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Relationships Among Music Listening, Temperament, and Cognitive Abilities of Four-Year-Old Children

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Abstract

The purpose of the study was twofold: (a) to investigate electrophysiological (EEG) responses in children while listening to two contrasting styles of music, and (b) to investigate the relationship between listening to recorded music and the cognitive abilities of four-year-old children. EEG data were collected on a baseline condition of eyes open. These data were then compared to EEG data produced when children listened to selections of music by Bach, while they listened to selections of rock music, and while they performed a standardized cognitive test of visual closure. Behavioral data were also collected on sex, age, home environment, and temperament. Results indicated children's EEG data were not significantly different for the two styles of music, a finding which suggests that young children may be more accepting of different musical styles. However, children scoring high on the visual closure test could be predicted by Beta band electrical brain activity at site F3 (F3 is in the left hemisphere associated with reward, attention, long-term memory, planning, and drive) and by Alpha band electrical brain activity at site O2 (O2 is in right hemisphere occipital lobe associated with visual processing). Discriminant analysis indicated that electrical brain activity at those two sites correctly classified 90% of the cases of children scoring high on the visual closure test. Neither sex nor the home environment measure yielded significant differences. Children scoring high on the visual closure test were shown by a temperament measure to be more outgoing in new situations than low scoring children. Their temperament probably interacted with music and social climate of the classroom.

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Background

In early childhood, it is common practice for children to listen to music. Controversy exists about interpretation of research related to music listening and the extent to which the research base should influence early childhood teachers, parents' decisions, and government practice about what music is good for children (Flohr, Miller, & Persellin, 2000; Flohr & Trevarthen, 2008; Flohr & Trollinger, 2010; Persellin, 2007, 2009; Sims, 2006). Recent neuroscience and child development research has shed light on the value of music listening in a young child's life (Flohr, 2010).

In addition to a long history of common practice, there are at least three research strands that support music listening and music listening activities for young children: (a) Recent advances in neuroscience have yielded a better view of the human brain and given preliminary support and specificity to the idea that music has a positive effect on brain function (Flohr & Hodges, 2006); (b) Infant studies have shown several positive effects of music listening including less time in a warmer or isolette, less total time in intensive care, less weight loss, more nonstress behaviors, fewer high arousal states, and positive effects on oxygen saturation levels, heart rate, and respiration (Standley, 2002, 2003); and (c) Young children can discern the main components of music and speech and are also very adept at hearing, responding, and choosing music (Flohr, 2004; Flohr, Atkins, Bower, & Aldridge, 2000).

Purpose

There are remaining questions, however, about how listening to music and music listening activities influence development in early childhood. The purpose of the study was twofold: (a) to investigate electrophysiological (EEG) responses in children while listening to two contrasting styles of music, and (b) to investigate the relationship between listening to recorded music and the cognitive abilities of four-year-old children. Research questions were:

1. What differences exist in EEG activation when listening to different styles of music?
2. Is there a relationship between EEG activations while listening to music and while engaging in a cognitive activity?

Method

Participants

Parents of children in three preschools were given informed consent documents describing the research study in either English and/or Spanish. A total of 57 preschool children from the three preschools were enlisted into the study. One school was a United Way funded, predominately non-English speaking school designed for at-risk children (n = 21). The second school was a university campus preschool of student, faculty, staff, and community children (n = 22). The third school was a preschool housed in a church (n = 14). The final sample of useable data was comprised of 22 girls and 35 boys, with a mean age of 4.8 years.

Instrumentation

Electrophysiological data (EEG) were collected using a 19-site protocol. EEG data conditions (what children were doing during EEG collection) were (a) a baseline condition of eyes open, (b) listening to a selection of an excerpt of Bach's Brandenburg Concerto No. 2 in F major, BWV 1047 (Andante) (Smart Symphonies, 1999), (c) listening to a rock n' roll excerpt of the band Aerosmith's "Ragdoll," (Tyler, Perry, Vallance, & Knight, 1987), and (d) performing a standardized cognitive test, the Visual Closure test (Woodcock & Johnson, 1990). The Visual Closure test was presented to each individual child on an easel approximately 20" in front of the child's head. The test required the child to identify an object from an incomplete or masked visual representation--essentially a visual closure task. The Visual Closure score that was obtained for each participant was a standard score with a mean of 100 and a standard deviation of 15.

