CHAPTER-3
REVIEW OF LITERATURE

There has been a remarkable surge of empirical research on the relationship of music and cognition in the recent years. The relevant review of literature has been summarized under convenient sub headings as follows:

- The Mozart Effect: Empirical Studies
- Music, Mathematics and Visuo-Spatial Abilities.
- Music and Verbal Reasoning
- Music and Memory
- Music and Creativity
- Main Objectives of the Study
- Specific Hypothesis of the Study

The Mozart Effect: Empirical Studies

In the October 14, 1993 issue of *Nature* magazine, UC Irvine researchers Frances Rauscher, Gordon Shaw, and Katherine Ky published a short article entitled “Music and Spatial Task Performance,” which detailed their research involving exposing college students to 10 minutes of Mozart’s Sonata for Two Pianos in D Major, a relaxation tape, or silence, followed by a test on spatial-temporal reasoning, taken from the Stanford-Binet intelligence test. Their research showed a statistically significant rise in scores from those students who had listened to the Mozart sonata. The popular response was phenomenal.

The media christened their finding “the Mozart Effect,” and the Mozart recording used in the study quickly sold out everywhere. A new industry sprung up, as Don Campbell published a book titled “The Mozart
Effect”; claiming that Mozart’s music could improve intelligence and make children smarter. Original researchers reacted to how media inflated the findings—Frances Rauscher repeatedly denounced the over-reaction in the popular press. “I’m horrified and very surprised over what has happened,” she said. “It’s a very giant leap to think that if music has a short-term effect on college students that it will produce smarter children. When we published the study results, we didn’t think anyone would care. The whole thing has really gotten out of hand” (Newman2002).

Since 1993, the year of the original breakthrough, many teams of researchers and scientists have attempted to replicate the Mozart Effect. These attempts produced mixed results; some reproduced the findings, while others found no significant increase in short-term spatial reasoning. However, researchers have been inconsistent in their test methods, for different studies utilized different variables, music compositions, and sample sizes. Moreover, scientists that have attempted to validate (or invalidate) the Mozart Effect used different intelligence tests to measure the increase in spatial-temporal reasoning. Until there is a consistent standard for the test method, the true effects of Mozart’s music on spatial-temporal reasoning will be difficult to conclude.

The Seeds of Discovery

To fully understand the effects of the original 1993 breakthrough study, we must look at the events that led up to the discovery. The idea that music could increase some form of human intelligence is actually not a novel concept—in the 1960’s, French physician Alfred Tomatis observed that listening to Mozart improved spatial reasoning and creativity. Two decades later (1984), the team of Hassler, Birbaumer, and Feil studied the
relationship between children with musical talent and visual-spatial ability. Hassler and his colleagues hypothesized that “Musically-gifted persons should obtain higher test scores in spatial tasks than non-musicians” (Hassler et al.). To examine this hypothesis, they formed 3 groups of 40 children each (20 boys and 20 girls in each group). Group 1 consisted of children with musical talent and the ability to compose and/or improvise; Group 2 consisted of children with musical talent without the ability to compose and/or improvise; Group 3 was a control group of non-musicians.

The researchers concluded, “Analysis of variance demonstrated a significant relationship between musical talent and visualization, but not between musical talent and orientation” (Hassler et al.). A follow-up study conducted a year later (1985) by Hassler confirmed their first hypothesis that musicians perform better than average on spatial tasks. These experiments provided a basis for Gordon Shaw and his team of researchers to work from. Shaw took a major step towards discovering the Mozart Effect in 1988 while trying to model brain activity on a computer. Gordon Shaw, a neurobiologist at the University of California at Irvine, was simulating the way nerve cells were connected to one another in predisposed groups of cells to adopt certain specific firing patterns and rhythms (Chabris). These natural patterns, he believes, form the basic grammar of mental activity.

Later that year Shaw and his student Xiaodan Leng decided to turn the output of their simulations into sounds instead of a conventional printout. To their surprise, the rhythmic patterns sounded like baroque, new age, or Eastern music. “I don’t mean it was great music, but we got distinct, recognizable styles,” Shaw says (Chabris). If brain activity can sound like music, Shaw wondered, might we learn to understand the neural grammar by working backwards and watching how the brain responds to music? In other
words, might patterns in music somehow prime the brain by activating similar firing patterns of nerve clusters? If so, Shaw thought he knew where to start: Mozart, a prodigy who began composing at age four. “We thought if anyone might be tapping into this inherent neural structure, it might be Mozart,” says Shaw (Chabris,). This initial finding was the steppingstone for Shaw and his colleagues to further investigate the effects of music on intelligence.

The Breakthrough

Gordon Shaw’s experience with brain waves and rhythmic patterns in 1988 propelled him to investigate the effects of music on the brain. In 1993 Gordon Shaw, Frances Rauscher, and Katherine Ky performed an experiment in which 36 college students were given three sets of standard IQ spatial reasoning tasks; each task was preceded by 10 minutes of (1) listening to Mozart’s sonata for two pianos in D major, K448; (2) listening to a relaxation tape; or (3) silence (Rauscher et al). Immediately following each listening condition, the student’s spatial reasoning skills were tested using the Stanford-Binet intelligence scale, which consisted of paper folding and cutting scenarios.

Students were presented with a picture of a paper before it was folded and cut (figure below). The dotted lines and arrows represent where and in what direction the paper would be folded; the solid lines show where the paper would be cut. This paper, for example, would be folded in half and then cut in two places. The student was instructed to visualize the folds and cuts and then choose the alternative which shows how the paper would look if it were unfolded.
The subjects who listened to Mozart before the test scored on average 119, while the relaxation group scored 111 and silence group scored 110. Thus, the spatial reasoning scores of subjects participating in the music condition were 8-9 points above the other two conditions. The enhancing effect of the music condition was temporal, and did not extend beyond the 10-15 minute period during which subjects were engaged in each spatial task (Rauscher et al.). Shaw and his colleagues concluded that listening to Mozart temporarily improves spatial-temporal reasoning: It would also be interesting to vary the listening time to optimize the enhancing effect, and to examine whether other measures of general intelligence (verbal reasoning, quantitative reasoning, and short-term memory) would be similarly facilitated. Because we used only one musical sample of one composer, various other compositions and musical styles should also be examined. We predict that music lacking complexity or which is repetitive may interfere with, rather than enhance, abstract reasoning. Also, as musicians may process music in a different way from non-musicians, it would be interesting to compare these two groups.

Shaw and his colleagues specifically state that listening Mozart does not increase general intelligence because they propose to test it in the future. They also conclude that the increased spatial reasoning lasts only 10-15 minutes after listening to Mozart (Shaw).

**Successful Attempts to Replicate the Mozart Effect**

Since the 1993 breakthrough received so much attention and hype, Shaw, Rauscher, and Ky decided to follow up their initial experiment with a more advanced study two years later (1995). In this follow-up study, Shaw and his colleagues examined the effects of repeated exposure to the Mozart
Sonata on spatial reasoning and the effects of highly repetitive music (minimalist) on spatial task performance. Finally, to find out whether the results were specific to spatial reasoning or also included memory, they tested the effects of listening to Mozart versus silence on a short-term memory task.

The study tested 84 college students who were offered $30.00 to participate for five consecutive days. In order to divide students into groups with equivalent abilities on the experimental tasks, all students were issued 16 Paper Folding and Cutting items and 16 Memory items on the first day of participation. The Paper Folding and Cutting items, designed to measure spatial reasoning, were derived from the Stanford-Binet Intelligence Scale and were pre-tested to be equally difficult across the five days of participation (same test as the 1993 study). In the pre-test, the paper folding items were displayed on an overhead projector for precisely one minute, and the students were warned 5 seconds before the item was removed, to give them sufficient time to choose an answer and to record it in a test booklet. Students were tested in three equal groups; items were presented one after the other, at a rate of exactly one per minute, as timed by a stopwatch. All three groups of students were issued the same task items and based on their performance on the Paper Folding and Cutting task (PFC), the students were reassigned to one of three groups (silence, minimalist, or Mozart) of equal means and distributions (Shaw).

