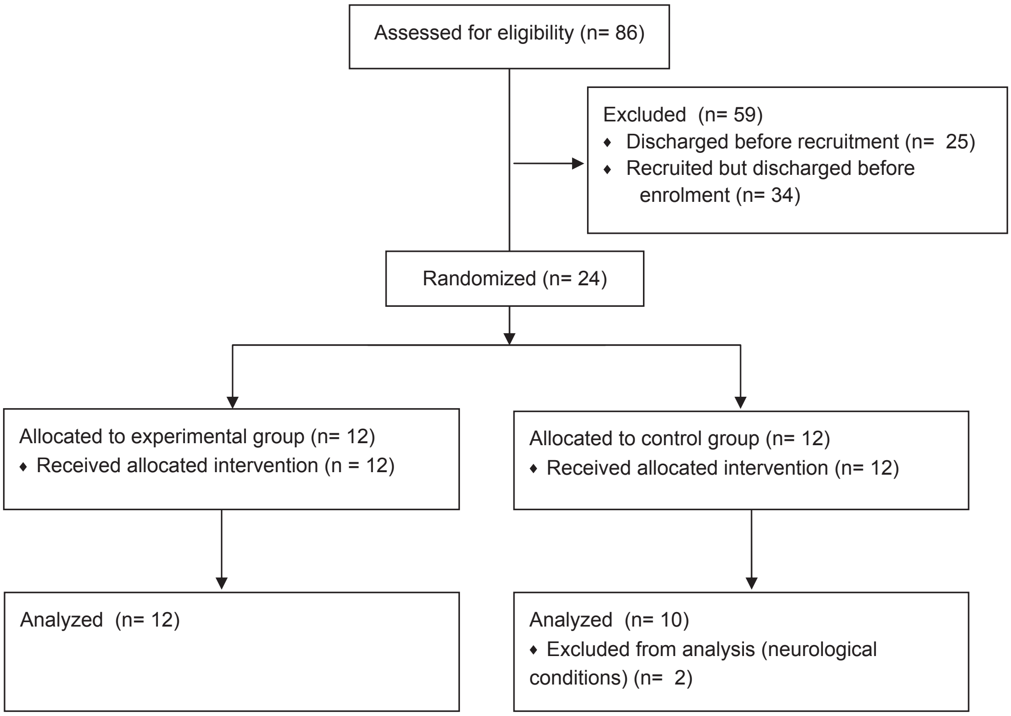

Figure 1. Participant flow diagram.

to have neurological conditions. Demographics of the cohort are presented in Table 2.

Before examining the effect of maternal presence, we first considered the infant's response to the ambient sound and the addition of music. With one exception, sound levels (ambient, and ambient plus music) were maintained between 46.08 to 57.4 dB (A weighted slow response) throughout the data collection period. A preliminary analysis of infant response to music found no significant change in mean HR, SpO_2, and proportion of QS during music. There was no significant difference within groups across time for HR ($p = .9$), SpO_2 ($p = .3$), or proportion of time in QS ($p = .7$) during music and no significant difference between the groups for heart rate ($p = .3$), SpO_2 ($p = .089$) or behavior across time ($p = .4$).

Results indicated that the mothers spent 63.3% of time uninvolved, 24% of time touching, 7% of the time talking, and 4% of their time interacting with their infants. There were no significant differences in mean heart rate ($p = .4$, confidence interval [CI] [−1.52, 3.72]) or QS ($p = .9$, CI [0.18, 0.20]) when mothers were present, however infants displayed significantly higher oxygen saturation when mothers were present ($p = .024$, CI [0.12, 1.40]).

The role of the control group was to compare the effect of maternal presence, but there was no additional control group with no mother and no music. Given that there was no difference between the two available groups, they were collapsed. There were no significant correlations between HR and Apgar 5-minute score, PCA at commencement of the study, or use of Caffeine Citrate but evidence for a negative correlation between heart rate and gestational age at birth and between heart rate and birth weight.