Additional behavior data were collected on sex, age, and home music environment using the HOMES measure (Brand, 1986), as well as temperament data which were collected using the Child Temperament Evaluation measure adapted by Atkins from the work of Thomas and Chess (1977). The Home Musical Environment Scale (HOMES) is a 15-item, parent self-reporting measure to assess home musical environment. It includes questions about parental musical involvement with the child, the parental attitude toward music, and other aspects of the child's home musical environment. The Child Temperament Evaluation form includes questions on activity level, adaptability, regularity, approach/withdrawal, physical sensitivity, intensity of reaction, mood, distractibility, and persistence. Classroom teachers were asked to score each child on a scale of 1-5 for each question. All forms and directions for parents and children were presented in English or Spanish.

Results

Data analyses

Subjects were divided into 2 groups. A high score group (n = 22) obtained the highest standardized scores on the Visual Closure test (99 and above, mean = 113.68). A low score group (n = 21) obtained the lowest standardized scores on the Visual Closure test (0-98, mean = 85.19).

Temperament analysis- There were significant differences between high and low scoring groups on two temperament questions. The questions were (a) *Approach/Withdrawal*-How does the child usually react the first time to new people, new foods, new toys, and new activities? (Mann-Whitney two-tailed statistic = .025) and (b) *Intensity of Reaction*-How strong or violent are the child's reactions? Does the child laugh and cry energetically, or does he or she just smile or fuss mildly? (Mann-Whitney two tailed statistic = .028). High scoring children were more outgoing in new situations and more intense in reaction than low scoring children.

Sex- Analysis of sex using the chi square statistic yielded no significant differences.

Home music environment- The mean of higher scoring children indicated that those children lived in an environment with more music activities, but the difference was not significant (mean 4.124 vs. 3.733 for low scoring children).

EEG analysis- EEG data analysis techniques employed were similar to those used by other brain researchers using advanced statistical procedures in order to reduce large amounts of EEG data in their research studies (Chabot & Serfontien, 1996; Thatcher, et al., 2001). For example, in the present study there were over 300 sites and bandwidths to analyze. A repeated measure analysis would lead to spurious data findings (Type 1 error). Consequently, data were analyzed by independent t-tests (groups were high vs. low scorers) for site and condition on the absolute power of brain electrical activity. The four conditions were eyes open, music listening Bach, music listening rock n' roll, and Visual Closure Test. Absolute power refers to electrical voltage found within a given frequency range at a particular site. Frequently reported frequency components of EEG are Delta, Theta, Alpha, and Beta waves (Flohr & Hodges, 2006). Typically, when the brain is in a relaxed or resting state, dominant frequencies are within the slower Alpha and Theta bands. When presented with a cognitive task or directed thinking, brain activity produces dominant frequencies within the Beta and Gamma wave band (Gevins, et al., 1979). There is an indication that brain activity is related to low, moderate, and high workload; the activity increased with difficulty (Murata, 2005). When presented with a cognitive task, activity is shifted to faster frequencies of the brain. It should be noted that the EEG process captures surface cortical activity, such as that used in a cognitive task. PET or fMRI types of brain imaging measure brain activity, such as emotion or rhythm, in the lower brain stem and subcortical and midbrain amygdala or hippocampal regions. In addition, EEG has been positively correlated with PET data thereby demonstrating that the techniques of PET and EEG measure similar brain activities (Nakamura, Sadato, Oohashi, Hishina, Fuwamoto, & Yonekura, 1999). Significant t-test results were found at 10 sites. Beta frequencies were split into two separate categories for closer examination of Beta frequency activity (Beta1 = 12.25 – 20.0 Hz, and Beta2 = 20.25 – 28.0 Hz). Power statistics for the 10 sites that proved significant ranged between .539 and .845 (mean= .691). T-test significance for some sites would be expected according to chance and the number of t-tests conducted. Further analysis was needed in order to determine the extent to which any of the t-test significant sites could be related to high or low scoring group. Therefore, the second step of the analysis was to load significant site/condition combinations into a factor analysis to further reduce the data set (see Table 1).

