RIME Research and Issues in Music Education

Contact Us

Volume 1, No. 1 September 2003

EFFECTS OF SEQUENCED KODÁLY LITERACY-BASED MUSIC INSTRUCTION ON THE SPATIAL REASONING SKILLS OF KINDERGARTEN STUDENTS

Marlene Hanson
Glacier Gateway Elementary School
Columbia Falls, Montana

music12@sd6.k12.mt.us

INTRODUCTION

Researchers' continued fascination with the effects of music training on the neural connections in the brain or its transfer effects, particularly in the area of spatial abilities, reflects the importance of such abilities since those skills are a foundation for geometry and calculus, tactical planning, engineering, architecture, and design. As a result, a substantial amount of research has been devoted to whether or not active music instruction enhances spatial skills (Costa-Giomi, 1999; Flohr, Miller & Persellin, 1998; Graziano, Peterson & Shaw, 1999; Mallory & Philbrick, 1995; Rauscher, Shaw, Levine, Wright, Dennis & Newcomb, 1997; Rauscher & Zupan, 2000). In the meta-analyses, *Learning to Make Music Enhances Spatial Reasoning,* Hetland (2000), project manager for Project Zero, discovered that active music instruction might enhance spatial tasks requiring spatial recognition, spatial memory, mental rotation, or spatial visualization. Music instruction seemed to specifically enhance spatial-temporal performance (the transformation of mental images in the absence of a physical model) of preschool and elementary children with a moderate effect (r = .37) (Hetland, 2000). The speculation that active music instruction (that incorporates standard notation) enhances a range of spatial abilities prompted the rationale for this study in order to examine the effects of Kodály music instruction on spatial skills, including spatial-temporal.

REVIEW OF LITERATURE

Spatial Processes

Psychologists hold various perspectives regarding the identification and classification of specific spatial abilities and the characterization of the processes used to solve spatial tasks. Spatial ability is not single dimensional, but a multi-faceted construct that includes spatial perception, spatial memory, spatial attention, spatial mental operations, and spatial construction (Kritchevsky, 1988). Linn and Petersen (1985) distinguish among three dimensions of spatial ability: spatial perception (the ability to determine spatial relationships with respect to the orientation of one's body), mental rotation (the ability to mentally turn a two- or three-dimensional figure in space), and spatial visualization (the ability to perform multi-step manipulations of figural information). Rauscher and Shaw (1998) proposed another distinction when they contended that spatial-temporal tasks require the ability to transform mental images in the absence of a physical model.

"Neural Connections" and "Near Transfer" Theories

Two kinds of theories have been proposed regarding the reason for music instruction's enhancement of spatial tasks: "neural connections" theories and "near transfer" theories. The "neural connections" theory, proposed by Shaw and his colleagues, Scheibel, Roney, Patera, Silverman, and Pearson, (Shaw, 2000), termed the "trion" theory, suggests that musical and spatial abilities share the same processing regions in the brain. Shaw and his fellow researcher, Leng, speculate that any higher level brain function must make use of many of the same cortical areas and that musical and spatial abilities are linked due to neurological connections in the cortex (Leng & Shaw, 1991). Specifically, these researchers contend that musical abilities are related to "spatial-temporal" abilities, distinguished as processes that require mental manipulation of two- or three-dimensional objects in the absence of physical models (Rauscher & Shaw, 1998), and that early music experiences serve as exercise for higher brain functions such as spatial-temporal reasoning (Leng & Shaw, 1991). Leng and Shaw (1991) proposed that music may be a 'pre-language' that can excite inherent firing patterns and, at an early age, allow accessibility to brain pattern development and enhancement of additional higher brain functions. Graziano, Peterson, and Shaw (1999) maintained that the brief period of music instruction required to improve spatial skills suggests an innate ability of the brain to recognize symmetries. Shaw (2000) proposed that the brain not only recognizes, but also uses these symmetries to see how patterns develop in space and time.

Another "neural connections" theory, the "rhythm" theory, proposed by Lawrence Parsons and colleagues (Parsons & Fox, 1995, 1997; Parsons, Hodges & Fox, 1998), also suggests a neurological connection between music and spatial processes that require mental rotation, a component of spatial-temporal ability. This theory suggests that the rhythmic element of music links musical and spatial processing. Parsons argued that if rhythm is processed in the cerebellum, as is mental rotation (the ability to rotate a two- or three-dimensional figure rapidly and accurately), then it is possible that processing rhythm stimulates the ability to perform mental rotation tasks, with the result that music enhances spatial skills that require mental rotation.

Orsmond and Miller (1999) believe that another possibility for a causal relationship between music and other cognitive abilities is that various musical activities have transfer effects to specific cognitive skills, consequently the term, cognitive or "near transfer." Cognitive transfer or "near transfer" theories propose that one kind of learning assists performance on other kinds of tasks as in music and spatial processes. These two categories of theories, "near transfer" and "neural connections" theories such as the "trion" model and the "rhythm" theory are not autonomous and could, combined together, account for the effects of music training on spatial abilities.

