Journal of Pediatric Nursing (2013) **xx**, xxx–xxx

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Physiologic Responses of Preterm Infants to the Male and Female Voice in the NICU

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Key words:
Preterm infant;
Vocal stimulation;
NICU

The aim of this study was to investigate the effects of postconceptional age and voice type (male and female) on heart rate, respiratory rate, and oxygen saturation of preterm infants in the neonatal intensive care unit(NICU). Nineteen preterm infants born 31 weeks of gestation heard male and female voices on a weekly basis and their physiologic responses were recorded while hearing each voices. Results revealed that infants responded to the male voice with decreased HR as they grew older. Male voices including the father's voice can be considered an auditory stimulus for young preterm infants in the NICU.

Background

PRETERM INFANTS ARE more likely to be born without experiencing sufficient intrauterine auditory sounds, including the maternal and human voice (Gerhardt & Abrams, 2000). Once born, they hear the inanimate mechanical noises produced by life-support equipment in the NICU for weeks or even months (Kent, Tan, Clarke, & Bardell, 2002). The human auditory system begins to respond to sound at 22–24 weeks gestation. An immature auditory system is more sensitive to lower frequency sounds (perceived as lower pitched) than to higher frequency sounds (perceived as higher pitched) (Lecanuet, Granier-Deferre, & Busnel, 1988). Full-term newborn infants who have had typical auditory sensitivity development during pregnancy are able to attend to the mother's voice, as evidenced by a decrease in HR and RR (Fifer & Moon, 1988). A newborn infant's early attentive behaviors such as quiet alert and self-organized behaviors to the mother's voice are known to enhance early interaction between mothers and their infants (Bozzett, 2008). However, preterm infants born with immature auditory function may be more responsive and attentive to lower pitched sounds, that is, the male voice, than to higher pitched sounds, the female voice, while in the NICU. And yet, limited studies have examined the effects of both age and sex of voices on physiologic responses in preterm infants. Therefore, the aim of this study was to investigate the effects of post-conceptional age (PCA) and voice type (male and female) on heart rate (HR), respiratory rate (RR), and oxygen saturation (SaO_2) of preterm infants in the neonatal intensive care unit (NICU).

Methods

This study used a descriptive repeated measures, quasi-experimental design. Nineteen preterm infants born prior to 31 weeks gestational age (GA) participated in the experiment, which was conducted every week until hospital discharge. Audio CDs (A and B) were created using live male and female voices reading *Good Night Moon*. Both male and female were instructed to read as if they were

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0882-5963/$ – see front matter
http://dx.doi.org/10.1016/j.pedn.2013.04.007

reading to the infant. Audio CD A began with 3 minutes of silence, then 1 minute of the male voice, followed by 3 minutes of silence; this same tripartite recording sequence was followed for the female voice (total 14 minutes). Audio CD B was recorded in the reverse order: the female voice first, followed by the male voice. To demonstrate that two voices are different in their frequency ranges, spectral analysis was performed and the intensity of sound within frequency ranges (< 1000Hz) compared, with the result that they were statistically significantly different ($p < .005$).

When the infant reached to 32 weeks PCA, he or she was moved to the quiet testing room and placed in a radiant warmer wearing shirt and diaper. The infant was given time to adjust to the headphone connected to the audio-player. The audio CD was randomly selected before the experiment. The sound levels of each voice presented via headphone set were tested before applying to the infant and measured at between 58 and 65 dB SPL due to prosodic characteristics of voices. Before the vocal stimulation started playing, the infant' sleep state was confirmed with his or her respiration and motor activity. Once the CD started playing, the Gould TA 4000 Recording System (Gould Instruments, OH) and Novametrix 515 A pulse oximiter (Novametrix, CT) started to record the infant's HR and RR simultaneously. The infant heard two voices, male and female, in each session, which occurred on a weekly basis. When the data collection session was completed, the infant was returned to the NICU incubator/open crib. Although the data were collected from 32 weeks PCA until infant hospital discharge, the data from 32 to 35 weeks PCA were used for data analysis since only a few infants were available for data collection session at 36 weeks PCA.