Infants positioned in prone had significantly higher mean HR than infants in side-lying position and supine position during Music 1($p = .05$), No Music 2 ($p = .033$), and No Music 3 ($p = .047$). Infants who had been on ventilator support of any kind during their admission had a higher mean HR than infants who had not, and this was statistically significant during No Music 1 ($p = .049$), Music 2, ($p = .007$), and No Music 3 ($p = .017$). Infants who had been on ventilator support for 15 days or more during their admission showed a consistent trend toward higher HR compared with infants who had received $<$15 days ventilation, but this difference of 14.9 BPM was statistically significant only during the Music 2 period, with a p value of 0.042.

Table 2: Baseline Demographic and Clinical Characteristics for Groups

Groups	Experimental	Control
Total number	10	12
Gender	5 M/5 F	5 M/7 F
Ethnicity	10 White	10 White/2 Other
Gestational age at birth (weeks)	32.5 weeks (28.6 – 36)	31.7 weeks (29.2 – 35)
Post conception age when studied	34.9 (32.3 – 37)	34.3 (32.1 – 37.1)
Birth weight (grams)	1848 (1212 – 3410)	1733 (1265 – 2505)
5 min Apgar > 7	10 of 10	11 of 12
Singletons	7	6
Automated Auditory Brainstem Response (AABR) pass (not done)	10	10 (2)
Incubator/Open cot	3/7	6/6
Diagnoses	3 Respiratory Distress Syndrome (RDS)	3 RDS
	2 RDS + (Pulmonary Valve Stenosis [1]; Transient Tachypnoea [1[)	2 RDS + (Patent Ductus [1] Ateriosis; Patent Foramen Ovale [1])
	2 Patent Foramen Ovale	3 Prematurity
	2 Prematurity	1 Hylane Membrane disease + sepsis
	1 Hypoglycemia	1 Patent Foramen Ovale
		1 IVH Gr 1 (bilateral)
		1 Transient Tachypnoea
Mean time after feed	78 min (40 to 120)	72 min (60 to 120)
Expressed breast milk fed	1 yes, 9 no	2 yes, 10 no
Vent. support	6 yes, 4 no	10 yes, 2 no
Caffeine	6 yes, 4 no	7 yes, 5 no
Position	Prone 2, Supine 1, Side 7	Prone 3, Supine 1, Side 8

Infants who had received Caffeine Citrate showed significantly higher mean HR compared to infants who had not, during No Music 1 (p=.026), Music 1 (p=.047), Music 2 (p=.020) and No Music 3 (p=.014). No significant associations were found between HR and gender.

There was a significant association between proportion of QS and prior ventilation during No Music 1 (p=.008), with infants who had received ventilator support having significantly more QS than infants who had not. There was a significant association between QS and position during No Music 1 ($p = .033$) and No Music 3 ($p = .047$) with infants in prone position having significantly more QS than infants in the other two positions. No significant associations were found between QS and ventilation, 15+ days on ventilation, Caffeine Citrate, or gender. There were no significant correlations or associations with any of the above variables and oxygen saturation.

Discussion

The findings of this study showed no significant difference in any aspect of infant response to recorded music in the SCN. The most obvious explanation for the difference between this study and previous studies that found strong effects for recorded music is that compliance with the AAP requirements for Leq meant that the music was not audible to the infant against the ambient sound environment. The study design promoted detection of the music by providing music in an appropriate frequency range (centering around 500–1000HZ) for optimum infant hearing capabilities (Roeser, 1996). Unfortunately it may have been masked by the lower speech frequencies of staff and visitors in the NICU (Gray & Philbin, 2004), and the difference between ambient sound and music may have been insufficient for detection. A larger difference was not possible given the recommended levels for the auditory environment.