Music Instruction and Spatial-Temporal Reasoning

Research studies have investigated the relationship between music instruction and spatial-temporal reasoning by examining various contexts of instructional methods such as piano keyboard training, the Orff approach, active Orff in combination with the Kodály approach, and Kodály exclusively. Rauscher, Shaw, Levine, Ky, and Wright (1994) found that piano training significantly enhanced spatial-temporal reasoning skills. A more structured treatment condition than that of the pilot study involved individual piano keyboard lessons combined with singing. The results produced a significant effect ($p < .0001$) on spatial-temporal task performance.

In an additional investigation, Rauscher et al. (1997) tested the hypothesis that music instruction of young children, whose cortices are plastic (receptive to stimulation), produces long-term enhancement of spatial-temporal reasoning. Preschool children who participated in this study ($N = 78$) were divided into four groups: the Keyboard group ($n = 34$), which received private piano keyboard lessons and group singing sessions; the Singing group ($n = 10$); the Computer group ($n = 20$); and the No Lessons group ($n = 14$). Four subtests from the *Wechsler Preschool and Primary Scale of Intelligence-Revised (WPPSI-R)* (1989), one spatial-temporal task and three spatial recognition tasks were used. Significant improvement on the spatial-temporal task was found for the keyboard group only. There was no significant improvement on the spatial recognition tests by any of the four groups.

Piano/Keyboard

Costa-Giomi (1999) reported significant, though temporary, effects on general cognitive and spatial abilities when individual piano lessons, which incorporated standard notation, were administered to less-privileged fourth through sixth grade students ($N = 78$) over a three-year period. The experimental group ($n = 43$) performed significantly better on spatial-temporal tasks after 1 year and 2 years of instruction than did the control group ($n = 35$). However, the improvements were only temporary; the groups did not differ in general or specific cognitive abilities after 3 years of instruction.

Rauscher (1999b), in her "Head Start Music Intervention Study," which involved low socio-economic status subjects, found that piano training had a significant effect ($p < .0001$) on the spatial-temporal task performance of 3- to 6-year-olds. Preschool children ($N = 87$) received weekly piano keyboard instruction (in combination with group singing), or computer instruction or no music training over a three-year period. The researcher stated that the instruction was mainly Kodály-based with the 3-year-olds and Yamaha keyboard-based with the kindergarteners.

Graziano, Peterson, and Shaw (1999) discovered that combining piano keyboard instruction with Math Video Game training increased the scores of second graders on a proportional math and fractions test. Students in the experimental group who received piano keyboard training in conjunction with Spatial-Temporal Math Video Game training, a newly developed software program specifically designed to boost children's spatial-temporal reasoning, scored 27% higher on a test of proportional math and fractions than those who used the software and received English language training and those who received no special instruction.

Rauscher (1999a) studied kindergarten students ($N = 66$) from Franklin Elementary in Oshkosh, Wisconsin and further established the positive effect of piano keyboard training on spatial-temporal reasoning abilities using a computer animated assessment program, *Spatial-Temporal Animation Reasoning (STAR)*. She determined that the experimental group ($n = 35$) provided with weekly 40-minute group keyboard lessons, increased significantly ($p < .0006$) on proportional reasoning skills compared to the control group ($n = 31$) provided with animated reading instruction.

Rauscher and Zupan (2000) found that 8 months of piano keyboard training improved kindergarteners' ($N = 68$) spatial-temporal reasoning scores compared to children who did not receive the lessons. The keyboard, or experimental group ($n = 34$), who received bi-weekly 20-minute group keyboard lessons scored significantly higher than the no music, or control group ($n = 28$) on two spatial-temporal tasks after 4 months of lessons, a difference that was greater in magnitude after 8 months of lessons. A third subtest, the Pictorial Memory Task from the *McCarthy Scales of Children's Abilities (MSCA)* (1972), for which no significance was found, served as a visual memory comparison task test.

Orff

Additional studies that indicate that music training enhances spatial-temporal skills incorporated the Orff approach, Orff in combination with the Kodály concept, or Kodály exclusively as a method of active classroom music instruction. Mallory and Philbrick (1995), in a partial replication of a study by Rauscher and colleagues (1994), suggested that music training enhances spatial skills by exercising the same neural pathways that govern other right hemisphere activities such as higher mathematical reasoning and puzzle completion. Three- to five-year-old children who attended preschool classes, with or without active Orff music instruction, 1 hour a week for 6 months were assessed at three- and six-month intervals using the Object Assembly Task from the *Wechsler Preschool and Primary Scale of Intelligence-Revised (WPPSI-R)* (1989). Children who received training showed significant improvement (p = .003), although average scores on the Object Assembly Task increased for both groups.

