Title:

The Effect of Music and Multimodal Stimulation on Responses of Premature Infants In Neonatal Intensive Care

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Abstract:
To assess the benefits of lullaby singing and multimodal stimulation on premature infants in neonatal intensive care, 40 infants in a Level 111 Newborn Intermediate Care Unit were divided into control (n=20) and experimental (n=20) groups by pair matching on the basis of gender, birthweight, gestational age at birth and severity of medical complications. Participants met these project criteria: (a) corrected gestational age [is greater than] 32 weeks; (b) age since birth [is greater than] 10 days; and (c) weight [is greater than] 1700 g. All participants had been referred for developmental stimulation by the medical staff. Experimental infants received reciprocal, multimodal (ATVV) stimulation paired with line singing of Brahms' Lullaby. Stimulation was provided for 15-30 minutes, one or two times per week from referral to discharge. Dependent variables were (a) days to discharge, (b) weight gain/day, and (c) experimental infants' tolerance for stimulation. Results showed that music and multimodal stimulation significantly benefited females' days to discharge and increased weight gain/day for both males and females. Both male and female infants' tolerance for stimulation showed marked and steady increase across the stimulation intervals with females' tolerance increasing more rapidly than males.

Full Text:
A variety of stimulation techniques administered to preterm infants have been shown to ameliorate some of the adverse neurologic effects of preterm birth and negative consequences of prolonged hospitalization (Britt & Myers, 1994; Gomes-Pedro et al., 1995; Harrison, 1987; Oehler, 1993). Benefits from supplemental stimulation have been noted primarily in increased weight gain and improved motor development (Burns, Cunningham, White-Traut, Silvestri, & Nelson, 1994). Continuous music stimulation, such as the use of recorded lullabies, has been particularly effective with premature infants in increasing weight gain (Chapman, 1979), reducing observed stress behaviors and length of hospitalization (Caine, 1992), and increasing oxygen saturation levels for short periods of time (Cassidy & Standley, 1995; Standley & Moore, 1995; Collins & Kuck, 1991).

Despite these benefits there is increasing concern that prolonged intensive care continues to be detrimental to the preterm infant's intellectual development. For term infants, learning and memory begin developing in the womb (Kolata, 1984). Newborn infants recognize their mother's voice within hours of birth (DeCasper & Fifer, 1980) while auditory stimuli such as lullabies played daily prior to birth have been recognized by infants at four weeks of age (Polverini-Rey, 1992). After birth, infant learning occurs in an environment of reciprocal participation in cause/effect relationships. In fact, normal infants have demonstrated the ability to discriminate a contingent stimulus two days after birth (DeCasper & Carstens, 1981). Infants who first received the same stimulus noncontingently never learned the contingent relationship between the stimulus and their behavior. Unfortunately, the preterm infant leaves the secure womb environment too soon and usually spends a prolonged period in an intensive care unit, which disrupts access to normal bonding and learning activities. Health care personnel have become concerned that stimulation in this environment is both noncontingent and nonreciprocal and thus may have lifelong implications for reduced intellectual development (Burns et al., 1994).

White-Traut and Tubeszewski (1986) reported experimental results of the Auditory, Tactile, Vestibular, Visual (ATVV) protocol for reciprocal, multimodal stimulation of premature infants. Their study used the spoken voice as an initial auditory stimulus to contact the infant and prepare for subsequent tactile, vestibular, and visual stimulation. In this study of 33 infants with gestation age at birth between 29 and 35 weeks, ATVV stimulation was given 15 minutes/day for 10 days or until discharge. Mean length of hospital stay was 34.3 and 32.3 days, respectively, for the control and experimental groups, a difference that was not statistically significant. Differences in weight gain/day (20.7 and 24.4 g/day, respectively, for control and experimental groups) were also not statistically or clinically significant.

Music therapists are specialists in developmental training and regularly participate in infant stimulation and early intervention programs after the infant's hospital discharge (Standley, 1991). Little research exists to document the use of music to promote developmental goals during the intermediate phase of neonatal care.

The purpose of this study was to test a music-enhanced procedure for stimulation and reinforcement of infants' acquisition of developmental behaviors in the areas of sensory, social, and motor skills. Specifically this study examined the following outcomes: (a) visual and aural attending, (b) social bonding, (c) differentiated vocal responses, and (d) reaching/ grasping motor behavior.

