The Mozart effect and fourth grade spelling test scores

by Laurie Jo Howard

A thesis submitted in partial fulfillment Of the requirements for the degree of Masters of Science in Elementary School Administration
Montana State University

Abstract:
The purpose of this study was to investigate the effect of listening to the music of Mozart on improved knowledge of spelling as measured by Test of Written Spelling, 3 rd edition (TWS-3) gain scores. Two public school classes of fourth grade students were given the TWS-3 as a pretest. Over a twelve-week period, the experimental group listened to 30 minutes of the music of Mozart during a silent reading period prior to receiving instruction in the Cast-A-Spell spelling program. The control group engaged in spelling lessons without listening to music. After the twelve week treatment period, the students were administered the TWS-3 posttest. Mean comparisons and t-tests proved the groups to be statistically equivalent at the beginning of the study in regard to gender, age, knowledge of spelling, and overall academic achievement. At the end of the treatment period, the results of a t-test established that there was not a statistically significant difference between the two groups in fourth grade spelling test scores as measured by the TWS-3. The significance level of the t-score equaled .081 and was tested at a .05 a level and approached significance. The students in both groups were classified as high achieving, average achieving, or below average achieving on the basis of their third grade CTBS total score. An F-test between the three achievement levels indicated that the treatment was not statistically significant between the achievement levels. The most compelling finding of this study was the interaction between treatment and achievement levels across the groups. It was found that low achieving students in the treatment group made significant gains in spelling knowledge as measured by the TWS-3. As improving instruction and learning is the goal of every educational program and strategies to assist all students in the assimilation of curricular knowledge and skill are in demand, academic leaders might wish to consider the possible benefits of music on cognition and behavior. It is recommended that research in this area be continued to achieve a more complete understanding of the role of music in daily memory and its implications to impact other spatial-temporal tasks.

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Laurie Jo Howard

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CHAPTER 1

DEVELOPMENT OF THE PROBLEM

"Music training is a more potent instrument than any other, because rhythm and harmony find their way into the inward places of the soul." Plato

Introduction

Because the English language is a compilation of words from many languages, it lacks a predictable, systematic spelling system rendering it a difficult language to learn and spell. The development of spelling skills has been linked to both phonemic and phonological awareness. Over the years many strategies have been tried to assist the learner of English to encode accurate spellings into long-term memory. The difference in spelling competency can be attributed to the mental strategies utilized to learn the proper spellings of a multitude of words. Successful spellers make use of three modalities when learning to spell: visual memory, auditory memory, and kinesthetic memory.

It has been noted that music has been beneficial to help improve the performance of children in a variety of subjects. Recently, researchers have discovered that musical activity and other higher cognitive functions share inherent neural firing patterns organized in a highly structured spatial-temporal code over large regions of the cortex (Rauscher, Shaw, Levine, & Ky, 1994). According to Jensen, (1998), music can serve to arouse the brain. Depending on the type of music, the activity of attentional neurotransmitters can either increase or decrease, serving to prime the brain's neural pathways. According to Norman Weinberger (as cited in Jensen, 1998, p. 37), "An increasing amount of research findings supports the theory that the brain is specialized for the building blocks of music." New findings indicate that the auditory cortex responds to pitch and tones rather than mere raw sound frequencies. It appears that individual brain cells process melodic contour. Jensen (1998) suggests that music may, in fact, be critical for later cognitive activities.

The utilization of music to facilitate the encoding of spelling words into long-term memory is inspired by the well-publicized "Mozart Effect" study conducted by Rauscher, Shaw, and Ky (1993) at the University of California at Irvine. Their original study demonstrated that listening to a Mozart sonata brought about an increase of 8 to 9 points on the spatial IQ reasoning subtest of the Stanford-Binet Intelligence Scale (Thorndike, Hagen & Jerome, 1968). In their study, Rauscher et al. (1993, p. 611) determined that "there are correlational, historical, and anecdotal relationships between music cognition and other higher brain functions." Rauscher also suggests that listening to music may very well be the single cause of building intelligence (Jensen, 1998).

Research indicates that listening to Mozart before testing is valuable. The research contained in this study attempted to determine if there was a correlation between the spelling test scores of fourth grade students who listened to the music of Mozart prior to receiving instruction in spelling over a 12-week period compared to fourth grade students who engaged in spelling instruction without listening to music.