Flohr, Miller, and Persellin (1998) reported that active Orff-based classroom music instruction significantly enhanced the spatial-temporal skills of 4- to 6-year-olds (N = 22). The researchers used non-standard notation with the active Orff-based experimental group and no music instruction for the control group. Using the Object Assembly Task from the *WPPSI-R* (1989) as the dependent measure, they found a significant effect (p = .05) in spatial-temporal task performance.

A study of kindergarten students (N = 68) by Taetle (1999) revealed significantly higher spatial-temporal increases due to active music instruction featuring the Orff approach. Students in the experimental group (n = 28), who used Orff xylophones, which provided a visual-linear representation of pitch, were compared with a singing group (n = 26) and a passive listening group (n = 14).

Similarly, Persellin (1999) conducted a study with kindergarten students (N = 13), which further established the positive effect of Orff-based time-intensive music instruction on spatial-temporal skills. Lessons included singing and full body movement in addition to the instrument playing three times a week for 6 weeks. Subjects were pretested before instructional treatment and posttested twice, immediately after treatment and again after an additional six-week period.

Orff/Kodály

Gromko and Poorman (1998) implemented an active Orff- and Kodály-based approach that resulted in a positive effect on the spatial skill development of preschool children (N = 30). The music treatment for the experimental group (n = 15) "engaged children in sensory motor actions in response to music and promoted their perception of and memory for the rhythmic pulse and tonal contour of music" (p. 175). Both groups received regular preschool classroom music instruction; however, in addition, the experimental group (n = 15) sang, moved to, and notated the pieces they played on songbells, while the control group (n = 15) received no additional special music instruction. Although the *WPPSI-R* (1989) testing failed to achieve significant results, the music training evoked a positive effect on the children's spatial skill development.

Kodály

Hurwitz, Wolff, Bortnick, and Kokas (1975) found no significant effect of 7 months of daily Kodály music instruction on the spatial-temporal abilities of first graders using the Object Assembly Scale of the *Wechsler Intelligence Scale for Children (WISC)* (1974) as the dependent measure. These studies reveal that music training, which includes instruction in standard notation, significantly impacts the acquisition of spatial-temporal reasoning abilities.

Music Instruction and Spatial Reasoning

Studies have indicated that active music instruction significantly enhances the acquisition of a range of spatial reasoning skills. Flohr (2000) studied 20 subjects and implemented active Orff-based classroom music instruction with 4-year-olds. With the same (treatment and control) study design as employed in a previous study (Flohr, Miller & Persellin, 1998), Flohr used the Visual Closure Test from the *Woodcock-Johnson Psycho-Educational Battery-Revised (WJ-R)* (1989) and found no significant effect ($p = .15$) on the spatial recognition task.

Bilhartz, Bruhn, and Olson (2000) found a significant connection between early music instruction and spatial reasoning abilities. The researchers explored a structured music curriculum and cognitive development with 4- to 6-year-olds ($N = 71$). The experimental group ($n = 36$) received 75-minute weekly, parent-involved Kindermusic lessons for 30 weeks, while the control group ($n = 35$) received no treatment. Analysis showed significant gains on a spatial memory subtest from the *Stanford-Binet Intelligence Scale (SBIS)* (1986), the Bead Memory subtest, for subjects who received music instruction.

A study by Parente and O'Malley (1975) revealed that active rhythm training, which influenced the spatial dimension of field independence (perception of one's environment as consisting of objects as distinct from their surroundings) in children, resulted in significant effects on a spatial visualization task. An experimental group ($n = 12$) showed significant improvement ($p = .03$) on the Children's Embedded Figures Test from *The Manual for Embedded Figures Test* (1971), used as a spatial visualization task, while a matched control group ($n = 12$), which received alternative unrelated activities, did not improve.

Similarly, Hurwitz et al. (1975), in a study with first graders, reported a significant effect ($p = .05$) of active Kodály training on spatial abilities, specifically a spatial visualization task test using the Children's Embedded Figures Test. Additional studies by Rauscher et al. (1997), Gromko and Poorman (1998), and Taetle (1999) indicated that piano keyboard training, an Orff- and Kodály-based approach, and an active Orff approach, respectively, produced a significant effect or improvement on children's spatial-temporal skills.

Kodály-Based Music Instruction

Kodály-based music instruction embodies a sequential process, by which a culture's folk songs and active, authentic singing games are implemented to teach rhythm, melody, harmony, form, timbre, texture, and expression, in addition to the skills of singing, listening, moving, reading and writing notation, and the analysis of music. Zoltán Kodály, Hungarian composer, ethnomusicologist, and educator, founded a philosophy of music education presently referred to as the Kodály approach. The approach incorporates moveable-do solfa, hand signs, rhythmic syllables, and singing, which is its most definitive component. Kodály emphasized the use of moveable-do solfa and hand signs, initially developed by Sarah Glover and adapted by John Spencer Curwen as a part of his tonic solfege [sic] system (Choksy, 1999). Music literacy, one of the major foci of the Kodály concept, involves "from the aural to the visual" by developing the ability to comprehend what is heard and apply that learning to reading and writing notation, music analysis, composition, and improvisation.