The physiologic data were reviewed for accuracy and missing data were examined for possible movement artifact. Individual sessions missing more than 20% of the raw data were excluded from further data analysis. The raw data sampled at a rate of 200 samples per second were averaged every second. Since 1 minute of vocal stimulation was selected for final data analysis, 60 data points was yielded per vocal stimulation. Descriptive statistics were used for demographic characteristics and generalized estimate equations (GEE) were used for examining the effect of independent variables (voice type; the order of voice presentation [male or female first]; PCA; GA; postnatal age [GA + chronological age]; and Apgar scores at 1 and 5 minutes) on HR, RR, and SaO_2 of the preterm infant.

Participants

Seven infants were male and 12 infants were female. Birth weights ranged from 645 to 1870 with a mean of 1166 g (*SD* = 345 g). The mean GA was 28.1 weeks (*SD* = 2.24 weeks) with a range of 24 to 31 weeks. Apgar scores at 1 and 5 minutes ranged from 3 to 9 and from 6 to 9, with a mean of 6.6 and 7.9, respectively.

Results

A GEE analysis revealed that PCA (p = .016), postnatal age (p = .001), the male voice (p = .000), the order of voice (p = .028), and the Apgar score at 1 minute (p = .027) were significant factors for HR of the preterm infant to vocal stimulation (Table 1). The greater PCA and the male voice decreased the infant's HR whereas a greater postnatal age and Apgar score at 1 minute significantly increased HR. A significant interaction effect of PCA with the type of voice ($p < .001$) indicated that infants responded to the male voice with decreased HR as they grew older. None of the variables caused change in the infants' RR to vocal stimulation. Any voice presented second decreased infants' SaO_2 (p = .040). A significant interaction effect between voice (male or female) and the order of voice (p = .003) indicated that the when the male voice was presented second it increased SaO_2.

Table 1 Generalized Equation Estimation Results on Physiologic Responses to Voices.

	HR			RR			SaO_2		
Variables	β	SE (β)	p	β	SE(β)	p	β	SE (β)	p
Main effects									
GA	0.4443	0.2967	.134	0.2424	0.3876	.532	0.1295	0.1432	.366
PCA	−0.8185	0.3387	.016 *	0.7982	0.5717	.163	0.1397	0.1054	.185
Postnatal age	0.1269	0.0383	.001 *	−0.0757	0.0583	.194	−0.0014	0.0112	.897
Male (1)	−31.111	6.8699	< .000 *	12.269	14.256	.389	−1.686	2.1545	.434
Second (1)	−0.8116	0.3695	.028 *	−0.1389	0.7256	.853	−0.2369	0.1154	.040 *
Apgar score 1	0.9907	0.4465	.027 *	−0.7584	0.4833	.117	−0.2236	0.2796	.424
Apgar score 5	−0.70523	0.7067	.318	0.1801	0.7764	.817	−0.0366	0.4413	.934
Interaction effects									
Voice and order	−0.1667	0.5943	.779	−1.2980	1.1261	.249	0.5522	0.1860	.003 *
PCA and voice	0.9271	0.2061	< .001 *	−0.2834	0.4278	.508	0.0323	0.0646	.617

Note: First autoregressive was used. HR: heart rate; RR: respiratory rate; SaO_2: oxygen saturation; GA: gestational age; PCA: post-conceptional age.
* < .05.

Conclusions

The present study demonstrated that preterm infants as young as 32 and 35 weeks PCA were able to respond differentially to the male voice with decreased HR, which can be interpreted as an attention (orientation) response (Barreto, Morris, Philbin, Gray, & Lasky, 2006). The results also partially support the fact that the immature hearing function of preterm infants is more responsive physiologically to the male voice. However, a greater postnatal age, indicating a longer stay in the NICU, was associated with an increase of HR in preterm infants, indicating a defense response. This result indicates that preterm infants born smaller and sicker can be vulnerable to auditory stimulation, including the human voice. Thus, before providing auditory stimulation with preterm infants, previous exposure to human speech sounds and prosodic characteristics of vocal stimulation, which were not controlled in this study, should be taken into account.

Relevance to Clinical Practice

Human vocal stimulation can be safely presented to the preterm infants in the NICU, with particular attention given to their postnatal age and Apgar score. Given that preterm infants' immature auditory systems have a relatively higher sensitivity to lower pitched voices, such as a male or father's voice, these voices can be considered an alternative choice of auditory stimuli for preterm infants in the NICU.

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