This time, the Mozart group increased their PFC scores an average of 9-10 points, which is more significant than the initial 1993 findings, but there was no increase in scores from testing days 3 through 5. In the silence group, there was no significant increase in scores from day 1 to 2, but there was a noticeable increase from day 2 to day 3. The minimalist music group
produced no increase in scores on any of the five days (Shaw). Shaw, Rauscher, and Ky speculated that the increase in the Mozart group was due to listening to the Mozart sonata (Mozart Effect), while the increase in the silence group from day 2 to day 3 was due to the learning curve, which meant that test scores improved only because subjects “learned” how to answer the test questions with increased exposure.

There are indeed many tensions and problems with the 1995 follow-up study that lead to unsubstantiated conclusions and problems in the future for later studies. For example, in the follow-up test, Shaw, Rauscher, and Ky changed the relaxation tape used in the 1993 to Phillip Glass’s *Music with Changing Parts*, a minimalist piece with highly repetitive themes and motifs. This inconsistency in testing conditions makes it difficult to conclude whether Mozart truly has an effect on short-term spatial reasoning. Nonetheless, Shaw’s team concluded that the immediate improvement of the Mozart group’s scores on day 2, and the lack of immediate improvement of the silence group’s scores, replicates the findings from their 1993 study. If this is true, why was the increase in the Mozart group scores attributed to the music, while the increase in the silence group scores attributed to “learning curve”? These problems and inconsistencies of the 1995 follow-up study lay down a tenuous foundation for future studies to test against.

However, there were some positive outcomes from the follow-up test. Shaw hypothesizes, “It seems that a particular organization of musical elements is necessary for improvement in spatial task performance. Finally, we have shown that short-term memory does not improve after listening to the Mozart sonata” (Shaw). Shaw clarifies that memory does not improve from listening to Mozart and proposes a basic explanation as to why Mozart’s music supposedly increases spatial task performance.
Dr. Robert Rideout of the Ursinus College in Collegeville, PA replicated the Mozart Effect in his 1996 study using an electroencephalogram (EEG), which monitors brain activity. Rideout studied 8 college students who listened to Mozart's Sonata for Two Pianos in one condition and no music in another condition. Changes in the EEG (brain wave activity) were examined prior to and while engaged in two spatial-reasoning tasks, tested by the Paper Folding and Cutting Test (PFC) portion of the Stanford-Binet Intelligence Test (Rideout). Rideout found that subjects performed better on the PFC tasks after listening to the Mozart music. In addition, the EEG recordings were slightly correlated with the students' performance, for increased activity was associated with increase in performance.

Although Rideout's study seems scientific and supportive of the Mozart Effect, the study contains a major weakness—the sample size of 8 students is extremely small and not substantial to prove any statistical results. Rideout, however, attempts to explain the Mozart Effect using a biological explanation (increased brain activity), which will be crucial for future researchers to develop upon.

In 1997, the Harvard School of Education initiated “Project Zero,” a three-year study to determine the effects of drama and arts on intelligence. Lois Hetland, the director of Project Zero, confirmed claims that listening to music temporarily enhances spatial skills (Mozart Effect), as well as claims that children who study music gain skill in spatial reasoning. However, researchers found no general, causal links between studying the arts and improvements in SAT scores, grades, or reading scores (Hetland). The finding suggests that music and spatial reasoning are related psychologically (i.e., they may rely on some of the same underlying skills) and perhaps
neurologically as well (i.e., they may rely on some of the same, or proximal, brain areas); however, they do not reveal conclusively why listening to music affects spatial-temporal thinking.

Hetland (2000), a music educator, adds, “Arts advocates need to stop making sweeping claims about the arts as a magic pill for turning students around academically. Arts in the curriculum should be justified in terms of their intrinsic merit—as they were in ancient Greece. An education without the arts is an impoverished education, and that leads to an impoverished Society.” (Hetland) Although Project Zero confirmed many claims supporting the Mozart Effect, their studies do not use scientific evidence; instead, Hetland and her colleagues reviewed past studies and reports on music and intelligence. Also, their reports do not offer any explanations as to why listening to music affects spatial-temporal thinking. Since music educators such as Lois Hetland back Project Zero, the main focus of the project is to prove that music education in public schools is valuable. Thus, some experts in music psychology disregard Project Zero as a valid source, thinking that educators use Project Zero as a tool for promoting music education (Chabris). Project Zero’s lack of scientific evidence and suspected hidden motive weaken their studies and conclusions that support the Mozart Effect.

Extensions of the Mozart Effect

1) The Beethoven Effect

In 1995, while following up on his Mozart Effect findings, he also found that college students who listened to ten minutes of Beethoven’s Moonlight Sonata showed improvements in the visual-spatial section of the Stanford-Binet Intelligence Test compared with students who listened to
nothing for ten minutes. However, this effect was not lasting. Three days later, the average scores on the visual-spatial section of the IQ test were similar for both groups.

MacTavish conducted a survey of 100 parents of preschoolers and found that preschoolers whose parents reported that they had been taking piano lessons for at least 6 months had higher IQ’s than preschoolers whose parents reported that they were not taking piano lessons. Furthermore, an article by Kyle found that a parent who constantly played classical music in her infant’s nursery claimed that the child developed a more advanced vocabulary at an earlier age than other children in his peer group.

Thus, it seems that there may be some validity to the Beethoven Effect, even among young children. Theorists propose that early exposure to classical music primes the portion of the brain responsible for spatial-temporal reasoning skills. Presumably, if this “priming” occurs over a period of time.

2) Mozart and Healing

Below is a summary of Don Campbell’s best-selling book, “The Mozart Effect: Tapping the Power of Music to Heal the Body, Strengthen the Mind, and Unlock the Creative Spirit”:

“Drawing on medicine, Eastern wisdom, and the latest research on learning and creativity, Campbell reveals how exposure to sound, music, and other forms of vibration, beginning in uterus, can have a lifelong effect on health, learning, and behavior. He shows how to use sound and music to stimulate learning and memory; how to strengthen listening abilities; how to use imagery to enhance The Mozart Effect; and how to harness the power of toning, chanting, mantras, rap, and other self-generated sounds.
The book lists 50 common conditions, ranging from migraines to substance abuse, for which music can be used as treatment or cure. Recommends more than 24 specific, easy-to-follow exercises to improve concentration, reduce pain, and boost creativity. This remarkable book points the way to a healthier, more harmonious way of life.

Campbell offers accounts of how doctors and other health care professionals, musicians, and healers use music as an aid in healing anxiety, cancer, high blood pressure, chronic pain, dyslexia, and even mental illness. Students who sing or play an instrument have scored up to 51 points higher on SATs than the national average. The director of Baltimore Hospital's coronary care unit says that half an hour of classical music produces the same effect as ten milligrams of Valium. And now, whatever your listening taste, learn how to make The Mozart Effect work for you.

The evidence is in: music is not just entertainment. It is medicine for body and soul. Unifying Eastern wisdom and the latest scientific research on everything from illness to creativity, The Mozart Effect is the definitive book on the astonishing powers of music--from Mozart to New Age, Latin and even Rock--to heal the body, mind and spirit.

The Mozart Effect opens doors to a new and more harmonious way of life and includes more than two dozen specific, easy-to-follow exercises to help you raise your spacial IQ, sound away pain, boost creativity and make your spirit sing.”

Rock and Rap Music

Researches at the John Hopkins University have found that rock music causes people to eat faster and to eat a larger volume of food, while slow classical music makes people eat more slowly and consume less.
Kevin J. Took and David S. Weiss in the journal *Adolescence* (1994) studied the relationships between listening to heavy metal and rap music and adolescent "psychosocial turmoil". Subjects were 12-18 years of age and equally divided between the sexes. Patients were under some treatment for various behavioral and psychological problems at a military medical center's adolescent medicine unit or similar facility.

