The Effect of Contingent Music to Increase Non-Nutritive Sucking of Premature Infants.

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THE EFFECT OF CONTINGENT MUSIC TO INCREASE NON-NUTRITIVE SUCKING OF PREMATURE INFANTS

This study assessed music as reinforcement for non-nutritive sucking of 12 premature infants born at an average gestation of 29.3 weeks and an average birthweight of 1111.9 g. At the time of the study, the infants' average post conception age was 35.5 weeks, and their average weight was 1747.3 g. A pacifier was fitted with a pressure transducer so that a sufficient suck activated frequency and duration signals as well as 10 seconds of recorded music consisting of lullabies sung by female vocalists. A 14-minute ABAB study design included a silence baseline for 2 minutes, 5 minutes of contingent music, 2 minutes of silence, and 5 minutes of contingent music. Frequency data were recorded for each 5-second interval in which the duration light was activated for at least 3 seconds. Results demonstrated that sucking rates during the periods of contingent music were 2.43 times greater than baseline (silence) sucking rates. In this study, music contributed significantly to the development of non-nutritive sucking of premature infants.

Little research exists to document the earliest discrimination behaviors of premature infants. In the third trimester, it is known that the human fetus is adding 250,000 neurons/minute in the developing brain (Fischer & Rose, 1994). During fetal development and at birth, these neural cells compete to link up with a specific neurological function. In fact, the most critical period for the growth of human cortex dendrites reportedly occurs between 20 weeks gestation and 2 years of age (Gardner, Garland, Merenstein, & Lubchenco, 1997). During this development, genetic endowment and environmental opportunity begin interacting. The newborn infant is, therefore, self-constructing with post-birth experiences, creating unique individualized neurological connections. It is known that term newborns begin discriminating cause/effect relationships within hours of birth (DeCasper & Fifer, 1980) and recognize auditory stimuli that was presented prenatally (DeCasper & Spence, 1986).

The premature infant loses the opportunity to continue normal neurological development in the womb. Those with health complications are subjected to painful and stressful medical procedures necessary for survival. Both the complications and the interventions are highly correlated with increased impairment in neurological development (Creasey, Jarvis, Myers, Markowitz, & Kerkering, 1993; Karmel, Gardner, & Magnano, 1991). The long-term neurological implications of premature birth are problematic, but fortunately the brain

continues to develop throughout life and some damaged neurological networks can be overcome by nurturing and carefully structured learning opportunities (Benes, 1994).

To this point, research with premature infants in the newborn intensive care unit (NICU) has primarily focused on medical procedures for survival and on nurturing techniques such as reducing environmental stimuli, non-nutritive sucking, and touch (Dieter & Emory, 1997). During medical treatment, the infant is often physically restrained by equipment. Additionally, treatments and nourishment are often scheduled with regard to health priorities, rather than with regard to the infant's desire for food or attention. The detrimental implications of lack of opportunity to experience normal post-birth cause/effect relationships at this stage of development have recently been lamented (Dieter & Emory, 1997).

The infant's sucking ability is a critical behavior for both survival and neurological development. Sucking is the first rhythmic behavior in which the infant engages, and it is theorized to contribute to neurological development by facilitating internally regulated rhythms (Goff, 1985). Time spent in non-nutritive sucking has been observed in third trimester fetuses. Unfortunately, medical and environmental constraints often inhibit non-nutritive sucking opportunities, as very premature infants are undergoing the third trimester of what would have been "fetal" development in the NICU.

When non-nutritive sucking opportunities are encouraged in the NICU, development of the premature infant is enhanced. The coordinated suck-swallow-breathe response, which develops in the 34th week of gestation, is a precursor to nutritive sucking ability and nipple feeding. Pacifiers offered during gavage at this stage of development increase the infants' daily weight gain (Field et al., 1982). Non-nutritive sucking also increases infant oxygenation (Burroughs, Asonye, Anderson-Shanklin, & Vidyasagar, 1973).

Auditory capability is one of the earliest discriminative abilities of the fetus (Cheour-Luhtanen et al., 1996). At 18 weeks gestation, increased fetal heart rate has been noted in response to loud sounds. At 25-27 weeks gestation, the majority of fetuses begin to give inconsistent responses to sound. At 29 weeks, the normally developing fetus consistently responds to auditory stimuli. At 30-35 weeks, the fetus is hearing maternal sounds, responding to these sounds, and beginning to discriminate among speech sounds, particularly with regard to pitch and rhythm (Lecanuet, Granier-Deferre, & Busnel, 1995).