Kodály-Based Music Instruction and Nonspatial Abilities

The research in Kodály-based contexts has examined the relationship between active music instruction and nonspatial abilities (general intelligence).[1] Laczo (1985) investigated the influence of Kodály music education on general intelligence (nonspatial abilities) and found improvement, though not significant, on *Raven's Progressive Matrices* (1986), also known as *Raven's Standard Progressive Matrices (RSPM)* (1986), regarded as a nonverbal measure of general or logical intelligence. Laczo's 2 three-year studies involved third or sixth graders in three groups, which received intensive Kodály music instruction, intensive language study, or no treatment (normal curricular instruction). Hurwitz et al. (1975) determined that intensive Kodály training with first graders produced a significant effect (p = .05) on their nonspatial abilities (general intelligence) using *Raven's Progressive Matrices* (1986).

Purpose of the Study

The purpose of this study was to examine the effects of sequenced Kodály literacy-based music instruction on the spatial skills of kindergarten students. More specifically, the study sought to determine the exact types of spatial skills that are enhanced—whether spatial-temporal only or other types of spatial skills (e.g., spatial recognition) as well. This study assessed the effects of Kodály music instruction on the dependent measures of spatial-temporal, spatial recognition, and nonspatial (verbal) abilities (the latter measure served as a comparison task test to minimize the presence of the Hawthorne effect or novelty effects). The following research questions guided the study:

1) What are the effects of sequenced Kodály literacy-based music instruction on kindergarteners' spatial-temporal skills?

2) What are the effects of sequenced Kodály literacy-based music instruction on kindergarteners' spatial recognition skills?

3) What are the effects of sequenced Kodály literacy-based music instruction on kindergarteners' nonspatial (verbal) skills?

METHODOLOGY

Subjects in this study included five- and six-year-old students (N = 54) enrolled in three kindergarten classes in a rural K-5 elementary school with an enrollment of approximately 400 students. This school did not offer classroom music instruction at the kindergarten level. Parent consent forms were required of each student at the onset of the investigation. Students who did not submit the proper consent form were not further considered for the study. The treatment period of this study spanned 31 weeks over 7 months from October, 2000 through April, 2001. The pretests were conducted in late September and early October, 2000 and the posttests in late April and early May, 2001.

Experimental Design

A pretest-posttest control group design (Campbell & Stanley, 1963, Design 10, p. 47) was used with three groups, two experimental groups and one control group. A coin toss determined the assignment of two morning kindergarten classes to experimental group one or the control group, since the afternoon kindergarten class was arbitrarily assigned as experimental group two and received computer instruction due to scheduling constraints with the computer laboratory and instructor. Computer instruction controlled for the Hawthorne effect, which proposes that students who experience or are exposed to any new situation will inevitably show improvement. The investigator chose a pretest-posttest control group design based on the assumption that subjects would not experience a "carry-over" effect (activation of processing areas in the brain by a spatial task that might carry over through a subsequent task test).

Internal Validity

The pretest-posttest control group design used in this study controlled for threats to internal validity of history, maturation, testing, and instrumentation through the similarity of recruitment and approximation of pretest scores of the experimental and control groups (Campbell & Stanley, 1963). Furthermore, the investigator observed additional measures to monitor for possible events beyond the control of the design of the study e.g., using non-homogeneous groups, only English-speaking students, and raw scores for statistical analyses. Subjects in this study were drawn from three kindergarten classes in one elementary school. Since randomization in the assignment of subjects to the groups was not possible, the three groups were recruited as intact classrooms. This similarity in recruitment controlled for possible selection bias.

External Validity

Employing the investigator as the music instructor for experimental group one and a certified school district educator as the computer instructor for experimental group two controlled for external influences such as experimenter bias. Although the subjects in all groups knew they were taking part in a study, none of the subjects were aware of the content of the study. In addition, the subjects had no previous music or computer instructional experiences by which to compare these specific treatment conditions, reducing the possibility of the

Hawthorne and novelty effects. The dependent measures for this study included testing methods that are standard procedures used to measure spatial and nonspatial skill performance. The subjects in this study represented typical kindergarten students enrolled in a rural school. Generalization of results is limited to students with similar socio-economic backgrounds.