Questionnaires revealed differences between teenagers who preferred heavy metal and rap compared to others who did not. They had poorer school grades, more behavioral problems in school, and more sexual activity, drug and alcohol use and arrests. The relationship was stronger for males than females.

One possible conclusion to draw is that the music caused the behavioral problems. However, further detailed analysis of each student's background revealed that the most troubled group exhibited serious behavioral problems in elementary school, generally before they started listening to heavy metal and rock. Thus, troubled students may be drawn to these types of music and no clear causative relationship exists. Generalizations from these findings would be premature because the sample does not represent a cross section of adolescents in the United States. The reliance of questionnaires, even with reliability checks used in the study, is subject to some error and the possibility that music could promote problems in already troubled teenagers was not investigated.

Recently, Dolf Zillman and several colleagues at the University of Alabama examined some effects of rap music in a controlled experiment. Reporting in the journal *Basic and Applied Social Psychology*, they studied the effects of radical rap and other types of music on political attitudes in high-school students. Specifically, various matched groups of students were
shown different types of rock videos. Next, students participated in mock
elections that featured candidates who differed in beliefs and political
agendas. Although Caucasian students enjoyed rock more than rap videos,
they showed a significantly greater amount of support for an African-
American ethnically liberal candidate and less support for a white
supremacist candidate, than control groups that viewed other types of
videos. The authors conclude that exposure to radical rap can support efforts
toward racial harmony in Caucasian high school students.

**Failures to Replicate the Mozart Effect**

Steele, K.M., Bass, K.E.& Crook, M.D. (1999) conducted an
investigation to test the Mozart effect: The temporary increase in spatial
reasoning after listening to Mozart’s music. The title of their research was:
The mystery of the Mozart effect: Failure to replicate.

The purpose of the investigation was to replicate the Mozart effect
using the exact procedural and material replication of the original research
(Rauscher et al., 1993). Past research has been mixed. Original research
found the effect (Rauscher et al., 1993), however since then, many have not
been able to replicate the effect (e.g., Carstens, Huskins, & Hounshell,
1995).

Hypotheses about the influence that type of musical passage has on
spatial-reasoning performance were not directly stated. However
investigators were clearly testing the influence that Mozart music, highly
repetitive music, and silence had on participants’ spatial-reasoning
performance. Investigators predicted that Mozart music would produce a
more elevated mood than Glass’s repetitive musical piece.
One hundred twenty five participants, from an introductory psychology class, took part in the study. The investigators manipulated the type of music to which the participants listened. The experimenters randomly assigned participants to listen to a different musical passage (levels: Mozart, Glass, silence).

There were two primary dependent variables. The first was participants’ performance on a paper folding and cutting task (PF & C) from the Stanford Binet IQ measure. The second was the Profile in Mood States measure (Educational & Industrial Testing Service, 1971). This measure was taken to determine if mood was a potential mediator variable for the Mozart Effect.

Experimental; participants were randomly assigned to different groups (Mozart, highly repetitive music or silence).

Participants were pre-tested on the PF & C task in the earlier evening hours. Forty-eight hours after the pre-test, participants were exposed to 1 of the 3 experimental conditions and tested again on a different PF & C task (order counter balanced). Finally, participants completed the Mood State questionnaire. Participants completed a paper folding and cutting task (PF & C) from the Stanford Binet IQ measure. Participants’ listened to tape recorded passages of either Mozart’s sonata for two pianos, or Philip Glass’s Music with changing parts, or no music. To control for the possibility that the Mozart effect occurs only due to the elevated mood in which it often puts listeners, investigators measured participants’ mood using portions of the Profile of Mood States (Educational & Industrial Testing Service, 1971).

Results showed that the mean number of correct paper folding tasks was similar across experimental groups (i.e., there was no relationship between type of music and spatial-reasoning performance). When pre-test
performance was used as a covariate, results were similar. However, there was a significant improvement in performance from the pre-test to the post-test. As predicted, the type of music did affect mood state – anger and tension scores were higher for participants listening to Glass compared to Mozart.

The authors suggest that support for the Mozart is a function of the mood in which the music puts participants.

Researchers concluded that there was little evidence to support basing intellectual enhancement programs on the existence of the causal relationship termed the Mozart effect” (pg. 368). The authors discussed issues in the discussion that shed doubt on the existence of the Mozart effect. First, the original researchers are vague as to what types of music should produce the effect (Nantais, 1997 found the effect using Yanni). Second, Rideout, Dougherty, and Wemert (1998) found the Mozart effect was not limited to Mozart’s music. Third, there are complex issues related to the similarity of various dependent measures used and which may show the Mozart effect and which may not.

Dr. John Newman(2002), a neurobiologist at the State University of Albany made a comprehensive test after Shaw’s 1995 follow-up study. Newman criticized Shaw’s 1993 study for having a very small sample size (only 36), so his study consisted of 114 participants. His experiment was designed to replicate the 1993 findings of Rauscher, Shaw, and Ky who reported a positive effect of listening to classical music on spatial reasoning. Newman employed the Raven's Progressive Matrices Advanced Form, then instructed subjects to listen to either 8 minutes of Mozart's music, relaxation tape, or silence (Newman). There was no evidence that the brief music had a different effect on subsequent problem solving according to listeners'
musical background and training. Experiment for Newman changed the intelligence test used to measure the increase in spatial reasoning and altered the duration of exposure to music. Shaw utilized the PFC portion of the Stanford-Binet Test, while Newman used the Raven's Progressive Matrices Advanced Form; Shaw's study exposed the subjects to 10 minutes of Mozart, relaxation, or silence, while Newman's study only allowed 8 minutes of exposure. Since Newman's study was different than the 1993 study done by Shaw et al, there is no standard for comparison between the two studies and thus, Newman cannot fully repudiate the initial findings by Shaw.

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Dr. Rideout concluded in 1996 that the Mozart Effect was valid after monitoring brain waves with an EEG. After receiving criticism for using a very small sample size (8 students) in his 1996 study, Rideout carried out another study one year later with a larger sample size (42 students). However, in the 1997 study, Rideout changed the variables—he changed the silence group to a contemporary music group; The three groups were: (1) listening to Mozart's piano sonata, (2) listening to a contemporary music piece with similar characteristics as Mozart, or (3) listening to a relaxation
tape (Rideout 514). This time, Rideout found that subjects who listened to the relaxation tape scored better than the other two groups. Rideout’s 1997 findings contradicted his study from the previous year; however, he did change the variables from his initial study, which may have affected the results.

**Music, Mathematics and Visuo-Spatial Abilities**

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)

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.
A research, involving first and second graders at two Pawtucket RI public elementary schools, produced strong evidence that sequential, skill building instruction in arts and music, integrated with the rest of the curriculum, can greatly improve children’s performance in reading and math. The study was a collaborative effort of The Music School (in Providence RI), arts specialists in the Pawtucket school system, and the Kodaly Center of America. (1996)

In its first year, the study included ninety-six students, ages 5-7 in eight first-grade classrooms. Four “test arts” classrooms (two each in two schools) participated in a music and visual art program that emphasized sequential skill development and that integrated music and visual art with the rest of the curriculum. Students in the “test arts” classrooms received one hour of music and one hour of visual art per week. Four control classrooms (two in each school) received the school system’s standard visual arts and musical training (one hour of visual arts and forty-five minutes of music in alternating weeks).

After seven months, all students were given standardized first-grade Metropolitan Achievement Tests. Martin Gardiner, research director at The Music School, compared the results with kindergarten achievement test scores for the 83% of students for whom kindergarten scores were available. He found that, although students in the test arts classes had started behind the control students in percentage of students at or above the national average kindergarten Metropolitan Achievement Test scores, they had caught up to statistical equality in reading, and had pulled ahead in mathematics. 77% of those in the “test arts” classes were now at grade level or above in mathematics, as compared to 55% of those in the control groups.
The study was continued the following year in four “test arts” and five control classrooms in second grade at the same schools. Achievement tests were again given after seven months. As in the first year, test and control groups were equal on reading, and “test arts” pupils were ahead on math. The percentage of students at or above grade level in second-grade math was highest in those with two years of the “test arts” program, lower in those with one year, and lowest in those who no “test arts” participation.