Problem

The problem addressed in this study was the relationship between listening to the music of Mozart and the spatial temporal task of spelling. This study contributed to the understanding of the relationship between music listening and spelling achievement. The teaching of spelling is problematic no matter what methodologies are used. Research has discovered that certain neural firing patterns are shared by music and other higher cognitive functions. Specifically, this study sought to determine if there was a connection between musical activity and proficiency in fourth grade students' ability to encode correct spellings of the English language into long-term memory. The original "Mozart Effect" study (Rauscher et al., 1993) study was conducted in a laboratory setting with a single ten minute listening period immediately preceding testing. The results of listening to the music of Mozart proved to be statistically significant. However the effect endured for only a 10 to 15 minute period during which the subjects were involved in the spatial task. This study examined the "Mozart Effect" on developing spelling skills over a 12-week period to ascertain whether or not listening to the music of Mozart over an extended period of time prior to engaging in instruction brought about long-term improvement in spelling.

Purpose

The purpose of this research was to determine if listening to the music of Mozart prior to engaging in spelling instruction over a 12-week period would result in a statistically significant improvement in spelling test scores in fourth grade students.

In addition to receiving spelling instruction as specified by the Cast-A-Spell Program (Fontenault & Salter 1993), the treatment group was exposed to the music of Mozart for 30 minutes during a silent reading period prior to receiving the spelling lesson. The music consisted of a variety of compositions by Mozart ranging from violin sonatas and piano music, to orchestral compositions. Mozart's compositions were played for the students in the treatment group in order to ascertain whether or not the music of Mozart 'primed' the brain and provided a positive, nonspecific transfer across domains and modalities. A study by Chan, Ho, & Cheung (1998) found preliminary evidence that music training may have a long-term effect on verbal memory. The research methodologies in this study attempted to determine if passive listening to music rather than overt music learning influenced the performance of fourth grade students in spelling over a 12-week period.

Fourth grade students are generally nine or ten years old. Between the ages of 9 and 11, the bridge across the left and right hemispheres of the brain completes its development. This permits both sides of the brain to respond to an event simultaneously which allows for more thorough processing of the information. According to Campbell's (1997) research, the corpus collosum (the hemispheric bridge in the brain) of musicians is thicker and more fully developed than in non-musicians. Campbell contends that music enlarges existing neural pathways and stimulates learning and creativity. The planum temporale, located in the temporal lobe of the cortex, is also more pronounced in musicians. This area of the brain appears to be associated with language processing and might also categorize sounds, which Campbell suggests is a perceptual link between language and music.

Research Questions

The purpose of this research was to determine is there was a difference in spelling achievement between two fourth grade classes when one listened to the music of Mozart and one the other did not. In order to address the purpose of this research, the following research questions were asked:

1. Was there a difference in spelling achievement as measured by the Test of Written Spelling, 3rd Edition (TWS-3) between the control group and the experimental group after the 12-week treatment period?
2. Was there a difference in spelling gains as measured by the TWS-3 among fourth grade students with below average, average, and above average total CTBS scores?
3. Was there an interaction between treatment and achievement level as measured by gain scores determined by the difference between TWS-3 posttest and pretest scores?

In order to answer to research questions the following analyses were conducted to establish the equality of the two groups.

1. Was there a difference between the control group and the experimental group in gender, knowledge of spelling, academic achievement level, or age at the beginning of study? This was tested by one comparison and three sub-hypotheses.

   Comparison: Was there a difference in the number of males and females in the control group and the experimental group?

   1.1. Was there a difference in spelling achievement as measured by the Test of Written Spelling, 3rd Edition (TWS-3) between the control group and experimental group prior to the treatment?

1.2. Was there a difference in academic achievement between the control group and experimental group as measured by their third grade CTBS total scores?

1.3. Was there a difference in mean age between students in the control group and students in the experimental group?

2. Was there a difference in gain scores between the groups at the end of the study? This was tested by two sub-hypotheses:

2.1. Was there a difference in spelling achievement from the pre-test to the posttest as measured by the TWS-3 in the control group?

2.2. Was there a difference in spelling achievement from the pre-test to the posttest as measured by the TWS-3 in the experimental group?

Definition of Terms

The following definitions were used in this research.