Table 1. Factor Analysis Component Matrix

	Components-three extracted		
	1	2	3
BETA2BF3	.939	.119	-.022
BETA2RF3	.889	.078	.067
BETA2BF4	.762	-.237	.429
BETA2EF4	.689	-.446	.342
BETA1ET3	.710	.347	-.478
BETA2ET3	.666	.297	-.611
DELTART4	.532	-.178	.366
BETA2ET5	.783	-.101	-.057
ALPHABO2	-.088	.808	.484
ALPHVCO2	.124	.861	.310

Extraction Method: Principal Component Analysis.

The site T4 for Delta frequency while listening to rock music did not have significant loading on any of three components and was deleted from the data set. Subsequently, the remaining sites were loaded into a discriminant analysis (see Table 2).

Table 2. Discriminant Analysis Variables Entered

		Wilks' Lambda	df1	df2	df3	Statistic Exact F			

		Statistic							
Step							Df1	df2	Sig.
1	BETA2BF3	.873	1	1	32.000	4.657	1	32.000	.039
2	ALPHVC2	.751	2	1	32.000	5.140	2	31.000	.012

EEG Findings

1. Styles of music (Bach and Rock) were highly correlated at Beta2-F3 (the site in the left hemisphere associated with reward, attention, long-term memory, planning, and drive). Rock data were deleted in the final discriminant function because Bach and Rock data contained similar information and the Bach music was more highly correlated than rock music (0.939 vs. 0.889). That is, if Bach data were not present, the rock music would still be significantly correlated. Testing assumptions necessary to obtain a valid discriminant function, Box's M statistic yielded a non-significant *p* value of 0.062.

2. Final discriminant function included Bach Beta2 at F3 and VC Alpha at O2 (the site in the right hemisphere occipital lobe associated with visual processing). Brain electrical activity at these two sites correctly classified 90% of high scores, 61% of low scores (an average 76% of all scores). The statistical tests do not support causality. However, data support the idea that listening to music and higher scores on the Visual Closure test may be related. During the Visual Closure test and listening to Bach, the high scoring group of children exhibited less Beta activity in the frontal F3 site. During the Visual Closure testing condition, the high scoring group exhibited more Alpha activity in the O2 (right, rear area of the brain).

Discussion

Temperament and home music environment data from the study support the idea that the social environment of learning is important to consider in instructional models (Bronfenbrenner, 1995; Vygotsky, 1962). There were significant differences between high and low scoring groups on two temperament questions. High scoring children were more outgoing in new situations and more intense in their reactions to new situations than low scoring children. Teaching and learning are influenced by social conditions. Interaction of temperament with the classroom social climate and music may be responsible for some differences in test scores.

Data from the present study support prior music early childhood listening research. Children's EEG data were not significantly different for the two styles of music (Bach and rock). A non-significant difference was also found in a study using two different styles of music (Vivaldi and an Irish folk song) with four and five-year-old children (Flohr & Miller, 1995). An interesting result in both studies was that groups of four and five-year-old children's brain wave activity were not significantly different for certain contrasting styles of music. Early childhood listening research demonstrates how children are individualistic in their responses to listening to music experiences (Sims, 2005, 2006). EEG data demonstrated that membership in the high scoring group on the Visual Closure test could be predicted by Beta 2 band electrical brain activity at site F3 and by Alpha band electrical brain activity at site O2.

Implications for music education and future research are: (a) Four and five-year-old children's brain wave activity was not significantly different for certain contrasting styles of music suggesting that young children may be more accepting of different musical styles. Young children are usually not acclimated or acculturated to specific musical styles; (b) Music listening and visual cognitive tasks are related. Lower Beta wave activity in the frontal F3 site by high scoring children during music listening and visual closure testing indicated that higher scoring children may approach the two tasks in a similar way; (c) Children who scored high on the visual closure test were shown by a temperament measure to be more outgoing in new situations than low scoring children. Their temperament probably interacts with music and the social climate of their home and or classroom; and (d) Data support the theory of modularity in brain function as listening to music had an influence on electrical activity in more than one area of the brain. More research is needed to determine the relationships among music, listening, and cognitive tasks in young children.

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References

Brand, M. (1986). Relationship between home musical environment and selected musical attributes of second grade children. *Journal of Research in Music Education, 34*(2), 110-120.

Bronfenbrenner, U. (1995). The bioecological model from a life course perspective: Reflections of a participant observer. In P. Moen, E. G.H. Jr & K. Luscher (Eds.), *Examining lives in context* (pp. 599-618). Washington, D.C.: American Psychological Association.