Another potential explanation for this lack of response is that the infants were already physiologically and behaviorally stable. The more recent studies reporting a significant effect of music on physiological and behavioral responses of premature infants were conducted with infants who were undergoing stressful procedures or were in an agitated state (Bo & Callaghan, 2000; Butt & Kisilevsky, 2000; Johnston et al., 2009; Keith et al., 2009; Whipple, 2008). Infants starting from a position of distress with a corresponding higher heart rate and agitated behavior have a greater range of improvement available, which was illustrated in these studies. However in this study all of the infants were physiologically stable and asleep (one hour postfeed), and therefore there was less scope for change. The current results concur with other investigations that report that premature infants have been shown to have lower autonomic responsiveness to external stimuli in certain sleep states (White-Traut et al., 2009).

This study examined the effect of the music/ambient sound and maternal presence within the broader context of the infant. Infant heart rate was significantly affected by GAB, birth weight, Caffeine Citrate, and ventilation usage. The position of the infant was also shown to have a significant effect on heart rate and quiet sleep. This concurs with nursing literature where variables have been shown to affect infant HR and behavior including age (White-Traut et al., 2009) caffeine (Soloveychik et al., 2009), position (Grenier et al., 2003), and ventilation (Sakatani et al., 1999). These findings confirm the need for a broader consideration of infant response when making changes to the infant's physical context.

There was a significant effect of maternal presence on infant oxygen saturation. Despite mothers being "uninvolved" for 63% of the time (looking, but not touching, talking, or moving the infant) her departure still resulted in a significant decrease in oxygen saturation, and a sudden drop in quiet sleep that was not evident at the same time period in the control group. These results reflect previous findings that maternal proximity influences infant physiological status (Ludington-Hoe & Hosseini, 2005; Scher et al., 2009). What is surprising is that such modest contact still produced a significant result. Given that infants can smell their mother's breast milk from the age of 28 weeks gestation (Schaal et al., 2004) it is possible that exposure to the smell of breast milk may have elicited this response. All the mothers in the experimental group were providing expressed breast milk to their infants (not during the actual data collection). Although it is not possible to confirm definitively that the infant recognized the mother, the infants were exposed to three components of their mother's presence: smell, voice, and touch, and although a very small percentage of time was spent in interactive behaviors of voice and touch (7% and 4%, respectively), intermittent talking and touching may be sufficient to physiologically affect the infant.

The lack of infant response to the music may suggest that the difference between ambient and music sound levels was too small for the infant to detect the music.

The stress of having a premature infant in the NICU has been extensively researched, with one of the most significant stressors for the mother being a loss of maternal role (Chesney & Champion, 2008). The finding of this study that indicates a significant effect for bedside maternal presence may serve to reduce mothers' feelings of helplessness and loss of nurturing role (Melnyk et al., 2006) that in turn could facilitate improved feelings of self-efficacy. In the longer term, a recent review of 18 studies of interventions with premature infants that included their mothers found positive effects on parent outcomes including psychosocial support for mothers that were associated with improved child outcomes (Benzies et al., 2013) .

Limitations

Sound levels during data collection were periodically louder than the recommended levels and thus aligned with most reports of NICU auditory environment (Busch-Vishniac et al., 2005; Byers et al., 2006; Lasky & Williams, 2009). Despite the mostly successful effort to present the music within the guidelines, the lack of infant response suggests that there may not have been enough difference between the background sound and the music for infants to detect the music. This is a limitation when attempting to evaluate the impact of maternal response on infant status during music. The lack of a control group who received no music means it is also not possible to say whether the infant status was in effect a response to music or simply a response to time itself.

Although sample size was originally determined by power analysis, the cohort excluded infants on ventilator support because it put the ambient Leq over the recommended level and precluded recorded music being added. Therefore the cohort included infants no longer on ventilator support and nearing discharge. A one-day delay between enrollment and data collection meant that 34 infants were discharged after recruitment but prior to data collection. The small number of participants and the homogenous cultural background of participants (mostly White) recruited in this study preclude generalizations to other maternal or newborn populations.