Instructional Procedures

The treatment for experimental group one (*n* = 18) consisted of sequenced Kodály literacy-based music instruction. During the first three months of treatment, the investigator taught kindergarteners introductory concepts e.g., beat, four voices (talking, whispering, singing, calling), fast/slow, loud/soft, high/low, short/long, and same/different. In the final four months of treatment, January through April, students learned basic literacy concepts, including heartbeat, rhythm, quarter note (ta), eighth notes (ti-ti), quarter rest, two-beat ostinato, two-beat meter, measure, bar line, double bar line, repeat sign, so/mi, and la. Kindergarteners added heartbeats, bar lines, and double bar lines to simple rhythmic patterns, which included quarter and eighth notes and quarter rests. They observed repeat signs in reading rhythmic and melodic patterns of songs. By the end of April, students read so, mi, and la from five-line staff notation and, with the same three pitches, notated melodic patterns in the keys of C, F, and G. Using inner hearing, they matched the first phrase (notated on a five-line staff) of six known songs (using two separate worksheets with three songs each) to a picture/icon representing each song. The kindergarteners used fine and gross motor skills as they sang, danced and played various unpitched percussion instruments e.g., hand drums, woodblocks, and triangles.

Experimental group two (*n* = 18) received instruction in which beginning computer keyboard skills, including how to use a mouse, were introduced. Using beginner computer software programs (Jumpstart ABC, Jumpstart Kindergarten, Pooh Kindergarten, and Reader Rabbit Learn to Read), students engaged in basic skill activities. The subjects in experimental group one and experimental group two met for 30 minutes twice a week. The computer instructor had a program started for the students when they arrived. They engaged in three activities from one compact disc during each class period. The instructor listed the activities on the board and announced to the class to switch to another specific activity approximately every 10 minutes. Kindergarteners learned how to quickly switch between activities on the compact discs. They were not required to log on to the computers since it would have involved entering a 7-letter logon name and a password and navigating through numerous programs on the Start menu to get to the desired program; however, they learned how to close down the program and log off the computers. The programs included a variety of activities and 3 different skill levels were available in all but one (Jumpstart Kindergarten). With Jumpstart ABC, students found letters (Casey's Pizza Place), matched pictures with words (Tuna Mountain), and matched letters (Train Station). In Pooh Kindergarten, kindergarteners matched letters with words (Word Shop), sorted shapes into jars

(Shape Sorting), drew and painted (Thoughtful Spot), and practiced counting and matched numbers (Number Balloons). Students worked with letters and sounds in Reader Rabbit Learn to Read and sorted by sizes, shapes, numbers, and colors in Jumpstart Kindergarten.

The control group (*n* = 18) received no classroom music or computer instruction. All three classroom teachers, at their own discretion, initiated musical activities such as singing (seasonal/holiday, patriotic, alphabet, and number songs) and performing rhymes and finger plays. These informal music activities were allowed and deemed not to affect the results of this study since kindergarteners in experimental group two and the control group did not actively make music e.g., clap, pat, or use rhythmic or melodic syllables (in the same manner as experimental group one) nor were any musical concepts or skills (specifically, reading standard notation) taught.

Data Collection

Data were collected in two phases: (a) pretest measures and (b) posttest measures. Upon receipt of all the parent consent forms, two school psychologists and a social worker pretested the kindergarten students on spatial and nonspatial reasoning skills, using three subtests, the Object Assembly Task (a spatial-temporal measure) from the *Wechsler Preschool and Primary Scale of Intelligence-Revised* (1989), the Visual Closure Test (a spatial recognition measure) from the *Woodcock-Johnson Psycho-Educational Battery-Revised* (1989), and the Absurdities Test (a nonspatial measure) from the *Stanford-Binet Intelligence Scale* (1986). After the seven-month instructional-treatment period, one retired school psychologist posttested all the subjects using the same three measures. No special training was required to administer the three subtests; the school psychologists and the social worker were qualified based upon their previous required training for the administration and scoring of these tests.

The *Wechsler Preschool and Primary Scale of Intelligence-Revised (WPPSI-R)* (1989) consists of six verbal subtests and six nonverbal performance measures, which provide standardized measures of a variety of intellectual abilities. The timed performance subtests of nonverbal intelligence include Object Assembly, Geometric Design, Block Design, Mazes, Picture Completion, and Animal Pegs. Spatial-temporal ability performance was measured using the Object Assembly Task. The individually administered subtest requires a child to complete simple puzzles, each within a specified time limit (from 2 to 2½ minutes). The test-retest reliability coefficient for the Object Assembly subtest, using a split half procedure corrected by the Spearman-Brown formula, is .70 and the concurrent validity of the Performance Scale is .82.

The *Woodcock-Johnson Psycho-Educational Battery-Revised (WJ-R)* (1989) is a comprehensive set of individually administered standardized tests for measuring cognitive abilities, scholastic aptitudes, and achievement. Spatial recognition ability performance was measured using the Visual Closure Test from the *Tests of*

Cognitive Ability, which requires a child to identify a picture altered in various ways. The test-retest reliability coefficient for the Visual Closure Test, using a split half procedure corrected by the Spearman-Brown formula, is .84 and the concurrent validity for the Broad Cognitive Ability Area is .69.