Gardiner, a biophysicist, and colleagues theorize that “learning arts skills forces mental ‘stretching’ useful to other areas of learning; the math learning advantage [found in this study] could, for example, reflect the development of mental skills such as ordering, and other elements of thinking on which mathematical learning at this age also depends.”

The “test arts” program (called the “Start With Arts Program”), developed by music teacher Donna Jeffreys and colleagues, was designed to integrate the areas of art and music with classroom subjects such as reading and math, while maintaining the integrity of the arts curricula. The collaborative team believes that the keys to the improvements in math and reading are the sequential skill-building arts curricula and the integration with the rest of the curriculum.

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.

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 song-bells, 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.

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.
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.

Wilson & Brown (1997) attempted to replicate the Mozart Effect using three different conditions (Mozart, relaxation music, and silence). Participants completed pencil-and-paper mazes varying in complexity and size and found that mean number of mazes completed increased, and number of errors was reduced in the Mozart condition. However, they also found that accuracy was increased in the ‘relaxation music’ condition.

The ‘Mozart Effect’ was replicated by Rideout et al., (1998). They used the same piece of Mozart and as a control condition also used a contemporary piece of classical music matched for tempo, structure, melodic and harmonic construction. Participants completed paper-folding tasks
similar to those used in the original study and they showed a similar short-term enhancement of spatial ability in both musical conditions. The authors argued that it does appear to be Mozart per se, which causes the effect, but rather music that has a rapid tempo and fairly high melodic complexity and variation.

Researchers, Flohr and Miller (1999) found that when students listening to classical music in the background scored higher in math than students who were not listening to any music. At the same time, researchers discovered that listening to soft rock, jazz or fast pace background music in the work place can enhance worker productivity and performance efficiency. 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).

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).

A meta-analysis combining six experimental studies provides tentative support for the notion that music training affects mathematical achievement (Vaughn, 2000). However, six is a very small number, and
more research is clearly needed. Several co relational studies do, however, suggest a relationship. For example, one study involving 96 children, ages 5-7 years, found that those who received 7 months of supplementary music and visual arts classes achieved higher standardized mathematics scores than children who received the schools' typical music and arts training (Gardiner et al., 1996).

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.

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.

Another study found that at-risk children who received two years of individual keyboard instruction scored higher on a standardized arithmetic
test than children in control groups, including a group that received computer instruction to rule out a possible Hawthorn effect (Rauscher & LeMieux, 2003). Children who received singing instruction also scored higher than controls. Children who received instruction on rhythm instruments performed best on a mathematical reasoning task.

Marleen Hanson (2003) tried 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 non-spatial (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:

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. According to author, the reasons for the subjects not achieving significance in their performance on a spatial-temporal measure can only be speculative. Perhaps the non significance 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 song bells) 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.

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 (Rauscher et al., 1997; Flohr, Gromko & Poorman, 1998, Taetle, 1999, Flohr 2000). Music instruction may or may not enhance (non spatial-temporal) spatial abilities.

The data from the non spatial 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 non spatial (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.

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 (Rauscher et al., 1997; Flohr, Gromko & Poorman, 1998, Taetle, 1999, Flohr 2000). 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.

Joyce Eastlund Gromko and her colleagues studied the affects music has on mathematical and spatial reasoning. Using sight-reading proficiency tests on high school wind instrument players, they wanted to see if there was any real correlation. They tested students from four Midwest high schools (one rural, one suburban, one east urban and one west urban) on their musical abilities, both rhythmic and tonal, and immediately after tested their spatial ability using rotations and cube comparisons. The results indicated that music and spatial reasoning exercise the same area of the brain that is stimulated by mathematics (Grokmo, 2004).

According to Anne Watson of the University of Oxford, “there are at least four aspects of mathematics that can be related to dance: spatial exploration, rhythm, structure and symbolization” (Watson, 2005). Dance can be used as a mnemonic for memory retrieval. If abstract concepts are acted out in a dance, the mind is more likely to form connections from prior experience to it and help develop it further into long term memory (Watson, 2005).

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.

Through exposure to an early music education, it is possible for young children to understand abstract concepts such as spatial reasoning, which will prepare them to become formal operational learners much earlier on. Besides its pleasantness to the ear, music has some biological affects on the brain as well. Plasticity involves the brain’s ability to change its circuitry early in life, and if one is exposed to music education before age 6 or 7, their neural connections become more strengthened than without (Steinkraus, 2005). A 2001 MRI study indicated that classical music, Mozart in particular, increased the blood flow in areas of the brain responsible for spatial reasoning (Steinkraus, 2005). Blood flow towards one part of the brain indicated whether subjects were listening to a burst of noise or the steady flow of classical music. Cells found in the auditory complex of the brain have shown to be processors of harmonic relationships. The processing of melody and rhythm are separated by specific brain lesions (Weinberger, 1994).

Music and Verbal Reasoning

The review of literature for the effect of music on verbal ability includes all verbal cognitive processes like language, reading, etc.
Crawford & Strapp of State University, Virginia, undertook a research on “Effects of vocal and instrumental music on visuo spatial and verbal performance, as moderated by studying preference and personality”. (1980); they investigated Cognitive performance as a function of 75 dB vocal or instrumental music in 61 university students. Three timed visuo-spatial and verbal tests were used. Vocal music disrupted performance significantly more than instrumental music on the Maze Tracing Speed (scanning speed) and Deciphering of Languages (logical reasoning) tests. Both vocal music and instrumental music disturbed performance more than no music on the Object-Number Test (associative learning and long-term memory), but this was moderated by studying preference. On the Object-Number Test those who typically did not study with music showed deterioration across conditions (no music > instrumental > vocal), while those who typically studied with music performed no better in the no music condition than either music condition.

An early music education has a significant impact on a child’s ability to read. According to a 1975 study published by Hurwitz, Wolff, Bortnick and Kalas, children learned folk songs in order to enhance their melodic and rhythmic knowledge. In comparison to a control group which received no formal training, the experimental group exhibited much higher reading scores than the control group, scoring in the 88th percentile as opposed to the 72nd percentile (Hurwitz, Wolff, Bortnick & Kokas, 1975). After another year of music training, the experimental group scored significantly higher than the control group, indicating that the ability to read is strongly facilitated by music education.

There have been a number of studies done on the effect of music on academic development. It has been shown that high school music students
have higher grade point averages than non-music students in the same school. At Mission Viejo High School in Southern California in 1981, the overall grade point average of music students was 3.59 and for non-music students the overall grade point average was 2.91. This same study also found that 16% of the music students had a 4.0 overall grade point average and only 5% of the non-music students had a 4.0 overall grade point average. A study of graduates of the New York City School of Performing Arts found that 90% of them go on to college.

Fred Hargadon, former Dean of Admissions for Stanford University, in a 1983 interview with Stauffer said, "We look for students who have taken part in orchestra, symphonic band, chorus and drama. It shows a level of energy and an ability to organize time that we are after here. It shows that they can carry a full academic load and learn something else."

Christensen (Biernat) has found that research studies have consistently shown that participation in student activities is beneficial to students. Success in college can be more accurately predicted by levels of individual achievements in student activities (drama, debate, music etc.) than it can from SAT scores, class rank and grades in school. Conversely, studies of dropout students show that these students have had the least amount of participation in school activities.

In a 1993 issue of Educational Psychology, Lamb and Gregory of the University of Manchester's Department of Psychology published the results of their study on the relationship between the ability to discriminate musical sounds and reading performance. "Children achieving high scores on pitch discrimination," they concluded, "also did well on phonemic awareness and showed good reading performance." Lamb and Gregory did not claim that an ability to discriminate pitch differences in children actually causes
improvements in reading performance. To establish this link, a longer, more involved study which tracked children's reading progress over time and isolated training in pitch discrimination from other musical abilities was necessary. Only once these conditions were met could an actual causal relation between musical training and reading ability be established. Given this qualification, Lamb and Gregory concluded that "The educational implication which would follow...is that carefully structured musical training should be an essential component in the primary school curriculum."