Recommendations

Further research by multidisciplinary teams is needed to determine the appropriate sound intensity level of a music stimulus to ensure it can be detected by the newborn without breaching recommended levels for the ambient environment. Our findings illustrated that when the ambient sound was below the recommended levels of 50 dBA, music could be presented around 55dBA and be audible to the adult but potentially not be loud enough for the premature infant to detect it. This provides an important methodological consideration for future research presenting recorded music. It is also recommended that further investigation be conducted into the most appropriate use of elements within the music stimulus to ensure that the "music" is designed to maximize detection by the premature infant. Close attention to key time points in clinical discharge planning and to noise abatement for infants on respiratory support may provide a larger cohort and time period for data collection and therefore promote larger sample size.

Implications for Clinical Practice

It is important for mothers to know that their presence is recognized by the infant and cannot be underestimated no matter how ill or preterm the infant is. Given that mothers have been reported to feel a loss of primary role in the NICU, it is anticipated that the results from this study may be reassuring to mothers that their presence at the bedside provides a significant benefit to their infants. Nurses can confirm that even a passive presence is beneficial which in turn may increase the number or length of visits by the mother. Additionally it may be a very positive and empowering concept for parents to know that their presence may support the infant when he is exposed to circumstances that typically result in a loss of physiological stability such as painful interventions or new stimuli being introduced into his environment.

Although NICU staff are generally aware of noise in the NICU, these findings do reinforce the need to be vigilant about ambient sound in the NICU particularly when additional stimuli are provided. For the addition of music to have a meaningful effect for the preterm infant, the ambient environment must be sufficiently quiet for the music to be detected above ongoing sound.

Conclusion

This study provides an initial investigation into the effect of maternal presence on the premature infant's physiological and behavioral status when exposed to recorded music and ambient sound in the NICU. Although the primary purpose of the study produced a null finding, with no discernible infant response to music, the bedside presence of mothers was responsible for significantly higher oxygen saturation for infants in the experimental group. The sudden decrease in oxygen saturation and less time spent in QS when mothers departed highlights the possibility that the infant was aware of the presence of the mother, even if only at a basic sensory level. This modest finding may broaden the scope for research about infant perception of maternal presence.

Acknowledgement

Funded by a grant from The Windemere Foundation. The authors thank Denise Grocke for her contribution through the National Music Therapy Research Unit, University of Melbourne.

REFERENCES

Aagaard, H., & Hall, E. (2008). Mothers' experiences of having a preterm infant in the Neonatal Care Unit: A meta-synthesis. *Journal of Pediatric Nursing*, *23*(3), e26–e36. doi:10.1016/j.pedn.2007.02.003

Arnon, S., Shapsa, A., Forman, L., Regev, R., Bauer, S., Litmanovitz, I., & Dolfin, T. (2006). Live music is beneficial to preterm infants in the neonatal intensive care unit environment. *Birth*, *33*, 131–136.

American Academy of Pediatrics Committee on Environmental Health. (1997). Noise: A hazard for the fetus and newborn. *Pediatrics*, *100*, 724–727. doi:10.1542/peds.100.4.724

Aucott, S., Donohue, P. K., Atkins, E., & Allen, M. C. (2002). Neurodevelopmental care in the NICU. *Mental Retardation and Developmental Disabilities Research Reviews*, *8*, 298–308. doi:10.1002/mrdd.10040

Benzies, K. M., Magill-Evans, J. E., Hayden, K. A., & Ballantyne, M. (2013). Key components of early intervention programs for preterm infants and their parents: A systematic review and meta-analysis. *BMC Pregnancy and Childbirth*, *13*(Suppl 1), 1–15. doi:10.1186/1471–2393–13-S1-S10

Bo, L. K., & Callaghan, P. (2000). Soothing pain-elicited distress in Chinese neonates. *Pediatrics*, *105*, E49.