Research shows that the full-term infant's response to auditory stimuli at birth is a consistent head turn, particularly to higher frequencies at a moderate decibel (dB) level with an 8-11 second latency following onset of auditory stimuli (Muir, 1985). Additionally, the term infant has processed much auditory information during prenatal development and at birth can

recognize its mother's voice, prefers women's voices, can recognize stories and melodies heard during the final trimester of fetal growth, and prefers his or her native language (DeCasper & Fifer, 1980; DeCasper & Spence, 1986; Moon, Cooper, & Fifer, 1993). Auditory exposure from birth is critical to the further development and specification of auditory abilities.

Since auditory capability and discrimination develop so early, several studies have focused on the effects of auditory stimuli on the premature infant in intensive care. Rhythmic auditory stimuli and the mother's voice have similar calming effects on preterm infants (Moore, Gladstone, & Standley, 1994) as do heartbeat sounds and white noise for term infants (Kawakami, Takai-Kawakami, Kurihara, Shimizu, & Yanaihara, 1996). Lullabies combine language information and calming, rhythmic stimuli and have been shown to have positive physiological and behavioral effects on premature infants in intensive care (Caine, 1992). Music listening increases oxygen saturation levels (Cassidy & Standley, 1995; Collins & Kuck, 1991; Standley & Moore, 1995) and shortens hospital stays for premature infants (Caine, 1992).

A recent study demonstrated that music in conjunction with progressive tactile stimulation enabled neurologically-immature, premature infants to tolerate ever increasing levels of multimodal stimulation (Standley, 1998). In this study of 40 premature infants, an interesting gender difference emerged. Female infants receiving music and multimodal stimulation were discharged an average of 11 days sooner than control female infants, while music/stimulation resulted in only an average earlier discharge of 1.5 days for male infants. Post hoc analysis of the study by Caine (1992) revealed almost identical differences in early discharge by gender as a result of music stimulation. An explanation for such differentiated response to music does not currently exist in the literature, and more research is warranted.

Music has been shown to be an effective reinforcer for teaching new behaviors to all ages of individuals from term infants to the elderly and for promoting diverse life goals within educational, home, and health settings (Standley, 1996). DeCasper and Carstens (1981) documented the earliest contingent relationship between music and sucking behavior in their study with 2-day-old term infants. Research in contingent cause/effect learning opportunities for NICU infants is sparse, however. Only one prior music study of this type has been identified. Schunk (1993) investigated the contingent effects of music on feeding behavior of premature infants. She conducted a pilot study with low-birth-weight infants to determine whether background music played contingently during feeding could enhance weight gain. Her analysis of effect for four subjects was inconclusive; however, caregivers reported positive changes in infant behavior during music. She recommended further research, particularly with regard to individual feedback for ineffective sucking rates.

The purpose of this study was to assess the contingent effects of music on premature infant behavior, specifically to determine whether pacifier activated lullaby music would reinforce non-nutritive sucking rates of premature infants who were evaluated as poor feeders by NICU personnel. Further, the study attempted to determine whether discrimination of on/off music stimuli would occur.

Methods

Participants. Participants were 12 premature infants (6 male, 6 female) born at an average gestational age of 29.3 weeks and an average weight of 1043.4 g. The average postconception age at the time of the study was 35.5 weeks, with infant weight at the time of the study averaging 1604.8 g. Individual infant demographics are shown in Table 1.

All infants were referred for participation in the study by the NICU physical therapist, a specialist trained in premature infant development, with agreement from the NICU nursing staff. Criteria for participation in the study were as follows: (a) infant showed early fatigue during nutritive sucking, (b) had achieved approximately 34 weeks postconception age, and (c) was able to tolerate two simultaneous types of stimulation (pacifier and auditory stimulation). All infants referred during the time period of the study and whose parents gave permission were included in this research.

Apparatus. The pacifier, a Minimam Newborn Orthodontic Pacifier by Ross Laboratories, #50486, was adapted so that a suck of predetermined strength activated a cassette tape recorder (Radio Shack CTR-62), via a pressure transducer, for a specified length of time. Pressure sensitivity and length of music activation could be controlled for each suck; for the purpose of this study these were set with sensitivity at minimal pressure and music duration at 10 seconds. Each appropriate suck reset the 10-second duration timer. Each suck strong enough to activate the music also activated a red light on the control box designating frequency. A second red light indicated duration of sucking bursts. It was lit upon the first suck and remained lit until 10 seconds had passed without additional sucks. This second light was used for data collection.