The *Stanford-Binet Intelligence Scale-Revised (SBIS)* (1986) is a comprehensive set of individually administered standardized tests for measuring verbal reasoning, abstract/visual reasoning, quantitative reasoning, and short-term memory. Verbal (nonspatial) reasoning was measured using the Absurdities Test from the Verbal Reasoning Area Tests, which requires a child to identify and verbally describe the incongruity in a picture. The test-retest reliability coefficient for the Absurdities Test, using the Kuder-Richardson formula 20 (KR-20), is .87 and the concurrent validity for the Verbal Reasoning Area is .73.

RESULTS

Spatial-Temporal Ability, Spatial Recognition Ability, and Nonspatial Ability

The means, standard deviations (*SD*), and ranges for all variables are presented in Table 1. Three separate one-way analyses of variance (one for each test/measure) were performed on the pretest scores and three additional analyses of variance were performed on the posttest scores of the three groups. There was no significant difference between the three groups in the pretest or posttest scores of the Object Assembly Task, the Visual Closure Test, and the Absurdities Test.

Table 1: *Pretest Means, Posttest Means, Standard Deviations (SD), and Ranges of the Object Assembly Task, the Visual Closure Test, and the Absurdities Test*

	Object Assembly		*Visual Closure*		*Absurdities*
Group	*n Mean Range* *(SD)*		*n Mean Range* *(SD)*		*n Mean Range* *(SD)*
Music					
Pretest	18 21.39 10-27 (5.16)		18 24.50 18-31 (2.79)		18 15.72 10-19 (2.40)
Posttest	18 25.61 20-31 (3.85)		18 28.78 20-34 (3.56)		18 18.83 15-23 (2.18)
Computer					
Pretest	18 22.78 15-29 (4.11)		18 26.50 21-32 (3.52)		18 17.33 12-21 (2.06)

Posttest	18 25.39 19-31 (3.74)		18 30.22 22-34 (2.88)		18 18.56 15-25 (2.09)
No Treatment					
Pretest	18 21.44 16-29 (4.38)		18 25.33 16-31 (3.91)		18 16.72 8-21 (3.08)
Posttest	18 26.78 14-30 (3.44)		18 30.00 26-35 (2.40)		18 19.22 16-23 (1.83)

One method for assessing learning over a period of time is to calculate and analyze gain scores (posttest minus pretest). This method, however, does not control for the general tendency of children who score the lowest usually improving the most over time. Table 2 contains the data for the mean gain scores of the Object Assembly Task, the Visual Closure Test, and the Absurdities Test.

Table 2: *Mean Gain Scores and Standard Deviations (SD) of the Object Assembly Task, the Visual Closure Test, and the Absurdities Test*

	Object Assembly		**Visual Closure**		**Absurdities**
Group	**n Mean SD**		**n Mean SD**		**n Mean SD**
Music	18 4.22 4.43		18 4.28 2.87		18 3.11 2.37
Computer	18 2.61 3.84		18 3.72 2.22		18 1.22 1.93
No Treatment	18 5.33 4.70		18 4.67 3.22		18 2.50 2.77

ANOVA Results

Three separate one-way analyses of variance were performed using the gain scores (posttest minus pretest) of each of the three dependent measures. The data in Table 3 represent the mean gain scores (posttest minus pretest) of the Object Assembly Task measure of spatial-temporal ability, the Visual Closure Test measure of spatial recognition ability, and the Absurdities Test measure of nonspatial (verbal) ability.

Table 3 *ANOVA Results of the Gain Scores (Posttest - Pretest) for the Object Assembly Task, the Visual Closure Test, and the Absurdities Test*

Source	*SS*	*df*	**MS**	*F*	*p*
Between groups (Object Assembly)	67.44	2	33.72	1.79	.177
Between groups (Visual Closure)	8.11	2	4.06	0.52	.599
Between groups (Absurdities)	33.44	2	16.72	2.95	.061

Results of the three analyses of variance show no significant difference between the music group, the computer group, and the no treatment group in gain scores on the spatial-temporal ability measure, the spatial recognition ability measure, or the nonspatial ability measure. Based upon the results of the analyses of variance, the findings of this study indicated that the effects of Kodály music instruction were not significant for spatial-temporal ability, spatial recognition ability, or nonspatial (verbal) ability.