Leopold (1998) studied language deficits among musical savants. Savants showed a discrepancy between phonological memory and verbal reasoning abilities. The implications of the findings were discussed in terms of music and language processing and the existence of a unique savant musical profile in savants.

In a research conducted by Costa-Giomi (1999) relationship between music and cognitive abilities was studied through observing the cognitive development of children provided (n = 63) and not provided (n = 54) with individual piano lessons from fourth to sixth grade. There were no differences in cognitive abilities, musical abilities, motor proficiency, self-esteem, academic achievement, or interest in studying piano between the two groups of children at the beginning of the study. It was found that the treatment affected children's general and spatial cognitive development. The magnitude of such effects (omega squared) was small. Additional analyses showed that although the experimental group obtained higher spatial abilities scores in the Developing Cognitive Abilities Test after 1 and 2 years of instruction than did the control group, the groups did not differ in general or specific cognitive abilities after 3 years of instruction. The treatment did not affect the development of quantitative and verbal cognitive abilities.
O’Loughlin (2000) studied the effect of musical intervention on the pre-linguistic communication skills among autistic children. It was found that autistic children’s response to music was positive in increasing attention.

Frick (2000) studied the effect of music on communication development and amelioration of communication disorders. Results obtained were partially supportive of the positive role of music on communication skills.

Berrors (2001) systematically investigated the relationship between spatial ability, musical aptitude and performance and verbal IQ. No significant relationships were discovered. Role of confounding variables like gender was discussed in the discussion of results.

Psychologists at the Chinese University of Hong Kong (2003) studied 90 boys between age six and 15. Half had musical training as members of their school’s string orchestra program, plus lessons in playing classical music on Western instruments, for one to five years. The other 45 participants were schoolmates with no musical training. The researchers, led by Agnes S. Chan, Ph.D., gave the children verbal memory tests, to see how many words they recalled from a list, and a comparable visual memory test for images.

Students with musical training recalled significantly more words than the untrained students, and they generally learned more words with each subsequent trial of three. After 30-minute delays, the trained boys also retained more words than the control group. There were no such differences for visual memory. What’s more, verbal learning performance rose in proportion to the duration of musical training.
Thus, the authors say, even fewer than six years of musical training can boost verbal memory. More training, they add, may be even better because of a “greater extent of cortical reorganization in the left temporal region.” In other words, the more that music training stimulates the left brain, the better that side can handle other assigned functions, such as verbal learning. It’s like cross training for the brain, comparable perhaps to how runners find that stronger legs help them play tennis better – even though they began wanting only to run. Similarly, says Chan, “Students with better verbal memory probably will find it easier to learn in school.”

Chan, along with Yim-Chi Ho, M.Phil., and Mei-Chun Cheung, Ph.D., followed up a year later with the 45 orchestra students. Thirty-three boys were still in the program; nine had dropped out fewer than three months after the first study. The authors now compared a third group of 17 children who had started music training after the initial assessment. This beginner’s group initially had shown significantly lower verbal-learning ability than the more musically experienced boys. However, one year later, these newer students again showed significant improvement in verbal learning.

On the other hand, unlike the music students who stuck it out, the dropouts showed no further improvement. However, although the beginners and the continued-training groups tended to improve significantly, there was one consolation for the dropouts: At least they didn’t backtrack. After a year, they didn’t lose the verbal memory advantage they had gained prior to stopping lessons.

Ho, Cheung and Chan propose that music training during childhood is a kind of sensory stimulation that “somehow contributes to the reorganization-better development of the left temporal lobe in musicians,
which in turn facilitates cognitive processing mediated by that specific brain area, that is, verbal memory.” They contrast their evidence with inconclusive reports that listening to Mozart improves spatiotemporal reasoning, which most researchers have been unable to replicate. At the same time, Chan notes that it’s too simplistic to divide brain functions (such as music) strictly into left or right, because “our brain works like a network system, it is interconnected, very co-operative and amazing.”

Most important, the authors say, “The [current] findings suggest that specific experience might affect the development of memory in a predictable way in accordance with the localization of brain functions. … Experience might affect the development of cognitive functions in a systematic fashion.” More research is needed, but knowledge of this mechanism can “stimulate further investigation into ways to enhance human brain functioning and to develop a blueprint for cognitive rehabilitation, such as using music training to enhance verbal memory.”

A meta-analysis of a set of 24 correlational studies, some involving sample sizes of over 500,000 high school students, found a strong and reliable association between music instruction and reading test scores (Butzlaff, 2000). A meta-analysis conducted on six experimental studies provided little evidence of a causal relationship (Butzlaff, 2000). The effect sizes were highly variable, indicating that the overall finding is not stable. Therefore, it is unwise to conclude that music affects reading ability based on this analysis.

Experimental research performed with 8- to 11-year-old children with reading problems found that the reading skills of children who received music instruction (n = 6) were significantly higher than those of children who did not receive the instruction (n = 6) (Douglas & Willatts, 1994).
However, a study of nine dyslexic boys with a mean age of 8.8 years found that music instruction improved rapid temporal processing skills, phonological skills, and spelling skills, but not reading skills (Overy, 2002). Overall, the studies suggest that it is premature to conclude that music instruction affects reading ability.

Based on 45 reports, researchers found evidence that spatial-temporal reasoning improves when children learn to make music, and this kind of reasoning improves temporarily when adults listen to certain kinds of music, including Mozart. The finding suggests that music and spatial reasoning are related psychologically (i.e., they may rely on some of the same underlying skills) and perhaps neurologically as well (i.e., they may rely on some of the same, or proximal, brain areas). However, the existing reports do not reveal conclusively why listening to music affects spatial-temporal thinking.

In another study, Lawrence Parsons and colleagues at the University of Texas in San Antonio found that an area on the right side of the brain interprets written musical notes and passages. This corresponds to an area in the left brain known to interpret written letters and words.

Eight right-handed faculty conductors were scanned as they read and listened to the score of an unfamiliar Bach chorale. They were instructed to point out errors in rhythm, harmony or melody. "All three tasks activated both left and right brain areas," Parsons said. All three elements also strongly activated the cerebellum -- a small region of the brain responsible for posture, balance, coordination and fine motor movements. Parsons said the understanding of links between musical language and spoken language could help in speech and language rehabilitation. Doctors already use a technique called melodic intonation therapy that teaches stroke patients to
Iris Xóchitl Galicia Moyeda, Ixtlixóchitl Contreras Gómez & María Teresa Peña Flore conducted a study on “Implementing a Musical Program to Promote Preschool Children’s Vocabulary Development” (2006). In light of the correlation between musical and linguistic skills, a program of musical activities was designed to promote discrimination of rhythmic and melodic elements and the association of auditory stimuli with visual stimuli and motor activities. The effects of the program on the vocabulary of preschool children were evaluated and compared with the vocabulary of children participating in the curricular subject of “Ritmos, Cantos y Juegos” [Rhythm, Songs, and Games] and that of children who were not exposed to either of the two programs. The results showed significant increases in receptive vocabulary only for the group exposed to the program with musical activities.

Besides sound sequences, the children in the group that was exposed to the musical intervention program also systematically discriminated rhythms and melodies. These activities may have strengthened the children's skills at identifying, recounting, omitting, and adding syllables and phonemes in oral language, skills that are considered part of phonological awareness. These skills are also known to be involved, not only in vocabulary acquisition processes (Walley, 1993; Bowey, 1996), but also in early reading skills (Bruck & Treiman, 1990; Stahl & Murray, 1994). Also, based on the evidence of the significant correlations of phonological awareness with melody and timbre discrimination and with receptive vocabulary (Anvari, Trainor, Woodside, & Levy, 2002), it can be inferred
that melody and timbre discrimination activities help to stimulate receptive vocabulary development.