Busch-Vishniac, I. J., West, J. E., Hunter, T., Orellana, D., & Chivukula, R. (2005). Noise levels in Johns Hopkins Hospital. *Journal of the Acoustical Society of America*, *118*, 3629–3645. doi:10.1121/1.211832

Butt, M. L., & Kisilevsky, B. S. (2000). Music modulates behaviour of premature infants following heel lance. *Canadian Journal of Nursing Research*, *31*(4), 17–39.

Byers, J., Lowman, L., & Waugh, R. (2006). Sound level exposure of high-risk infants in different environmental conditions. *Neonatal Network*, *25*, 25–32. doi:10.1891/0730–0832.25.1.25

Caine, J. (1991). The effects of music on the selected stress behaviors, weight, caloric and formula intake, and length of hospital stay of premature and low birth weight neonates in a newborn intensive care unit. *Journal of Music Therapy*, *28*, 180–192. doi:10.1093/jmt/28.4.180

Cassidy, J. W. (2009). The effect of decibel level of music stimuli and gender on head circumference and physiological responses of premature infants in the NICU. *Journal of Music Therapy*, *46*, 180–190. doi:10.1093/jmt/46.3.180

Cassidy, J. W., & Ditty, K. M. (1998). Presentation of aural stimuli to newborns and premature infants: An audiological perspective. *Journal of Music Therapy*, *35*, 70–87. doi:10.1093/jmt/35.2.70

Cassidy, J., & Standley, J. M. (1995). The effect of music listening on physiological responses of premature infants in the NICU. *Journal of Music Therapy*, *32*, 208–227. doi:10.1093/jmt/32.4.208

Cevasco, A. (2008). The effect of mothers' singing on fullterm and preterm infants and maternal and emotional responses. *Journal of Music Therapy*, *45*, 273–306. doi:10.1093/jmt/45.3.273

Chesney, A. R., & Champion, P. R. (2008). Understanding the dynamics between preterm infants and their families. *Support for Learning*, *23*, 144–151. doi:10.1111/j.1467–9604.2008.00385.x.

Coleman, J. M., Pratt, R. R., Stoddard, A., Gerstmann, D. R., & Abel, H. H. (1997). The effects of the male and female singing and speaking voices on selected physiological and behavioral measures of premature infants in the intensive care unit. *International Journal of Arts Medicine*, *5*(2), 4–11.

Davis, L., Mohay, H., & Edwards, H. (2003). Mothers' involvement in caring for their premature infants: An historical overview. *Journal of Advanced Nursing*, *42*, 578–586. doi:10.1046/j.1365–2648.2003.02661.x

deRegnier, R. A. (2008). Neurophysiologic evaluation of brain function in extremely premature newborn infants. *Seminars in Perinatology*, *32*, 2–10.

Gardner, G. B., & Goldson, E. (2011). The Neonate and the environment: Impact on development. In S. Gardner, B. Carter, M. Enzam-Hines & J. Hernandez (Eds.), *Merenstein and Gardner's handbook of neonatal intensive care* (7th ed.; pp. 270–332). St. Louis, MO: Mosby.

Gardner, G. B., & Hernandez, J. A. (2011). Initial nursery care. In S. Gardner, B. Carter, M. Enzam-Hines & J. Hernandez (Eds.), *Merenstein and Gardner's handbook of neonatal intensive care* (7th ed.; pp. 78–112). St. Louis, MO: Mosby.

Gilad, E., & Arnon, S. (2010). The role of live music and singing as a stress-reducing modality in the Neonatal intensive care unit environment. *Music and Medicine*, *2*, 18–22. doi:10.1177/1943862109357070

Gray, L., & Philbin, M. K. (2004). Effects of the neonatal intensive care unit on auditory attention and distraction. *Clinics in Perinatology*, *31*, 243–260.