Design and data collection. The study utilized subjects as their own control and was designed to stay within the 15-minute maximum length of stimulation suggested by the nursing staff as appropriate for infants at this stage of development. The design of the study was ABAB across 14 minutes with a silence condition for the first 2 minutes of baseline, then 5 minutes of contingent music, followed by another 2-minute period of silence and another 5 minutes of contingent music. The reversal conditions (the second AB) were implemented to assure that any differences between the first two conditions were not accidental. Each infant had the pacifier in his or her mouth across the entire 14 minutes, with only the availability of

the music added or deleted according to condition. Sucking duration per 5second interval was collected in the same way across all conditions.

Sucking duration data were recorded by two trained observers across the 14 minutes. Each 5-second interval in which the pacifier duration light was activated for at least 3 seconds was recorded on a data sheet divided into 12 5-second blocks/minute. Reliability among independent observers averaged 96% (Reliability was calculated as agreements divided by agreements plus disagreements).

Procedure. The specially adapted pacifier was offered between 4-5 p.m. in the interval of 1 hour past the last feeding and at least 1 hour prior to the next feeding. The infant was brought to a quiet alert state while in the isolette or crib. The pacifier was carefully placed in the infant's mouth and, due to the uncoordinated sucking response, was held there with light pressure but with no further manipulation that might have activated sucking. Due to the medial fragility of these infants it was planned that participation would be discontinued if any one of the following infant distress symptoms occurred: irregular respiration or apnea, flushing or mottling of skin, tremors, startles, flayed fingers or hand in stop position, facial twitches, eye rolling or floating, whimpering, hic-coughing, spitting up, gagging, or grunting (Rauh, Nurcombe, Achenbach, & Howell, 1987). However, there were no instances of overstimulation observed during this study.

The music was a selection of commercially recorded lullabies sung by female vocalists played free field (without earphones) at 65-70 dB measured at the tape recorder placed at the feet or to the lower side of the infant. This music dB level was chosen to be slightly louder than the unit background noise found in prior research to average 55 dB during daytime quiet times (American Academy of Pediatrics, 1997).

Results

Sucking duration rates were calculated for each subject as the mean number of 5-second intervals/minute in which the duration indicator was lit. Mean sucking rates for each subject were subjected to a multivariate repeated measures analysis for experimental condition and gender. Results were significant for condition only (see Table 2). Mean rate/minute by condition and gender are given in Table 3 and reveal that the first silence condition was significant from all other conditions. No other relationships were significant.

Results for all infants are shown in Figure 1 and demonstrate that sucking rates consistently increased across time during the first contingent music interval then dropped substantially during the second baseline condition. Sucking rates were highest in the first minute of the second contingent music condition. Overall, sucking rates during music were 2.43 times as those during silence. Infants averaged a sucking rate of 15 seconds/minute during silence,

increasing to 37.7 seconds/minute during music. These data indicate that infant learning and discrimination of music on/off conditions occurred and show music to be an effective reinforcer for non-nutritive sucking for this limited time period. The final music condition shows a steady decline in sucking rate across the 5-minute interval, which may be attributed to fatigue or to the infants lulling themselves to sleep prior to the end of the trial.

Since so little research exists for premature infant behavior responses or strength of response, the sucking rate for sufficient endurance during feeding is still unknown. Therefore, the average sucking time these premature infants achieved with music reinforcement was compared to existing sucking data for term infants. Research has previously shown that the combined nutritive/nonnutritive sucking rate of newborn term infants (40 weeks gestation) across a 15-minute feeding interval is 65% (Rybski, Almli, Gisei, Powers, & Maurer, 1984). This rate is only slightly higher than the 63% rate of 37.7 seconds per minute achieved in this study by premature infants who had been referred for poor sucking responses resulting in a need for physical therapy. The music reinforcement, therefore, increased premature infant non-nutritive sucking rates to combined nutritive/non-nutritive levels of term infants. If one were establishing a developmental goal for premature infants with lack of sucking endurance, these data might provide a guideline for a 14-15 minute interval.