With one adaptation, the study protocol used the suggested behavioral methodology of the Burns, Cunningham, White-Traut, Silvestri, and Nelson ATVV multimodal stimulation and response sequence described in the clinical literature (Burns et al., 1994). Instead of using speech as an initial auditory stimulus to calmly contact and prepare the infant for transition to tactile, vestibular, and visual stimulation, live singing of lullabies was used as the initial and ongoing auditory stimulus. Based on prior research, it was theorized that the sound of quiet singing might reduce stress and promote homeostasis, thereby facilitating tolerance for stimulation and furthering growth and development in the infant more than does the sound of speaking to the infant (Standley & Moore, 1995).

Method

Subjects for this study were 40 infants in the Intermediate section of a Level III Newborn Intensive Care Unit (NBICU) of a large regional medical center in the southeastern United States. The Intermediate section of the New Born Intensive Care Unit serves infants who require specialized care, but who are essentially stable. Study subjects were referred by the medical staff as being ready for developmental stimulation and met the following project entry criteria: (a) adjusted gestation age [is greater than] 32 weeks; (b) age since birth [is greater than] 10 days; and (c) weight [is greater than] 1700 grams. Of these 40 infants, 20 received the experimental treatment combining music and the adapted ATVV stimulation and 20 were in a control group receiving no additional stimulation beyond that of the usual services of the unit. The two groups were pair matched on the following characteristics: (a) gender; (b) birthweight; (c) gestational age at birth estimated via Dubowitz assessment +/-2 weeks; and (d) severity of medical complications determined by diagnostic matching or equivalence (i.e., different diagnoses, each requiring surgery with approximately equal times to recovery).

The study design and sample size were subjected to a power analysis according to the methods of Cohen (1988). A prior meta-analysis (Standley, 1996) revealed an average effect size of 0.48 for music benefits in medical treatment of infants.

Cohen cites 0.50 as a "medium" effect size. Thus, for this study, a medium effect was theorized ([f.sup.2] = 0.15). Therefore, for an analysis of covariate design with [Alpha] = 0.05, u = 1, v = 35, [Lambda] = 5.55, the power was determined to be 63.125.

Participant demographics for the matched pairs are given in Table 1. There were 10 females and 10 males in each of the experimental and control groups. Group averages reveal that experimental participants weighed less at birth than did their control counterparts. The female experimental participants were 0.5 weeks younger in gestational age than the female control participants, while the male experimental participants were 0.4 weeks older than the male control participants. To determine if any pre-project significant differences existed among the participant groups, Analysis of Variance tests (ANOVAs) were performed for the matching variables of birthweight and gestational age at birth. The Analysis of Variance of birthweight by gender and group showed no significant differences for gender (F = 3.759, df = 36, 1, p [is greater than] 0.05), group (F = 0.201, df = 36,1, p [is greater than] 0.05), or gender by group (F = 0.10, df = 36,1, p [is greater than] 0.05). Similar analysis of gestational age at birth by gender and group was significant for gender (F = 4.192, df = 36,1, p [is less than] 0.05) but was not significant for group (F = 0.001, df = 36,1, p [is greater than] 0.05) or group by gender (F= 0.358, df = 36,1, p [is greater than] 0.05). Therefore, it was determined that gestational age should be used as a covariate in subsequent analyses of project results.

Table 1. Matched Participant Variables by Gender and Group

	Experimental Group	
	Male (n=10)	Female (n=10)
Gestational Age (weeks)		
Mean	30.0	31.2
Range	27.5-33.0	27.0-34.5
Birth Weight (g)		
Mean	1185.6	1361.5
Range	900-1790	856-1800
	Male (n=10)	Female (n=10)
Gestational Age (weeks)		
Mean	29.6	31.7
Range	26.0-33.0	27.0-36.0
Birth Weight (g)		
Mean	1199.9	1444.5
Range	700-1700	795-2030

The control group in this study received only the ongoing health care services and developmental stimulation usually provided in the Intermediate Care Unit. In this area, some developmental training is incorporated into the health care services. Physical and Occupational Therapists facilitate developmental gains in feeding and neurologic organization of the infant as needed. Mothers who are able are encouraged and taught to "kangaroo" (hold the infant on their chest, skin-to-skin) to foster bonding and promote growth. If the mother cannot be present to engage in bonding activities, many infants receive "cuddling" from trained volunteers. Caution of overstimulation is paramount in all of these activities to avoid eliciting hypersensitive neurologic responses leading to treatment complications and failure to thrive.