Grenier, I., Bigsby, R., Vergara, E., & Lester, B. (2003). Comparison of motor self-regulatory and stress behaviors of preterm infants across body positions. *American Journal of Occcupational Therapy*, *57*, 289–297. doi:10.5014/ajot.57.3.289

Holditch-Davis, D., Cox, M. F., Miles, M. S., & Belyea, M. (2003). Mother–infant interactions of medically fragile infants and non-chronically ill premature infants. *Research in Nursing & Health*, *26*, 300–311. doi:10.1002/nur.10095

Inder, T. E., Warfield, S. K., Wang, H., Huppi, P. S., & Volpe, J. (2005). Abnormal cerebral structure is present at term in premature infants. *Pediatrics*, *115*, 286–294. doi:10.1542/peds.2004–0326.

Jardri, R., Pins, D., Houfflin-Debarge, V., Chaffiotte, C., Rocourt, N., Pruvo, J. P., . . . Thomas, P. (2008). Fetal cortical activation to sound at 33 weeks of gestation: A functional MRI study. *NeuroImage*, *42*, 10–18. doi:10.1016/j.neuroimage.2008.04.247

Johnston, C. C., Filion, F., Campbell-Yeo, M., Goulet, C., Bell, L., McNaughton, K., & Byron, J. (2009). Enhanced kangaroo mother care for heel lance in preterm neonates: a crossover trial. *Journal of Perinatology*, *29*, 51–56. doi:10.1038/jp.2008.113

Johnston, C. C., Filion, F., & Nuyt, A. M. (2007). Recorded maternal voice for preterm neonates undergoing heel lance. *Advances in Neonatal Care*, *7*, 258–266. doi:10.1097/01.ANC.0000296634.26669.13

Kaminski, J., & Hall, W. (1996). The effect of soothing music on neonatal behavioral states in the hospital newborn nursery. *Neonatal Network*, *15*(1), 45–54.

Keith, D. R., Russell, K., & Weaver, B. S. (2009). The effects of music listening on inconsolable crying in premature infants. *Journal of Music Therapy*, *46*, 191–203. doi:doi.org/10.1093/jmt/46.3.191

Kellam, B., & Bhatia, J. (2008). Sound spectral analysis in the intensive care nursery: Measuring high-frequency sound. *Journal of Pediatric Nursing*, *23*, 317–323. doi:10.1016/j.pedn.2007.09.009

Konstandy, R. R., Ludington-Hoe, S. M., Cong, X., Abouelfettoh, A., Bronson, C., Stankus, A., & Jarrell, J. R. (2008). Kangaroo care (skin contact) reduces crying response to pain in preterm neonates: Pilot results. *Pain Management Nursing*, *9*(2), 55–56. doi:10.1016/j.pmn.2007.11.004

Korja, R., Ahlqvist-Björkroth, S., Savonlahti, E., Stolt, S., Haataja, L., Lapinleimu, H., . . . Liisa Lehtonen, L. (2010). Relations between maternal attachment representations and the quality of mother–infant interaction in preterm and full-term infants. *Infant Behavior & Development*, *33*, 330–336. doi:10.1016/j.infbeh.2010.03.010

Lai, H.-L., Chen, C.-J., Peng, T.-C., Chang, F.-M., Hsieh, M.-L., Huang, H.-Y., & Chang, S.-C. (2006). Randomized controlled trial of music during kangaroo care on maternal state anxiety and preterm infants' responses. *International Journal of Nursing Studies*, *43*(2), 139–146. doi:http://dx.doi.org/10.1016/j.ijnurstu.2005.04.008

Lasky, R. E., & Williams, A. L. (2009). Noise and light exposures for extremely low birth weight newborns during their stay in the neonatal intensive care unit. *Pediatrics*, *123*, 540–546. doi:10.1542/peds.2007–3418

Laws, P., Li, Z., & Sullivan, E. (2010). *Australia's mothers and babies 2008. Perinatal statistics series no. 24.* Canberra, Australia: Australian Institute of Health and Welfare.