Cast-A-Spell Program	A spelling program developed by Diana Fontenault and Norma Salter in 1993 that teaches students effective mental strategies required in learning to spell the English language well. It requires daily mental training utilizing auditory, visual, and kinesthetic modalities to assist the student to encode accurate spellings into long-term memory.
California Test of Basic Skills (CTBS)	A nationally normed scholastic achievement test.
Fourth Grade Student	A person, usually between the ages of eight and ten enrolled in a public school, and in the fifth year of instruction. Developmentally, fourth grade students are beginning to establish mechanisms for concrete operations. They are able to focus on academic and social independence and utilize problem-solving techniques applicable to daily living. Grade four students, being inquisitive by nature, demonstrate self-motivation in their desire to expand their knowledge and skill academically as

	well as socially. Some are willing to take risks to generate their own solutions to problems that present themselves.
High Achieving Fourth Grade Student	A fourth grade public school student whose total score on the third grade CTBS was between 81 and 99.
Average Achieving Fourth Grade Student	A fourth grade public school student whose total score on the third grade CTBS was between 66 and 80.
Below Average Achieving Fourth Grade Student	A fourth grade public school student whose total score on the third grade CTBS was below 65.
Mozart Effect	A scientific method that explains how the use of music can improve memory, strengthen listening skills, and lead to a more harmonious way of life.
Pre-cortical priming	A phenomenon that takes place in the cerebral cortex of the brain wherein the columnar networks of the cortex are prepared for use or action by environmental stimuli, which activate neurotransmitter firing across multiple areas of the brain.
Test of Written Spelling 3rd edition (TWS-3)	A nationally normed spelling test administered through dictation that measures spelling competency for words that conform to rules and generalizations (predictable words) and words that do not conform to rules (non-predictable words).

Summary

This study focused on fourth grade students who were in their second year of instruction in the Cast-A-Spell Program (Fontenault & Salter, 1993). It was designed to study the relationship between listening to the music of Mozart prior to engaging in spelling instruction and improvement in spelling test scores as determined by a pretest and posttest score on the TWS-3. It was inspired by the highly publicized "Mozart Effect" which resulted from the findings of an innovative study conducted by Rauscher et al. (1993) at the University of California at Irvine. In the Rauscher et al (1993) study, 36 undergraduates from the psychology department scored 8 to 9 points higher on the spatial IQ portion of the Stanford-Binet intelligence test after listening to 10 minutes of *Mozart's Sonata in D major K488*, for two pianos. In the original study, the effect lasted only 10 to 15 minutes.

Proponents of the findings claim that music can stimulate learning, improve memory and strengthen listening skills. With their compelling findings, Rauscher et al.(1994) propose that public schools make use of the Mozart Effect when designing curriculums. They advocate the implementation of educational methodologies that can optimize the effect and integrate music training with standard higher cognitive training. They go on to say that further research is needed to add greater understanding of the neurophysiological relationships existing between music and cognition.

Therefore the purpose of this study was to ascertain if there was a relationship between listening to Mozart over a 12-week period prior to engaging in spelling instruction and improved spelling performance on the TWS-3 by fourth grade students in a public school setting.

CHAPTER 2

REVIEW OF THE LITERATURE

Introduction

The intent of this study was to determine if there was a relationship between listening to the music of Mozart prior to receiving spelling instruction and improved spelling in fourth grade students as demonstrated by performance on the TWS-3, which was administered as a pretest and again as a posttest after a 12-week treatment period.

Music has been considered a tool to prime the brain's neural pathways which serves to alter the state of learners and can, therefore, affect learning. Jenson (1998), proffers that music can enrich the ability to learn in three ways: to serve as an arousal agent, to act as a carrier of words, and to prime the brain for further stimulation. It has been suggested that the symmetries and patterns attributed to music might be fundamentally connected to the symmetries and patterns researchers have tracked in their study of brain waves. It is proposed that music taps into a structure inherent in the brain and might ultimately be a kind of fundamental or prelinguistic speech (Linton, 1999). Because Mozart was composing at a high level at a very young age, researchers determined it more plausible that his music, more than any other, could tap into the brain's inherent structure for patterns.

The data obtained in this study were used to determine if there was a relationship between listening to the music of Mozart with its complex melodic patterns and improved performance in spelling among fourth grade public school students as measured by posttest scores on the TWS-3.

Brain Basics

Recently brain researchers have discovered that musical activity and other higher cognitive functions share inherent neural firing patterns organized in a highly structured spatial-temporal code over large regions of the cortex (Rauscher, Shaw, Levine, & Ky, 1994). According to Shaw (Rauscher, et. al, 1994) "We suspect that complex music facilitates certain complex neuronal patterns involved in high brain activities like math and chess. In 1993 Rauscher, Shaw, and Ky noted a temporary improvement of 8 to 9 IQ points in spatial reasoning scores after subjects were exposed to a Mozart piano sonata. Control groups heard a relaxation tape or nothing at all. The findings were subsequently dubbed the Mozart Effect and have been used to suggest that studying music will provide long-term benefits. Proponents of the Mozart Effect contend that common neural firing patterns may underlie these typically right-hemispheric cognitive activities (Leng & Shaw, 1991). A study conducted by Rideout and Laubach (1996), suggested that the ability of music to influence spatial performance occurs by its ability to facilitate specific changes in brain state and associated EEG power.