Infants in the experimental group received the same array of services as above and in addition were given the experimental treatment consisting of a sung lullaby paired with reciprocal, multimodal (ATVV) stimulation. The music was constant repetition of Brahms' Lullaby, hummed softly and steadily without words, to reduce variability in the auditory stimulus. This stimulation was provided for 15-30 minutes, one or two times per week from the time of referral by the nursing staff to the time of discharge. (Table 2 shows actual number of days of stimulation/participant.) To qualify for inclusion in the study, experimental infants must have received the music/adapted ATVV stimulation for a minimum of 3 days, usually occurring across 2-3 weeks.

Table 2. Experimental (Music) Group: Days of Stimulation Received Prior to Discharge, by Gender

	Experimental Participants	
	Males (n = 10)	Females (n = 10)
Days of Stimulation		
3	5	9
4	0	0
5	0	0
6	5	1

The music/adapted ATVV stimulation (see Table 3) was given according to the following sequence. First, infants were held in cuddling position then given 30 seconds of humming without other stimulation. If the infant displayed no distress responses, the lullaby was continued while rocking, then tactile stimulation and eye contact were sequentially added. Throughout the cuddling period identification of physiologic distress responses resulted in the termination of all stimulation while observation of disengagement cues resulted in a 15 second pause, then continuation of the stimulation. Tolerance for stimulation resulted in continued presentation of multimodal stimulation progressing according to the specified sequence. Overt responses of infant pleasure and contact such as snuggling, cooing, prolonged eye contact, and finger grasping were reinforced by sustained eye contact or singing the infant's name to the lullaby melody. Stimulation was not given on any day the infant's nurse in the Intermediate NBICU determined that it was contraindicated due to other health care considerations.

Table 3. Auditory/Tactile/Visual/Vestibular Stimulation Sequence

1. Auditory only - 30 seconds (begin with quiet singing of lullaby)

2. Maintain lullaby and add rocking for 30 seconds

3. Maintain lullaby and rocking. Begin tactile stimulation (stroking, then light massage) in the following order:

Scalp - linear Back - linear Back - circular Throat - linear Arms - linear or circular Linea alba - linear Legs - linear or circular Cheeks - linear Forehead - linear Nose to ears - linear

4. Maintain lullaby and rocking and repeat tactile steps with engagement cues for eye contact and hand to hand contact. Note any of the following infant responses and reinforce by smiling and calling infant's name:

Head orientation Smiling Eye contact Vocalization Snuggling

NOTE ADVERSE PHYSIOLOGIC CHANGES:

1. Oxygen saturation drops below 86%

2. Heartrate [is less than] 100, [is greater than] 200. or [is greater than] 20% over baseline

3. Respiratory rate [is greater than] 20 over baseline

4. Observed Apnea/bradycardia Response: If any one of the above occurs, pause 15 seconds. Then if HR/RR is within normal limits, continue. If not, stop and consult nurse and discontinue all stimulation for the day.

NOTE DISENGAGEMENT CUES:

1. Subtle disengagement cues: hiccoughs, grimace, clinched eyes, eyes averted, tongue protrusion, finger splay, struggling movement Response: Soften auditory stimulation and, if needed, pause 15 seconds. If cue abates, continue stimulation at beginning of sequence. If cue does not abate, discontinue stimulation for the day.

2. Potent disengagement cues: crying, whining, fussing, cry face, spitting/vomiting, hand in halt position Response: Offer containment and, if needed, pause 15 seconds. If cue abates, continue stimulation at beginning of sequence. If cue does not abate, discontinue stimulation for the day.

Note: Editorial permission was given to publish a revised form of Table 1, p. 583, of Burns, K., Cunningham, N., White-Traut, R., Silvestri, J., & Nelson, M. (1994). Infant stimulation: Modification of an intervention based on physiologic and behavioral cues. Journal of Obstetric, Gynecologic, and Neonatal Nursing, 23(7), 581-589.

The dependent variables were (a) days to discharge, (b) weight gain/day, and (c) experimental infants' tolerance for stimulation. Days to discharge were calculated between the date of birth and date of discharge from the hospital. Weight gain per day was calculated by subtracting birthweight from discharge weight and dividing by the number of days in the hospital. The dependent variables of days to discharge and weight gain/day were chosen for comparison of effect with prior reports of similar methods of neonatal stimulation (Burns et al., 1994; Caine, 1992; Harrison, 1987; Standley & Moore, 1992; White-Traut & Tubeszewski, 1986).