Loewy, J., Stewart, K., Dassler, A-M., Telsey, A., & Homel, P. (2013). The effects of music therapy on vital signs, feeding, and sleep in premature infants. *Pediatrics*, *131*, 902–918. DOI: 10.1542/peds.2012–1367

Ludington-Hoe, S. M., & Hosseini, R. B. (2005). Skin-to-skin contact analgesia for preterm infant heel stick. *AACN Clinical Issues*, *16*, 373–387. doi:10.1097/00044067–200507000–00010

Melnyk, B. M., Feinstein, N. F., Alpert-Gillis, L., Fairbanks, E., Crean, H. F., Sinkin, R. A., . . . Gross, S. J. (2006). Reducing premature infants' length of stay and improving parents' mental health outcomes with the Creating Opportunities for Parent Empowerment (COPE) Neonatal Intensive Care Unit program:

A randomized, controlled trial. *Pediatrics*, *118*, e1414–e1427. doi:10.1542/peds.2005–2580

Morlet, T., Collet, L., Duclaus, R., Lapillone, A., Salle, B., & Putet, G. (1995). Spontaneous and evoked otoacoustic emissions in preterm and full-term neonates. Is there a clinical application? *International Journal of Pediatric Otorhinolaryngology*, 33, 207–211. doi:10.1016/0165–5876(95)01210–9

Nagorski Johnson, A. (2003). Adapting the neonatal intensive care environment to decrease noise. *Journal of Perinatal & Neonatal Nursing*, *17*(4), 280–290.

National Health and Medical Research Council, the Australian Research Council, & the Australian Vice-Chancellors' Committee. (2013). *National statement on ethical conduct in human research*. Retrieved from http://www.nhmrc.gov.au/_files_nhmrc/publications/attachments/e72_national_statement_131211.pdf

Neal, D. O., & Lindeke, L. L. (2008). Music as a nursing intervention for preterm infants in the NICU. *Neonatal Network*, *27*(5), 319–327.

Newnham, C. A., Milgrom, J., & Skouteris, H. (2009). Effectiveness of a modified mother–infant transaction program on outcomes for preterm infants from 3 to 24 months of age. *Infant Behavior and Development*, *32*, 17–26. doi.org/10.1016/j.infbeh.2008.09.004

Olischar, M., Shoemark, H., Trudy Holton, T., Weninger, M., & Hunt, R., W. (2011). The influence of music on aEEG activity in neurologically healthy newborns > 32 weeks' gestational age. *Acta Pædiatrica*, *100*, 670–675. doi: 10.1111/j.1651–2227.2011.02171.x

Philbin, M. K. (2000). The fullterm and preterm newborn: The influence of auditory experience on the behavior of preterm newborns. *Journal of Perinatology*, *20*, S76–S86.

Roeser, R. J. (1996). *Audiology desk reference*. New York: Thieme.

Romeo, D. M., Cioni, M., Palermo, F., Cilauro, S., & Romeo, M. G. (2013). Neurological assessment in infants discharged from a neonatal intensive care unit. *European Journal of Paediatric Neurology*, *17*, 192e–198. doi:http://dx.doi.org/10.1016/j.ejpn.2012.09.006

Sakatani, K., Chen, S., Lichty, W., Zuo, H., & Wang, Y.P. (1999). Cerebral blood oxygenation changes induced by auditory stimulation in newborn infants measured by near-infrared spectroscopy. *Early Human Development*, *5*, 229–236. doi:10.1016/S0378–3782(99)00019—5

Schaal, B., Hummel, T., & Soussignan, R. (2004). Olfaction in the fetal and premature infant: Functional status and clinical implications. *Clinics in Perinatology*, *31*, 261–285. doi:10.1016/j.clp.2004.04.003