Evidence such as that found by Rideout and Laubach (1996) indicates that certain environmental stimuli serve to "prime" the brain for subsequent activities. A body of research posits that exposure to complex musical compositions excites cortical firing patterns similar to those used in spatial-temporal reasoning (Nantais & Schellenberg, 1999). Gordon Shaw (as cited in Spencer, 1998, p.23), one of the researchers in the original Mozart Effect study, believes that music modifies circuits in the brain, including some that have no obvious connection with music. He says, "Music improves the hardware in the brain for thinking." In order to more fully comprehend the type of cortical priming referred to throughout this document, a review of brain basics is in order.

The adult human brain, on average, weighs about three pounds and is about the size of a large grapefruit. It is comprised of 78% water, 10% fat, and 8% protein. Basically, the human brain/mind has seven functions: sensory and perceptual, cognitive, planning movement and motor coordination, feedback and evaluation of behaviors, motivational and hedonic, learning, and memory. The three main parts of the brain--the brainstem, the limbic system, and the neocortex--integrate to carry out these seven functions.

The brain stem is a finger-sized structure located at the top of the spinal cord. It regulates basic body functions such as circulation, respiration, appetite, digestion, sexuality, and fight-or-flight-behaviors. A small structure called the reticular formation is located at the top of the brain stem. It is the regulator of consciousness, sleeping/waking patterns, arousal, and attention.

Folded around the brainstem in the middle of the brain is the limbic system. It is composed of several interconnected thumb-sized structures that emerge out of the cerebral cortex. The limbic system is responsible for emotions, sleep, attention, body regulation, hormones, sexuality, smell, and production of most of the brains chemicals (Jensen, 1998). The limbic system structures that process emotion and memory are the amygdala, hippocampus, and the thalamus and hypothalamus. The interaction of these structures plays an important role in processing both emotion and memory. This is key to how learning takes place.

The amygdala are two almond shaped structures that connect the sensory-motor systems and autonomic nervous system that catalogue emotional memory. According to Sylwester (1995), emotion is an important ingredient in many memories. Thayer (as cited in Sylwester, 1995) found that memories formed during a specific emotional state tend to be easily recalled during events that provoke similar emotional states. Nantais and Schellenberg (1999) conducted a study entitled, "The Mozart Effect: An Artifact of Preference." Their findings indicated that improved performance on spatial-temporal tasks is not a consequence of listening to music, but rather of listening to auditory stimulus deemed pleasant or positive to the listener. The study points to the well-known psychological phenomena discovered by Schachter (as cited in Nantais & Schellenberg, 1999, p. 6) that "emotional states consist of qualitative, cognitive aspects, with mood associated with the former and arousal with the latter."

The hippocampus is located next to the amygdala and converts important short-term experiences into long-term declarative memories that are stored in the cortex. The walnut sized thalamus sorts incoming information and serves as the brain's relay station. The adjoining pea-sized hypothalamus sorts internal information and regulates appetite, hormone secretion, digestion, sexuality, circulation, emotions, and sleep.

The outer covering of the brain is the cerebral cortex and comprises a critical portion of the nervous system. It receives, categorizes, and interprets sensory information; makes rational decisions; and activates behavioral responses. The cerebral cortex comprises 85% of the brain and is made up of six distinct layers of neural tissue that is generally referred to as the gray matter. The cortex is organized into several hundred million neural networks that are arranged in vertical columns of neurons and extend through the six cortical layers (Sylwester 1995, p. 47). Each such column processes a very small segment of a brain function such as responding to a specific unit of sensory information in the surrounding environment. Adjacent columns may combine to form a module that processes more complex aspects of the function. Axons extend down the column through the cellular layers, then move horizontally along the *white matter*, a dense web of axon connections beneath the gray matter. Eventually, the axons leave the white matter to connect with neurons in a related nearby column or to project into another brain area. These complex patterns of connected columns allow sounds to become phonemes that become words that become sentences that ultimately make stories. Scientists believe that complex cognitive behaviors are created from combinations of basic columnar units. According to Wills (as cited in Sylwester, 1995, p. 49), "These columns, not individual neurons, are the fundamental unit of structure of the cortex."