Chabot, R. J., & Serfontein, G. (1996). Quantitative electroencephalographic profiles of children with attention deficit disorder. *Biological Psychiatry, 40*(10), 951-963.

Flohr, J. W. (2004). *Musical lives of young children*. Upper Saddle River, NJ: Prentice Hall.

Flohr, J. W. (2010). Best practices for young children's music education: Guidance from brain research. *General Music Today, 23*(2), 13-19.

Flohr, J. W., & Hodges, D. (2006). Music and neuroscience. In R. Colwell (Ed.), *MENC handbook of musical cognition and development* (pp. 3-39). New York: Oxford University Press.

Flohr, J. W., & Miller, D. C. (1995). *Developmental quantitative EEG differences during psychomotor response to music*. Paper presented at the Texas Music Educators Convention, San Antonio, Texas: ERIC Document PS025653.

Flohr, J. W., & Trevarthen, C. (2008). Music learning in childhood–Early developments of a musical brain and body. In W. Gruhn, & F. Rauscher (Eds.), *Neurosciences in music pedagogy* (pp. 53-99). Hauppage, New York: Nova Science Publishers.

Flohr, J. W., & Trollinger, V. (2010). *Music in elementary education*. Upper Saddle River, NJ: Prentice Hall.

Flohr, J. W., Atkins, D., Bower, T. G. R., & Aldridge, M. (2000). Infant music preferences: Implications for child development and music. *Music Education Research Reports: Texas Music Educators Association.*

Flohr, J. W., Miller, D. C., & Persellin, D. C. (2000). Recent brain research on young children. *Music makes the difference: Music, brain development, and learning* (pp. 37-43). Reston, VA:

Gevins, A.S., A. S., Zeitlin, G. M., Doyle, J. C., Yingling, C. D., Schaffer, R. E., Callaway, E., & Yeager, C. L. (1979). Electroencephalogram correlates of higher cortical functions. *Science, 203*(4381), 665-668.

Murata, A. (2005). An attempt to evaluate mental workload using wavelet transform of EEG. *Human Factors: The Journal of the Human Factors and Ergonomics Society, 47*(3), 498-508.

Nakamura, S., Sadato, N., Oohashi, T., Hishina, E., Fuwamoto, Y., & Yonekura, Y. (1999). Analysis of music-brain interaction with simultaneous measurement of regional cerebral blood flow and electroencephalogram beta rhythm in human subjects. *Neuroscience Letters, 275*, 222-226.

Smart symphonies. NARAS (Director). (1999). [CD] Santa Monica, CA: National Academy of Recording Arts and Sciences Foundation, Inc.

Persellin, D. (2007). Policies, practices, and promises: Challenges in early childhood music education in the United States. *Arts Education Policy Review, 109*(2), 54-64.
Persellin, D. (2009). Brain-based education in music: A new science or science fiction? *Orff Echo, 41*(3), 22-26.
Sims, W. L. (2005). Effects of free versus directed listening on duration of individual music listening by prekindergarten children. *Journal of Research in Music Education, 53*(1), 78-86.
Sims, W. L. (2006). Listening to learn–learning to listen. *Early Childhood Music and Movement Association Perspectives, 1*(2), 4-5.
Standley, J. (2002). A meta-analysis of the efficacy of music therapy for premature infants. *Journal of Pediatric Nursing, 17*(2), 107-113.
Standley, J. M. (2003). The effect of music-reinforced nonnutritive sucking on feeding rate of premature infants. *Journal of Pediatric Nursing, 8*(3), 169-173.
Thatcher, R. W., North, D. M., Curtin, R. T., Walker, R. A., Biver, C. J., Gomez, J. F., & Salazar, A. M. (2001). An EEG severity index of traumatic brain injury. *Journal of Clinical Neuropsychiatry, 13*(1), 77-87.
Thomas, A., & Chess, S. (1977). *Temperament and development*. New York: Bruner/Mazel.
Tyler, S., Perry, J., Vallance, J., & Knight, H. (1987). [Permanent Vacation]. Santa Monica, CA: Geffen Records.
Vygotsky, L. S. (1962). *Thought and language*. Cambridge, MA: MIT Press.
Woodcock, R. W., & Johnson, M. B. (1990). *Woodcock-Johnson psychoeducational battery - revised*. Circle Pines, MN: American Guidance Service.

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