For the infants receiving music/multimodal stimulation, tolerance for stimulation was assessed on ATVV items and a method of quantification developed. The ATVV scores ranged from 1-42 with points determined as follows. First, tolerance for stimulation was scored. One point was given for tolerated stimulation to each of the 11 body sites within 15 minutes. Tolerance across 2 entire sequences of stimulation in 30 minutes could result in a total of 22 points in this first section. Second, pleasure responses were scored. One point was given for intermittent infant responses of pleasure and two points given for constant infant responses of pleasure on each of the 5 items in 15 minutes for a maximum of 20 points for consistent infant responses across 30 minutes.

The 12 music/ATVV stimulators were Music Therapy faculty and qualified, trained students from a major southeastern university Music Therapy degree granting program. Training for stimulators was conducted by Music Therapy faculty and the Director of Nursing for the NBICU until criteria were met for stimulation techniques and reliability of observation/evaluation/recording of tolerance data. Table 4 shows the list of general training issues, procedural requirements, and criteria for the Music Therapy volunteers interacting with infants in the NBICU.

Table 4. Required Training for Music Therapy Developmental Stimulation

QUALIFICATIONS

Music Therapy Stimulation staff were faculty and graduate students or advanced senior MT majors.

All trainees also:

* signed confidentiality and liability statements as required by the risk management division of the hospital,

* acquired professional practice liability insurance, and

* completed all training requirements.

GENERAL TRAINING ISSUES

Nursery protocol

Professional confidentiality regarding infants and families

Nonjudgmental acceptance of infants' status and parent/staff decisions

Health issues, including instruction to not come to the nursery if exhibiting any of the following symptoms: cold, runny nose, diarrhea, fever, or fever blister, exposure to chicken pox

Scrubbing and glove requirements for diapering or stimulating infants as indicated by the medical staff

Permitted interactions: diapering, holding and rocking infants, offering a pacifier vs. nonpermitted interactions: feeding

Requirements: to be accompanied by a Music Therapy faculty member on all occasions and the need for nursing approval to work with individual infants

STIMULATION/DATA COLLECTION ISSUES

Music/stimulation techniques

Recognition of warning signs of infant distress and appropriate response. with 100% accuracy

Assessment of infant responses (95% accuracy during training with video tapes followed by instruction with infants)

Results

Results of the analysis of covariance (ANCOVA) for days in hospital are shown in Table 5. There was a significant interaction of condition by gender. This interaction is graphed in Figure 1 and shows beneficial effects of music/adapted ATVV stimulation for females but not for males. Results of the analysis of covariance for weight gain/day are shown in Table 6. The experimental participants gained significantly more weight/day than the control participants. No other comparisons were significant.

[Figure 1 ILLUSTRATION OMITTED]

Table 5. Analysis of Covariance of Days in Hospital with Gestational Age at Birth as Covariate

SOURCE OF VARIANCE	SS	DF	MS	F
Group	472.754	1	472.754	3.136
Gender	375.282	1	375.282	2.489
Group X Gender	722.172	1	722.172	4.790(*)
Gestation al Age	11214.058	1	11214.058	74.379(*)
Error	5276.942	35	150.770	

(*)p < 0.05

Table 6. Analysis of Covariance of Weight Gain/Day with Gestational Age at Birth as Covariate

SOURCE OF VARIANCE	SS	df	MS	F
Gender	24.724	1	24.724	1.11
Group	152.806	1	152.806	6.833(*)
Gender X Group	23.570	1	23.570	1.054
Gestational Age	12.636	1	12.636	0.565
Error	782.719	35	22.363	

(*) p < 0.05

Table 7 shows means by group and gender for days in hospital and weight gain/day. Female experimental participants left the hospital an average of 11.9 days earlier than the control females. The stimulation had little noticeable effect upon experimental male infants who left the hospital only 1.5 days earlier than their matched counterparts. Both male and female experimental infants gained significantly more weight/day than their matched counterparts.

Table 7. Mean Results by Group and Gender

	Male (n = 10)	Female (n = 10)
Days in Hospital	55.4	32.3
Weight Gain/Day(g)	18.2	17.8
	Male (n = 10)	Female (n = 10)
Days in Hospital	56.9	44.2
Weight Gain/Day(g)	16.0	12.3

Infant tolerance to stimulation is shown in Figure 2. All 20 experimental infants in the study are included in data for the first 3 days. Female infants were able to tolerate slightly greater amounts of stimulation initially and showed greater gains across days. After 3 days of stimulation, all of the female infants but one were discharged and she was discharged after 5 days of stimulation. Male infants showed steady, but slower, progress. After 6 days of stimulation, a total of only 5 male infants had been discharged. The graph shows a delayed, but increasing rate of tolerance for those male and female infants who required a longer hospital stay and received up to 6 days of music/adapted ATVV stimulation. No negative consequences of project participation were noted in the data collected or in reports of nursing personnel during this study.