A music-based intervention program can also be considered as a resource for stimulating language at the preschool level, similar to that of reading stories. A wealth of evidence supports the relationship between story reading at home and preschool children's language skills. In particular, children's active participation in reading has been shown to increase their receptive and productive vocabulary in comparison to passive reading (Beals, 1997; Wasik & Bond, 2001; Penno, Wilkinson, & Moore, 2002). These strategies have had good results in the classroom; children have been seen to improve not only their command of words used in stories, but also of other words that they were not taught, such as those contained in the Peabody Test (Wasik & Bond, 2001).


According to researchers, although language functions are, in general, attributed to the left hemisphere, it is still a matter of debate to what extent the cognitive functions underlying the processing of music are lateralized in the human brain. To investigate hemispheric specialization, they evaluated the effect of different overt musical and linguistic tasks on the excitability of both left and right hand motor cortices using transcranial magnetic stimulation (TMS). Task-dependent changes of the size of the TMS-elicited motor evoked potentials were recorded in 12 right-handed, musically naive
subjects during and after overt speech, singing and humming, i.e. the production of melody without word articulation. The articulation of meaningless syllables served as control condition. They found reciprocal lateralized effects of overt speech and musical tasks on motor cortex excitability. During overt speech, the corticospinal projection of the left (i.e. dominant) hemisphere to the right hand was facilitated. In contrast, excitability of the right motor cortex increased during both overt singing and humming, whereas no effect was observed on the left hemisphere. Although the traditional concept of hemispheric lateralization of music has been challenged by recent neuroimaging studies, their findings demonstrate that right-hemisphere preponderance of music is nevertheless present. They discuss their results in terms of the recent concepts on evolution of language and gesture, which hypothesize that cerebral networks mediating hand movement and those subserving language processing are functionally linked. TMS may constitute a useful tool to further investigate the relationship between cortical representations of motor functions, music and language using comparative approaches.

**Music and Memory**

Once a melody is encoded with a lyric and well rehearsed, it is an effective recall cue. Supporting evidence is offered by Rubin (1977), who studied the interaction of music with long-term verbatim memory. 31 undergraduates were placed in the right music group ("The Star Spangled Banner"), 32 in the wrong music group ("Stars and Stripes Forever") and 32 in the no music group - and asked to write the lyrics of "The National Anthem." Rubin states: The strongest results cannot be given here in a quantitative fashion. The subjects in the no music condition behaved as most
subjects in verbal learning experiments do, with perhaps more of an expression of frustration. The subjects in the wrong music condition appeared to be in slightly more pain, and a few on occasion put their hands over their ears. Most interesting, however, were the subjects in the right music condition. They would write as fast as they could until the music got ahead of them, and then they would switch to the behaviors of the wrong music condition. By the second or third repetition of "The Star Spangled Banner" almost all of the subjects in the right music condition adopted a strategy of waiting until the music came around to where they had stopped writing the previous time, and then writing another burst until the music got ahead of them again. The effect was quite striking and has since provided an effective classroom demonstration of the role of coding in memory.” (Rubin). Subjects in the right, wrong and no music groups scored an average of 52, 28, and 32 of the 80 words recalled. $F(2,92) = 12.68, p < .001, M_s = 422$. Recall of lyrics is better facilitated by melody (right music group), than by a descriptive title (no music group) and is inhibited by a wrong music cue (wrong music group).

Martin (1994) examined the effects of musical mood induction on recall of childhood memories as a preliminary step in developing an intervention for memory retrieval with abuse victims. Results of the study showed that there were significantly more happy memories in the happy treatment condition than in other conditions. In this study four mood conditions: happy musical mood, sad musical mood, neutral musical mood and no music condition were used.

In a research Marcinkiewicz et al., (1995) studied how Integrating Piano Keyboarding into the Elementary Classroom affected memory skills and sentiment towards school. The researchers discovered that the
introduction of piano keyboarding into elementary school music instruction produced a positive effect regarding children's sentiment towards school. However, no discernible effect was revealed concerning memory skills.

Hardy (1995) conducted a study to examine the effect of music on the immediate recall and understanding of 3 equivalent science lessons delivered by a computer. The results over all did not provide very strong support to the favorable effect of music.

Amuah (1995) studied the role of music behavior, personal factors, environmental factors such as the extent to which musical activities are organized in the home influence primary and middle school students' abilities to remember isolated musical tones. The results of the study indicated that there were positive but low correlations between the number of years spent in the study of a musical instrument and the memory for music. There was a weak but positive correlation between memory for music and music ensemble experience. There was no significant relationship between subject's musical preference and memory for music.

Fretz (1995), in a study: “The Effects of Accelerated Learning on Tertiary Students Learning to Write” investigated how Accelerated Learning (AL), a teaching methodology that purports to increase the quantity and improve the quality of learning, affected tertiary students' knowledge and skills in writing and their feelings towards writing. AL has its origins in G. Lozanov's "suggestopedia." Believing that formal teaching methods were a cause of mental illness or brain sickness, Lozanov began research on how to heal the mind and expand the memory. His research indicated that by stimulating both the left and right hemispheres of the brain, learning could be accelerated. His teaching methodology, called Suggestopedia, uses the power of suggestion, music, relaxation, deep breathing, metaphors, guided
imagery, role-play, and "concert sessions" (reading to instrumental music) to facilitate whole brain learning. The target group for the study consisted of 80 first-year students in business communication in a Singaporean polytechnic. Findings suggest incongruence between the actual outcomes and perceived outcomes: there were no obvious improvements in writing ability amongst the experimental groups; however, students felt that AL affected their learning to write. Students indicated that the methodology had a positive effect on both their ability to write better and their enjoyment of writing. Educators should consider using AL in the classroom and longitudinal studies should be undertaken on the effects of AL on writing.

Hardy and Jost (1996) studied “The Use of Music in the Instructional Design of Multimedia.” This investigation explored the way music operates in the mental processing of computer-supported instructional messages, whose other modes are text and graphics. The experiment examined the effect of music on the immediate recall and understanding of three equivalent science lessons delivered by a computer. The objective properties of the music were manipulated to produce feelings that were congruent with the psychological dynamics of the lessons' instructional strategies. This technique sought to enhance achievement by stimulating multiple (triple) encoding in short term memory. It aligned an abstract musical input, which elaborated subjectively on content, with instructional strategy, which is a subjective lesson element. This research, therefore, proposed and tested a variable, Music-Instructional Strategy-Integration (MISI) element that moderated the instructional treatments. The study also sought subjects' affective evaluations of the lessons accompanied by music as well as their preferences for music in association with academic endeavors. The experimental procedure examined the effects on achievement of three forms
of ninth grade lessons on physical science topics, each of which was
differently moderated by music or ran in silence. The primary analysis of
variance showed no significant statistical results regarding achievement.
There was no statistically significant difference in the subjects' rating of the
musical patterns, and no relationship between achievement scores and
subjects' ratings was found. The subjects were consistent in favoring an
association of music with academic activity. The study found that the
inclusion of music can stimulate positive student affect toward computer-
supported instruction and toward science instruction. It identifies the need
for additional research with multiple encoding, and with literal music, which
depicts content by becoming one of its objective parts.

Sullivan (1996) studied the effects of four mood conditions on three
measures of working memory. Subjects mainly belonging to grades four to
seven were assigned to four conditions of mood induction: negative mood
induced by heavy metal music, positive mood by self referent visual
imagery, neutral mood by a counting task and positive mood by a happy
music. These subjects were then administered memory tasks. Results of
MANOVA indicated that subjects in the happy music condition significantly
out performed peers in the neutral condition.