The cerebral cortex is divided into left and right cerebral hemispheres connected by 250 million nerve fibers called the corpus collosum. The left hemisphere processes information more in parts and sequentially while the right deals with wholes and is more spatial. In the vast majority of people, the left hemisphere of the brain is dominant in the production and comprehension of language (Schlaug, Jancke, Huang, & Steinmetz, 1995). Imagery produced by positron emission tomography (PET) has documented left hemispheric activation sites during phonological, lexical, or semantic language task performance (Schlaug et al., 1995). Pantev et al. (1998) replicated the finding of Schlaug et al. and found that there is indeed a structural enlargement of the planum temporale of the left hemisphere in musicians compared with non-musicians. Pantev et al. (1998, p. 813) went on to postulate that there is a "use-correlated functional property with cortical architectonics and raised the possibility that musical experience during childhood may influence structural development of the auditory cortex." Musical novices experience right hemispheric preponderances for melodic and pitch perception whereas musically trained or gifted individuals process this information in the left hemisphere. The study conducted by Chan et al. (1998) reported, ". . . that the left planum temporale regions of the brain is larger in musicians than in nonmusicians." Preliminary indications are that this is a result of a change in cortical organization, possibly resulting in better-developed cognitive function in the left temporal lobe than in the right temporal lobe in the brains of musicians. Likewise, high-level mathematicians and chess players process in the right hemisphere, whereas beginners process in the left hemisphere. The right hemisphere deals with negative emotions and the left with positive emotions. Although differentiation of tasks does occur, the hemispheres collaborate on most tasks, and the corpus collosum synchronizes the activities (Sylwester, 1995).

Scientists have identified four lobes of the brain: the occipital, frontal, parietal, and temporal. Located in the area of the forehead is the frontal lobe that is associated with judgment, creativity, problem solving, and planning. The parietal lobe is on the top back area and is responsible for processing higher sensory and language function. The temporal lobes above and around the ears are responsible for hearing, memory, meaning, and language (Jensen, 1998). As is the case with most brain functioning, the functions of the lobes overlap.

Neuroscientists believe that learning begins in the brains cells themselves. There are two kinds of brain cells: glia and neurons. The glia outnumber the neurons 10:1. They carry nutrients, speed repair, and regulate the immune system. The neurons are responsible for information processing and converting chemical and electrical signals back and forth. The neuron receives stimulation from its branches, known as dendrites, and communicates to other neurons by firing as nerve impulses along an axon (Jensen, 1998).

Learning and memory are conjunct to neuroscientists. Hebb, (as cited in Jensen, 1998), posits that learning occurs when a cell requires less input from another cell the next time it is activated. The functional connections between brain cells are their synapses. According to Jensen (1998, p.15), "The key to getting smarter is growing more synaptic connections between brain cells and not losing existing connections." Active synapses are strengthened, and inactive synapses are weakened.

It is thought that the short-term memory process functions through temporary synchronized firing patterns that emerge between related networks in the thalamus, a structure in the limbic brain, and the cortex. The thalamus deals with the current stimulation and the cortex with related memories. The more rapidly firing, synchronized thalamus-cortex networks become foreground (stimulatory) information, and the less active neural networks become background informational (contextual).

There are two types of long-term memory--declarative and procedural. The principal brain mechanisms involved in processing declarative memories are the hippocampus in the limbic system and the temporal lobes of the cortex. The hippocampus organizes the information and the cortex stores it. Procedural long-term memories are processed in the limbic brain structure known as the amygdala (the brain's emotional center), the cerebellum (located in the back of the brain), and the autonomic nervous system (which regulates circulation and respiration). Procedural memories almost always involve an alteration of the muscle system.

The Mozart Effect

For centuries music has been held as one of the hallmarks of a civilized society. Human intelligence and its link to music have been the source of contemplation since the classical discoveries of the ancient Greek philosopher and mathematician, Pythagoras. Because music is constructed from musical intervals that are defined by mathematical ratios, Pythagoras argued that music was divine. Plato, in his attempt to describe the perfect state in *The Republic*, suggested that music encodes ethical conduct into the human soul and fosters harmonious societal relationships. The notion that music has properties and powers that can sharpen the mind and transform the soul formed the basis of Confucian civilization in China (Linton, 1999).