DISCUSSION

Spatial-Temporal Ability

In this study, the investigator found no significant difference between the three groups in pretest, posttest, or gain scores for a measure of spatial-temporal ability (the Object Assembly Task) as a result of Kodály music instruction. These findings substantiated those of Hurwitz et al. (1975) and Gromko and Poorman (1998), who reported no significant difference in spatial-temporal ability using the same Object Assembly Task measure. The reasons for the subjects not achieving significance in their performance on a spatial-temporal measure can only be speculative. Perhaps the nonsignificance of the outcomes can be attributed to several pedagogical issues that remain unanswered. First, the ideal age at which training should begin is not known. Although enhancement of spatial-temporal ability is expected throughout early childhood, the neural plasticity of children three years old or younger may be responsible for the largest effects (Mallory & Philbrick, 1995). Second, little is known regarding the long-term effects of spatial-temporal enhancement. Rauscher et al. (1997) found that the effect lasts at least one day. Whether the enhancement remains after music instruction is discontinued is also in question. Third, it is uncertain whether the contributions of either the curriculum or the type of musical instrument are responsible for the acquisition of spatial-temporal skills. A keyboard represents a linear relationship of the spatial distances between pitches aurally, visually, and motorically. Perhaps any instrument (e.g., a xylophone or a set of songbells) that provides spatial representation is acceptable. It is also difficult to attribute the enhancements to specific musical activities such as playing instruments, reading and writing notation, or movement without isolating them. Experience with reading and writing standard notation was the key component of the Kodály music instruction in this study in attempting to achieve significant results. Kindergarteners were exposed to standard notation for not more than 6 weeks.

Spatial Recognition Ability

Analysis of the data for the spatial recognition ability measure (the Visual Closure Test) showed no significant difference between the music group, the computer group, and the no treatment group in pretest, posttest, or gain scores. These results correspond to the findings of other researchers who found no significant enhancement of spatial ability due to music instruction (Flohr, 2000; Gromko & Poorman, 1998; Rauscher et al., 1997; Taetle, 1999). Music instruction may or may not enhance (nonspatial-temporal) spatial abilities.

Nonspatial Ability

The data from the nonspatial ability measure, as expected, did not show a significant difference between experimental group one, experimental group two, and the control group in pretest, posttest, or gain scores. These findings correspond with those of Laczo (1985), who reported no significant improvement on a nonverbal measure of general intelligence. The Absurdities Test served as a nonspatial (verbal) comparison task test. The between-group uniformity of the posttest scores of the Absurdities Test minimized the presence of the Hawthorne effect or novelty effects for the spatial-temporal or spatial recognition tasks.

CONCLUSIONS

The results of this study indicated that Kodály music instruction does not adversely affect students' spatial-temporal or spatial (recognition) reasoning skills. The outcomes reinforce the findings of other investigations involving Kodály music instruction (Hurwitz et al., 1975) and additional methods of music instruction (Flohr, 2000; Gromko & Poorman, 1998; Rauscher et al., 1997; Taetle, 1999). Kodály music instruction may be effective in the enhancement of spatial-temporal and spatial recognition reasoning skills. The music teacher/investigator in this study positively viewed the improvements and achievements of the kindergarten music students and gained a favorable appreciation for the benefits of Kodály music instruction.

The logistics of the study, specifically the limited amount of experience with standard notation by kindergarteners, due to the content and design of music lessons, may have contributed to the difficulty in achieving significance, particularly on the spatial-temporal measure (the Object Assembly Task). The music teacher/investigator kept the scientific goals secondary to instruction that was developmentally appropriate for kindergarteners (e.g., teaching and using standard notation with a foundation of pre-literacy concepts and skills).

The investigator, before beginning this study, considered whether or not the kindergarteners would be able to understand the musical concepts and perform rhythmic and melodic patterns with a certain degree of accuracy. Students were not only able to do this, but their performance and worksheets evidenced comprehension and skill ability that far exceeded the investigator's expectations.

The following recommendations are suggested for future investigations:

1. Extend the instructional-treatment period beyond 1 year (to 2 or possibly 3 years) to determine if successive instruction would enhance spatial reasoning skills including spatial-temporal ones.

2. Use a larger sample (of students) to increase power and improve generalization of results.

3. Secure one licensed (school) psychologist for pre- and posttesting to facilitate uniformity in testing and accuracy in the recording of test scores.

---

[1] *Raven's Standard Progressive Matrices (RSPM)* (1986), the measurement used to test general intelligence in the subsequent two studies, is generally considered to be primarily nonspatial, although several researchers included *RSPM* in their lists of spatial ability measures.

REFERENCES

Bilhartz, T.D., Bruhn, R.A., & Olson, J.E. (2000). The effect of early music training on child cognitive development. *Journal of Applied Developmental Psychology, 20* (4), 615-636.

Campbell, D.T., & Stanley, J.C. (1963). *Experimental and quasi-experimental designs for research.* Chicago: Rand McNally and Company.

Choksy, L. (1999). *The Kodály method I: Comprehensive music education (3rd ed.).* Upper Saddle River, NJ: Prentice Hall.

Costa-Giomi, E. (1999). The effects of three years of piano instruction on children's cognitive development. *Journal of Research in Music Education, 47*(5), 198-212.

Flohr, J.W. (2000). *Brain research applied to music education.* Paper presented at the meeting of the Music Educators National Conference, Washington, D.C.