Wilcox (1996) investigated the effects of classroom singing and music
cues on memory for pronunciation in second language acquisition. The
review of literature supported the influence of music on pronunciation
memory through organizational framework, linear time orders, lowering
affective barriers, repetition, residual learning, expectation, and anticipation
of patterns, resolution cues and anchors for memory. The results of the
present study were found to be in line with the previous information.
Furnham & Bradley, Department of Psychology, University College London, undertook an investigation (1996), to find the effect of music on cognition, particularly memory. The title of their research was: "Music while you work: the differential distraction of background music on the cognitive test performance of introverts and extraverts" The researchers looked at the distracting effects of pop music on introverts' and extraverts' performance on various cognitive tasks. It was predicted that there would be a main effect for music and an interaction effect with introverts performing less well in the presence of music than extraverts. Ten introverts and ten extraverts were given two tests (a memory test with immediate and delayed recall and a reading comprehension test), which were completed, either while being exposed to pop music, or in silence. The results showed that there was a detrimental effect on immediate recall on the memory test for both groups when music was played, and two of the three interactions were significant. After a 6-minute interval the introverts who had memorized the objects in the presence of the pop music had a significantly lower recall than the extraverts in the same condition and the introverts who had observed them in silence. The introverts who completed a reading comprehension task when music was being played also performed significantly less well than these two groups. These findings have implications for the study habits of introverts when needing to retain or process complex information.

A study on music and memory in individuals with Alzheimer-type dementia by Walsh (1997) investigated whether sung presentation of a paragraph facilitates long term retrieval of facts more effectively than text without melody. All 8 subjects resided in a skilled nursing facility and carried a diagnosis of dementia due to probable Alzheimer’s disease. The subjects were administered a hearing screening, a pre-training assessment a
series of eight remediation sessions, and post training assessment. Responses were collected in a naturalistic condition and were then transcribed and categorized according to approach type and presentation and information recalled. Statistical analysis of pre training and post training accuracy reflected an improvement in long term retrieval. These findings suggest that importance of creating songs that emphasize sequential, sung instructions of steps involved in grooming and dressing to offer the Alzheimer population a compensatory strategy that will promote optimal independence with these and other activities of daily living.

Carruth (1997) found that the face-name recognition of Alzheimer's patients significantly improved while listening to music. A study conducted at the University of California found that scores on memory tests of Alzheimer's patients greatly improved when listening to Mozart (Music Therapy, 2001). Elizabeth Valentine found that dementia patients had better memory recall after being exposed to music rather than background noise or silence (Larkin, 2001). As shown, the results of this experiment deviate from much of the literature and research on the effects of music on memory.

A study was conducted by Kaniel and Aram (1998) on the effects of background music on working memory. 300 children in kindergarten, grade 2, and grade 6 participated in the study. It was found that background music improved visual discrimination in a memory task performance at the youngest and middle ages and had no effect on the oldest participants.

Swingler (1998) highlighted that the use of a technology based on music, "Soundbeam MIDI (Musical Instrument Digital Interface) Controller," develops skills such as aesthetic awareness, imagination, listening skills, motor planning skills, memory skills, language skills, and social skills. "Sound beam MIDI (Musical Instrument Digital Interface) Controller," is a
technology which allows even those students who have severe physical disabilities to create interesting aural and musical effects. Sound beam works by emitting an invisible beam of high frequency sound inaudible to human ears.

Tomaino (1998) conducted a qualitative study to see the effects using familiar music to stimulate preserved memory function in persons with dementia. Finding indicates that music memory is still preserved in those with dementia despite language deficits and other cognitive problems.

Wasserman (2000) studied retention among 164 3 months old infants. The purpose was to examine how infants remember information when it is presented in a situation defined by different contextual cues (crib bumper and a musical selection). Among other things it was found that retention under music condition was favorably affected.

The effect of music training on electroencephalographic coherence of pre-school children was studied by deBeus, Roger John (2000). The results indicated that the listening to music condition identified connections including a topographical pattern of auditory analysis, increased working memory activation, increased activity between musically sensitive areas, and increased inter-hemispheric activity.

Noll (2003) in a study to test long term retention of verses from the Bible compared memory for verses through two different methods. In one method the children were made to repeat the verses till they were able to recite them from memory. In the second method the verses were put to song and the children learnt the song and practiced by singing the songs. The two groups were then compared and the researcher concluded that the memorization of verses to song had significant effect on the long-term retention of Bible verses.
In a study conducted by Korenman and Peynircioglu and Zehra (2005), “the Role of Familiarity in Episodic Memory and Meta-memory for Music” was investigated. Participants heard music snippets of varying melodic and instrumental familiarity paired with animal-name titles. They then recalled the target when given either the melody or the title as a cue, or they gave name feeling-of-knowing (FOK) ratings. In general, recall for titles was better than it was for melodies, and recall was enhanced with increasing melodic familiarity of both the cues and the targets. This study supports that music has a positive impact on memory and learning.

“The Effects of Familiar Music, Unfamiliar Music, and No Music on Face-Name Recall in Aging Adults” was studied by Stull, Jara Elizabeth (2005). The purpose of this study was to examine the effects of familiar music, unfamiliar music, and no music on face-name recall in aging adults. Residents from assisted living facilities and individuals living independently served as participants. Sixty participants were randomly assigned to a control group (no music) and two treatment groups (familiar music and unfamiliar music). Participants in treatments one and two heard the names set to either familiar music or unfamiliar music while they viewed the corresponding faces. Participants were invited to sing along as the song was sung three times. Participants in the control group condition heard the names spoken while they viewed the corresponding faces. Participants were then asked to: recall as many names as possible (free recall), given a name, select the correct face from a closed response set of three faces (recognition), and recall the correct name for each face (face-name recall). All sessions were audio taped in order to record participants’ verbal responses. Data taken from these tapes were then analyzed using a one-way analysis of variance (ANOVA) which indicated no significant differences between groups. While
no significant difference was found between the experimental and control groups; the groups that received music had a higher mean score than did the control group. Furthermore, the group with familiar music had a higher mean score than did the group with unfamiliar music. Participants’ comments indicated that music made the recall task more enjoyable.

Sarah E Roy (2006) conducted a study: “The effects of different types of music on cognitive processes.” This experiment looked at the effects of different types of music, namely moderate rock and classical music, on memory and some other cognitive processes. Sixty-one participants, both male and female, ages 18 to 47, participated in this experiment, in which they were asked to complete a brief assessment of memory and two questionnaires. A one-way ANOVA revealed that there was a relationship between the type of music played and performance on the “Memory Game.” The mean score on the “Memory Game” no music condition was 8.44 (SD = 2.63). In the mellow rock condition, the mean score was 7.24 (SD = 1.70). The mean score for the classical music group was 6.88 (SD = 1.90). The mean scores indicate that participants in the no music group performed the best, and the worst in the classical music group. It is worth mentioning here that in this study too, the music was played while the subjects performed the tasks. This could have interfered with their performance causing it to deteriorate.

In a study conducted by Kirkweg (2006) on “The effects of music on memory”, 60 students participated. They were exposed to three types of background sounds namely; white noise, classical music by Haydn, and heavy metal music by Metallica. This study found that there was not a significant interaction between any of the music groups and memory. Although, the white noise group did have the fewest amount of memory
errors. According to the researcher the results can be attributed to the limitations of the experimental itself. Another reason could be that since the music was played simultaneously it could have actually interfered with the performance instead of having a positive effect.

**Music and Creativity**

Gamble, James Arthur (1981) studied the effects of relaxation training and music upon creativity. The purpose of this study was to determine the effect of relaxation training and music background, two components of Lozanov’s Suggestopedia, upon figural creativity. The subjects were divided into three groups: control, music and music and relaxation. (The researchers found significant effects due to treatment on the post test scores of the sum of the five non-referenced creativity variables, figural fluency and originality, using Statistical analysis of the study (ANCOVA) for the pre test and post test of Torrance Test of Creative Thinking- Figural Battery (Torrance 1966) and the State Anxiety Inventory (Speilberger. Gorsuch and Lushene, 1970. In general, the music and relaxation treatment group had the greatest effect, with the music group having the next greatest effect.

Wells, Nancy F. and Stevens, Ted (1984), explored the effect of music as a stimulus in creative story writing in an on going in patient group psychotherapy with young adolescent, age 10-14 years. While short segments of music were played each group member was instructed to compose a story of his or her choice, as the musical selection changed, the stories were rotated among group members to allow each to write part of every story. This technique served as a projective diagnostic tool and as an aid in promoting positive interaction and group cohesion. It was observed that subjects who were scapegoated or rejected by peers in traditional verbal
group psychotherapy, as well as in general in-patient milieu, were more readily accepted as members of the creative expression group through their participation in the exercise.