[Figure 2 ILLUSTRATION OMITTED]

Discussion

The findings regarding length of hospitalization demonstrate highly differentiated response by gender, a finding previously unreported in the literature for neonatal intensive care unit developmental intervention. It is interesting to compare these data with a previous music study with premature infants that evaluated days to discharge. Caine (1992) played recorded lullabies in 26 infants' isolettes from placement in the isolette to discharge and compared days to discharge for these subjects and a group of 26 control infants (Caine, 1992). In her study, experimental infants were discharged an average of 5 days sooner than control infants. She did not report data by gender. Subsequent analysis of her original data demonstrated that this differential was primarily due to gains among the female infants who left an average of 11 days sooner than control infants, in Caine's study less than half of the males in the experimental group were discharged in a shorter time period than were the males in the control group while 80% of the females in the experimental group were discharged in a shorter time period than were the control female infants.

Both this study and the Caine study (1992) showed strong, positive effects of music stimulation for female infants only. A meta-analysis of music's impact in medical treatment for all age ranges did demonstrate a greater female response (mean effect size = 0.90) than male response (mean effect size=.57) to music (Standley, 1996). It seems apparent that gender affects responses to music during medical treatment, perhaps even from the earliest stages of premature birth. More research on gender differences in response to music in medical treatment and causes for these differences is definitely warranted.

In comparison to the nonsignificant results of the White-Traut and

Tubeszewski (1986) study that used an introductory spoken cue to the infant as the auditory stimulus, this procedure using continuous, quiet, live singing (humming) showed that experimental infants could sustain stimulation for longer periods of time/interaction than could control infants; that experimental infants had benefits in weight gain/day and that female experimental infants achieved an earlier discharge from the hospital.

The medical costs related to premature birth are high with the cost of initial hospitalization being the greatest expenditure (Lewit, Baker, Corman, & Shiono, 1995). Programs that shorten hospitalization and additionally increase developmental skills during hospitalization would be desirable developmental training interventions with benefits in relation to both cost and human growth.

At the current time, most low birthweight infants receive special developmental training only after discharge from the hospital and many will have disabilities requiring such services through adolescence. Professional music therapy programs have been an integral and important aspect of early intervention and special education services to these children for over 10 years and have demonstrated excellent success (Standley 6, Hughes, 1996). Research in music therapy procedures implemented during neonatal intensive care is just beginning to show earlier benefits are possible (Cassidy & Standley, 1995; Standley & Moore, 1995). Music seems to have unique benefits for development of premature infants, especially with regard to enhancing homeostasis. Overstimulation of premature infants is a serious concern and music has the ability to assist the baby in making the transition from passive recipient to involved participant in learning experiences. This study has demonstrated that music/adapted ATVV stimulation can be particularly effective in this capacity and may be indicated for premature infants in intensive care, especially female infants.

In NBICU health care services, the music/adapted ATVV protocol might be used regularly by parents, cuddlers, and nurses from around 30-32 weeks gestation to discharge. This study shows that live singing (humming) demonstrates immediate developmental gains. It may also have long-term implication for the infant's future ability to learn by introducing sustained cause/effect relationships early in the infant's development. Further, the systematic, reciprocal approach to the infant interaction teaches response sensitivity and appropriate stimulation patterns to caregivers and parents. Singing of lullabies is inherent to all cultures and would seem to have direct application to soothing distressed infants in health care.

How could music have such an immediate impact on infant development as demonstrated in this study and other prior research? Medical researchers have been concerned about high stress and subsequent cortisol levels during hospitalization adversely affecting neurologic development of premature infants. Prior research has shown that music reduces release of the stress hormone, cortisol, during invasive procedures with adults and children (Standley, 1996). Perhaps music reduces cortisol levels in premature infants as it does in more mature individuals and thus prevents adverse neurologic effects.

Why do female infants benefit more from music than do male infants? Though this study and that of Caine (1992) show that the response to music in medical treatment is differentiated by gender, no specific causes have been identified. Neurologic research is beginning to find more and more indications that female brains are quite different from male brains in physiology, cognitive and language ability, and in response to hormonal variations. It may be that the ability to process music or hormonally respond to music is also gender specific. More research in these areas is definitely warranted.

Further research into neurologic development by gestational age and gender and subsequent physiologic and behavioral responses to the specific auditory stimulus of music are greatly needed. The implications of music's benefits to premature infants at gestational ages from 28 weeks when hearing develops to 40 weeks (term development), have yet to be fully documented.

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