Scher, M. S., Ludington-Hoe, S., Kaffashi, F., Johnson, M. W., Holditch-Davis, D., & Loparo, K. A. (2009). Neurophysiologic assessment of brain maturation after an 8-week trial of skin-to-skin contact on preterm infants. *Clinical Neurophysiology*, *120*, 1812–1818. doi:10.1016/j.clinph.2009.08.004

Shoemark, H. (1999). Indicators for the inclusion of music therapy in the care of infants with Bronchopulmonary Dysplasia. In T. Wigram & J. De Backer (Eds.), *Clinical applications of music therapy in developmental disability, paediatrics and neurology*. (pp. 32–46). London, UK: Jessica Kingsley.

Shoemark, H., & Dearn, T. (2008). Keeping Parents at the centre of family centred music therapy with hospitalised infants. *Australian Journal of Music Therapy*, *19*, 3–24.

Soloveychik, V., Bin-Nun, A., Lonchev, A., Sriram, S., & Meadow, W. (2009). Acute hemodynamic effects of caffeine administration in premature infants. *Journal of Perinatology*, *29*, 205–208. doi:10.1038/jp.2008.193

Standley, J. (2012). Music therapy research in the NICU: An updated meta-analysis. *Neonatal Network*, *31*(5), 311–316.

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. doi:10.1053/jpdn.2003.34

Standley, J. M. (2000). The effect of contingent music to increase nonnutritive sucking of premature infants. *Pediatric Nursing*, *26*(5), 493–499.

Standley, J. M., & Moore, R. S. (1995). Therapeutic effects of music and mother's voice on premature infants. *Pediatric Nursing*, *21*, 509–512.

Standley, J. M., & Walworth, D. (2010). *Music therapy with premature infants* (2nd ed.). Silver Spring, MD: American Music Therapy Association, Inc.

Teckenberg-Jansson, P., Huotilainen, M., Pölkki, T., Lipsanen, J., & Järvenpääf, A. L. (2011). Rapid effects of neonatal music therapy combined with kangaroo care on prematurely-born infants. *Nordic Journal of Music Therapy*, *20*(1), 22–42. doi:10.1080/08098131003768123

Thoman, E. B. (1990). Sleeping and waking states in infants: A functional perspective. *Neuroscience & Biobehavioral Reviews*, *14*, 93–107. doi:http://dx.doi.org/10.1016/S0149--7634(05)80165--4

Vanderveen, J. A., Bassler, D., Robertson, C., & Kirpalani, H. (2009). Early interventions involving parents to improve neurodevelopmental outcomes of premature infants: A meta- analysis. *Journal of Perinatology*, *29*, 343–351. doi:10.1038/jp.2008.229

Werner, L. A. (2007). Issues in human auditory development. *Journal of Communication Disorders*, *40*(4), 275–283.

Westrup, B., Kleberg, A., & Stjernquist, K. (2005). Newborn individualised developmental care and assessment program. In J. Sizun & J. Browne (Eds.), *Research on early developmental care* (pp. 75–84). Montrouge, France: Libbey.

Whipple, J. (2008). The effect of music-reinforced nonnutritive sucking on state of preterm, low birthweight infants experiencing heel prick. *Journal of Music Therapy*, *45*(3), 227–272.

Whipple, J. (2000). The effect of parent training in music and multimodal stimulation on parent-neonate interactions in the neonatal intensive care unit. *Journal of Music Therapy*, *37*, 250–268. 10.1093/jmt/37.4.250

White-Traut, R. C., Nelson, M. N., Silvestri, J. M., Patel, M., Lee, H., Cimo, S., & Reynolds, E. (2009). Maturation of the cardiac response to sound in high-risk preterm infants. *Newborn and Infant Nursing Reviews*, *9*, 193–199. doi:10.1053/j.nainr.2009.09.011

White, R. D. (2012). Recommended standards for the newborn ICU. *Journal of Perinatology*, *27*, S4–S19. doi:10.1038/sj.jp.7211837