Wright, Susan (1985), describes a teaching techniques that may be used to help mildly to moderately retarded children learn through instrumental musical experiences. It is suggested that instrumental experiences help intellectually handicapped children develop creativity, self expression, socialization and musical competence. Three stages of musical creativity are described that are characterized by:

1. Exploration, experimentation and imitation.
2. Discrimination, organization and creation.
3. Reorganization, production and conceptualization.

An investigation of the relationship among music audition, musical creativity and cognitive style was made by Schmidt, Charles P. and Sinor, Jean in 1986. They studied achievement in convergent and divergent musical tasks as a function of cognitive style (reflection /impulsivity). The effect of gender and its interaction with cognitive style were also examined. Forty seven second graders were screened according to reflective/impulsive cognitive style, resulting in a sample of thirty four subjects who were given the Primary Measures of Music Audition (PMMA), Measure of Creative Thinking in Music (MCTM) and Matching Familiar Figures Test. Results indicate that (a) reflective subjects had significantly higher PMMA tonal scores than impulsive subjects. (b) PPMA rhythm was significantly negatively related to two dimensions of MCTM; and (c) there was a significant difference of sex on 3 of 4 dimensions of MCTM, with boys scoring higher than girls on all three dimensions- music originality, music flexibility and music syntax.
The effect of participation in a musical theatre music class, and creative thinking skills of middle school students was studied by Perrine, Veronica Beader in 1989. The primary assumption of this study was that participation in a musical production at the middle school grade level can have a positive effect on the students’ self esteem, attitude towards music and creative thinking ability. The results of the study supported the hypothesis that participation in a musical production at the middle school level grade has positive, though not statistically significant results on students’ attitude toward music and encourages the development of some creative thinking skills.

Music educators feel, and have observed, that student involvement in school music has a positive impact on other areas of their lives. These educators will tell you that musical involvement improves a student's self-discipline, dexterity, coordination, self-esteem, thinking skills, listening skills, creative abilities and personal expression. Most music educators, however, are not aware of specific researches that ill support these feelings and observations.

The Gemeinhardt Company conducted two major surveys in the 1980's about the school band movement. They interviewed band directors, music dealers, parents (band and non-band) and students (band and non-band).

In the first Gemeinhardt study, the responses indicate that the majority of people surveyed in all categories recognize many of the benefits a student can receive from being in a band program. Those benefits are: accomplishment, appreciation, discipline, fun, active participation and maturing relationships.
The survey of band parents found that 96% of them agree that "many people don't know or understand the benefits of band." In fact, 95% of the non-band parents surveyed felt that band provides educational benefits not found in other classrooms and that 78% of the same group felt that band is more educational than extracurricular.

Band directors surveyed talk in general terms about the benefits of a band education. These directors list such benefits as: creativity, discipline, teamwork, coordination, development of skills, pride, lifetime skills, accomplishment, cooperation, self-confidence, sense of belonging, responsibility, self-expression, performance, companionship, builds character and personality, improves self-esteem, social development, and enjoyment.

In the second Gemeinhardt study non-band parents, non-band students, drop-out band parents and drop-out band students were surveyed. Among these four groups there is much agreement that band builds self-esteem, self-confidence, and a sense of accomplishment. When given the choices of "Agree a lot," Agree a little," and "Don't agree," 91% of the non-band parents, 90% of drop-out band parents, 79% of non-band students and 82% of drop-out band students chose to "Agree a lot" with the above statement.

In a study by Mohanty and Hejmadi, the effects of a music education on learning and creativity were investigated. Four and five year olds were instructed on learning the names of various body parts, with four different groups using different methods of learning: non-training control, verbal instruction on learning the names by rote, verbal instructions accompanied with an acting out of the movements and music and dance. Their creativity was assessed with the Torrance Test of Creative Thinking. The experimental
groups all performed much better on test scores than the controlled group, but the music and dance group had the greatest improvement on learning the body parts and overall creativity (Mohanty & Hejmadi, 1992).

A consideration of the divergent theoretical viewpoints regarding the relationship between music and cognition and a review of empirical information based on available literature provided the rational and justification for the present study. Information obtained overall revealed the complexity of the relationship between music and cognition, and the researchers as to the different aspects of this relationship. Taking cognizance of all the factual and theoretical, the present study designed to have a more comprehensive exploration of the relationship between music and cognitive performance. Different kinds of music and different dimensions of cognition have been incurred to achieve this end. The main objectives and hypotheses which were formulated, on the basis of overall understanding, are given below:

**Main Objectives of the Study**

- To study the effect of four different kinds of music on performance on mathematical and visuo-spatial tasks.
- To study the effect of four kinds of music on verbal reasoning.
- To investigate the impact of four different kinds of music on memory span for verbal and non-verbal stimuli.
- To assess the effect of four kinds of music on verbal and figural indices of creativity.
- To study the comparative effects of the different kinds of music on the above mentioned cognitive tasks.
Specific Hypothesis of the Study

Researches have tried to conceive and conceptualize the phenomenon of music in different ways. Acoustics of music, phenomenological analysis, psychology of music, neurophysiological basis of music all are legitimate ways to understand music and its effects on human mind. In the contemporary context neurophysiological and neurocognitive approaches are the dominant influences which are regulating the research efforts of scientists in this area. The present study while drawing upon different perspectives has tried to make constructive use of neurophysiological insights in order to apprehend the relationship between music and cognition which is the focus of the present study.

One time honoured controversy in the field of neurophysiology of music has been the differential role of right-left hemispheres versus the integrated holistic working of human brain. Even though the latter view has become more predominant in the recent years, the adherents of the former viewpoint still subscribe to the view that the crucial role of right hemisphere in the processing of music in human brain cannot be ruled out (Sparing et al., 2007).

The present study drawing upon the traditional understanding regarding hemispheric specialization as well as the new researches relating to and integrated working of human mind has tried to from some hypotheses which are described below:

1. Neurophysiological researches suggest that there is a relationship between the way music mathematical and visuo spatial tasks is processed by the brain. This relationship observed when comparing the neural firing patters of the subjects involved with either music or mathematics (Rudd
and Stephen Wayne 2000). This reasoning led to the formulation of the fourth hypothesis as given below:

(a) **Instrumental music has positive effect on performance on mathematical and visuo-spatial tasks, viz., (a) numerical ability, (b) geometrical ability, (c) Space relations.**

2. Neuro physiological researches further have shown that semantic operations (language), logical and reasoning activities are not processed wherein music in processed. Following from these insights it was conjectured that:

(b) **The effect of vocal music is positive on performance on verbal reasoning tasks.**

3. There are evidences indicating that if there is some kind of training in the exercise of skills belonging to same processing region, there will be a positive transfer in the exercise of another set of skills belonging to the same region. Training in calligraphy, for instance, can have positive effect on the acquisition of drawing skills since both the skills have many common elements and have their basis in the same processing regions. (Rudd, Wayne 2000). In the present study we consciously employed music which involved poetry (language). The expectation was that music imbued with semantic symbols will effect those processes which involve semantic concepts or words (language). This led to third conjecture, i.e.,:

(c) **Vocal music has positive effect on memory span for words.**

4. Neuro physiological findings also indicate that music, abstract operations and specifically figures and images are processed in the same region of the brain and can have facilitative effect on each other (Storr 1997). Following from these neuro-physiological insights it was hypothesized that:
(d) **Instrumental music has positive effect on memory span for figures.**

5. Following from the same neurophysiological findings, it is conjectured that since poetic music and semantic creativity, probably are processed in the same region of the brain, it is hypothesized that:

(e) **Vocal music has positive effect on creativity for words.**

6. The insight about the affinity between abstract sounds as used in instrumental music and creation of abstract images, and the way they are processed in the brain, lead to the expectation that:

(f) **Instrumental music has positive effect on figural creativity.**