Graphic analysis of sucking responses by gender is shown in Figure 2 and demonstrates that males sucked the pacifier at a slightly greater rate under all conditions than did females. Females, however, were steadier and more consistent in their learning responses. During the study, it was noted that 4 of the 6 female participants continued to suck strongly for several minutes past the 14 minute time limit for data collection, while 4 of the 6 male participants ceased to suck and appeared asleep by minutes 13-14 of data collection. These gender differences are viewed with caution, however, due to the small number of subjects in each group ($n = 6$).

Discussion

Despite the poor sucking endurance of the subjects, it is interesting to note that all showed increased sucking responses to music. The infants adapted to the music being cut on and off and showed no startle responses to these events. None of the subjects were observed to exhibit signs of over-stimulation during the experimental trials, and no evidence of overstimulation was reported by the nursing staff following trials. The graphs demonstrate that sucking rates consistently increased across the music intervals. Many of the infants continued to suck for several minutes past the data collection period and several infants were observed to have sucked themselves to sleep. The intervention increased non-nutritive sucking rates with no negative side effects noted.

These data demonstrate that premature infants are capable of increasing developmental responses while in the NICU. The graphs reflect learning curves that are clear and defined. They definitively demonstrate that the preterm babies discriminated on/off music conditions.

The music pacifier clearly functioned to reinforce infants' non-nutritive sucking. 'This may have implications for therapeutic application to increase feeding skill or duration, though knowledge concerning the relationship between non-nutritive and nutritive sucking requires further research.

The results of this study demonstrate a viable intervention to "teach" prolonged sucking behavior to premature infants in the neonatal intensive care unit (NICU), but many questions about its use remain. Additional research is required to investigate how long low birthweight babies might engage in non-nutritive sucking given the opportunity and reinforcement. Delineation of the optimal sucking time for building strength and endurance while avoiding negative effects of fatigue and energy consumption at a critical time for weight gain is still required.

Prior research has shown that prolonged sucking stimulation may have long-term implications for neurological organization and learning (Goff, 1986). This study has demonstrated a viable technique for increasing non-nutritive sucking and has documented the discriminative ability of the premature infant as early as 35 weeks post-conceptional age. More research is needed in the N1CU on the developmental benefits of music, especially lullabies, which pair language with soothing, consistent sound. Premature infant learning and the benefits of music appear to be viable and critical areas for future research.

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Table 1. Participant Demographics (n = 12)

Legend for Chart:

A - Gender
B - Gestational Age at Birth
C - Birthweight (g)
D - Adjusted GA at Study
E - Weight at Study (g)

A	B	C	D	E
F	30 wks	1219.0	33.0 wks	1508.6
F	28 wks	907.0	34.2 wks	1740.2
F	33 wks	1616.0	34.3 wks	1780.4
F	31 wks	1389.0	35.0 wks	1836.4
F	31 wks	1247.0	35.0 wks	1604.8

F	24 wks	794.0	32.0 wks	1485.2
Mean:	29.5 wks	1195.3	33.9 wks	1659.3
M	31 wks	1068.6	40.2 wks	1843.0
M	27 wks	677.2	41.0 wks	1843.0
M	32 wks	1258.2	34.5 wks	1825.2
M	29 wks	879.0	40.0 wks	1933.6
M	32 wks	1361.0	34.3 wks	1723.4
M	24 wks	926.6	33.0 wks	1843.0
Mean:	29.2 wks	1028.4	37.2 wks	1835.2
Combined				
Mean of				
Both Genders:	29.3 wks	1111.9	35.5 wks	1747.2

Table 2. Multivariate Analysis with Repeated Measures

Legend for Chart:

A - Source
B - SS
C - df
D - MS
E - F

A	B	C	D	E
Between Subjects				
Gender	0.653	1	0.653	0.026
Error	249.632	10	24.963	
Within Subjects				
Condition	161.097	3	53.699	7.460(*)
Condition X Gender	6.260	3	2.087	0.290
Error	215.948	30	7.198	

(*) $p < 0.001$

Table 3. Newman-Keuls Multiple Comparison Test on Mean Sucking Rate/Minute for Each Condition

Legend for Chart:

A - Condition
B - Silence 1
C - Music 1
D - Silence 2
E - Music 2

A	B	C	D	E
Mean	3.00(*)	7.28	5.42	7.60

(*) Music 1, Silence 2, and Music 2 were significantly different from Silence 1 ($p < 0.05$) but not from each other.

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