Flohr, J.W., Miller, D.C., & Persellin, D. (1998). *Quantitative EEG responses to music stimuli.* Paper presented at the Music Educators National Conference, Phoenix, AZ.

Graziano, A.B., Peterson, M., & Shaw, G.L. (1999). Enhanced learning of proportional math through music training and spatial-temporal training. *Neurological Research, 21,* 139-152.

Gromko, J.E., & Poorman, A.S. (1998). The effect of music training on preschoolers' spatial-temporal task performance. *Journal of Research in Music Education, 46,* 173-181.

Hetland, L. (2000). Learning to make music enhances spatial reasoning. *Journal of Aesthetic Education, 34*(3-4), 1-60.

Hurwitz, I., Wolff, P.H., Bortnick, B.D., & Kokas K. (1975). Nonmusical effects of the Kodály music curriculum in primary grade children. *Journal of Learning Disabilities, 8*(3), 167-174.

Kritchevsky, M. (1988). The elementary spatial functions of the brain. In J. Stiles-Davis, M. Kritchevsky & U. Bellugi (Eds.), Spatial cognition: Brain*bases and development* (pp. 111-140). Hillsdale, NJ: Erlbaum

Laczo, Z. (1985). The nonmusical outcomes of music education: Influence on intelligence. *Bulletin of the Council for Research in Music Education, 85,* 109-118.

Leng, X., & Shaw, G.L. (1991). Toward a neural theory of higher brain function using music as a window. *Concepts in Neuroscience, 2,* 229-258.

Linn, M.C., & Petersen, A.C. (1985). Emergence and characterization of sex differences in spatial ability: A meta-analysis. *Child Development, 56,* 1479-1498.

Mallory, M.E., & Philbrick, K.E. (1995). *Music training and spatial skills in preschool children.* Paper presented at the American Psychological Association, New

York, N.Y.

Orsmond, G.I., & Miller, L.K. (1999). Cognitive, musical and environmental correlates of early music instruction. *Psychology of Music, 27,* 18-37.

Parente, J.A., & O'Malley, J.J. (1975). Training in musical rhythm and field dependence of children. *Perceptual and Motor Skills, 40,* 392-394.

Parsons, L.M., & Fox, P.T. (1995). Neural basis of mental rotation. *Society for Neuroscience Abstracts, 21,* 272.

Parsons, L.M., & Fox, P.T. (1997). Sensory and cognitive functions. *International Review of Neurobiology, 41,* 255-272.

Parsons, L.M., Hodges, D.A., & Fox, P.T. (1998, April). *Neural basis of the comprehension of musical harmony, melody, and rhythm.* Poster session presented at the proceedings of the Cognitive Neuroscience Society Meeting, San Francisco, CA.

Persellin, D. (1999, November). *The effect of Orff-based, time-intensive music instruction on spatial-temporal task performance of young children.* Paper presented at the American Orff-Schulwerk Association National Conference, Phoenix, AZ.

Rauscher, F.H. (1999a, November). *Music, cognitive development, and the classroom:_Franklin Elementary.* Paper presented at the American Orff-Schulwerk Association National Conference, Phoenix, AZ.

Rauscher, F.H. (1999b, November). *Music, cognitive development, and the classroom: Head Start.* Paper presented at the American Orff-Schulwerk Association National Conference, Phoenix, AZ.

Rauscher, F.H., & Shaw, G.L. (1998). Key components of the Mozart effect. *Perceptual and Motor Skills, 86,* 835-841.

Rauscher, F.H., Shaw, G.L., Levine, L.J., Wright, E.L., Dennis, W.R., & Newcomb, R.L. (1997). Music training causes long-term enhancement of preschool children's spatial-temporal reasoning. *Neurological Research, 19,* 2-8.

Rauscher, F.H., & Zupan, M.A. (2000). Classroom keyboard instruction improves kindergarten children's spatial-temporal performance: A field experiment. *Early Childhood Research Quarterly, 15*(2), 215-228.

Raven, J.C. (1986). *Raven's Progressive Matrices.* San Antonio, TX: The Psychological Corporation.

Shaw, G.L. (2000). *Keeping Mozart in mind.* San Diego: Academic Press.

Taetle, L.D. (1999). *The effects of music instruction on the spatial ability of kindergarten children.* Unpublished doctoral dissertation, University of Arizona, Tucson.

Thorndike, R.L., Hagen, E.P., & Jerome, M.S. (1986). *The Stanford-Binet Intelligence Scale: Fourth Edition.* Chicago: Riverside Publishing.

Wechsler, D. (1989). *Wechsler Preschool and Primary Scale of Intelligence-Revised.* New York: The Psychological Corporation.

Woodcock, R.W., & Johnson, M.B. (1989). *Woodcock-Johnson Psycho-Educational Battery-Revised.* Allen, TX: DLM Teaching Resources.

ISSN 1532-8090