Through the course of history, music has served many purposes such as coordinating physical labor with a work song and keeping an army in step with a march. A melodic phrase can assist in the memorization of the alphabet just as a bugle can signal a military retreat. Music composed with the intent of aesthetic expression can induce emotional self-reflection, self-illumination, and expression. But can it excite and elicit supreme powers of learning? Rauscher, Shaw, and Ky (1993, p. 611) state: "There are correlational, historical and anecdotal relationships between music cognition and other higher brain functions."

In October of 1993, Rauscher, Ky, and Shaw submitted a "modest letter" to the British journal *Nature*, describing their study to test the hypothesis that listening to classical music enhances spatial reasoning. They used a within-subject design and rotated 36 college students through 3 experimental conditions, each lasting about 10 minutes. The conditions were sitting in silence, listening to a highly repetitive minimalist recording by Philip Glass, and the first movement of the *Mozart Sonata in D, K448* for two pianos. Following each treatment, subjects were administered a subtest of abstract-visual reasoning from the Stanford-Binet IV Intelligence Test (Thorndike, Hagen, & Jerome, 1986). According to their report, listening to the Mozart caused a significant improvement of almost 9 IQ points in the spatial reasoning of college students. They tempered this by adding, "The enhancing effect of the music condition is temporal, and does not extend beyond the 10 to 15 minute period during which subjects were engaged in each spatial task" (Rauscher et al. 1993). They discussed the need for more research.

Two replication studies conducted by Rauscher, Shaw, Levine, and Ky (1994), tested the causal relationship between music and spatial task performance. The first showed that listening to a Mozart sonata induced subsequent short-term spatial reasoning facilitation in college students. The second was a continuation of a 1993 pilot study that suggested that music training of three-year-olds provides long-term enhancements of non-verbal cognitive abilities already present at significant levels in infants. As in the pilot study, the group that studied music showed significantly higher scores on Object Assembly tasks than those of the no-music control group. With their compelling findings, Rauscher and others (1994) proposed that public schools make use of the Mozart effect when designing curriculums. They advocated the implementation of educational methodologies than could optimize the effect and integrate music training with standard higher cognitive training. They went on to say that further research was needed to add greater understanding of the neurophysiological relationships existing between music and cognition.

Physicist Dr. Gordon Shaw (as cited in Carroll, 1999, p. 1), one of the researchers of the original Mozart Effect on spatial-temporal reasoning study, said: "We have this common internal neural language that we're born with and so if you can exploit that with the right stimuli then you're going to help the brain develop to do things like reason."

Frances Rauscher, one of the authors of the three previously mentioned studies, is a former concert cellist and an authority on cognitive development. In an effort to support her findings from the original study, she exposed rats to different types of audio stimulation in utero and again 60 days after birth after which they ran a spatial maze. The rats that were exposed to the music of Mozart completed the maze faster and with fewer errors. Subsequently, the brains of the rats were removed for neuro-anatomical examination to determine what had changed as a result of the exposure. She postulates (as cited in Carroll, 1999, p. 1): " . . . this intense exposure to the music is a type of enrichment that has similar effects on the spatial areas of the hippocampus (associated with the long-term cataloguing of factual memories) of the brain." Should this prove to be a causal relationship, the use of music to facilitate the encoding of spelling words into long-term memory may prove to be an effective tool.

Rideout, Dougherty and Wernert (1998) performed a replication of the initial Rauscher et al. (1993) studies in February of 1998 with results similar to the original. They chose 32 adult subjects, divided into 8 groups, for their study. In their laboratory, the so-called 'Mozart Effect' was replicated in the context of an examination of EEG noting the change in performance and then repeated with a larger sample. Both studies used paper-folding-and-cutting items from the Stanford-Binet) as the dependent measure. (Rideout et al., 1998). The first movement of Mozart's Sonata for Two Pianos was used. Though the tasks employed are considered a measure of visual reasoning, the requirements for internal spatial manipulation are also clear. Analysis of the results yielded reliably higher mean correct responses on the spatial task with each music stimulus.

Klein (1998) found that music could have a positive effect on the coordination of children with special needs. Her study indicated that using Mozart's music had a facilitative effect on the ability of children to concentrate and perform with greater coordination in science classes.

The research of Winner and Hetland (1999) claims that the study of the music of Mozart improves the overall academic performance of children as evidenced by higher S.A.T. test scores. A study conducted by Lewis Thomas (Miller & Coen, 1994) examined the undergraduate majors of medical school applicants. He found that 66% of music majors who applied to medical school were admitted--the highest percentage of any group. Forty-four percent of biochemistry majors were admitted (Miller & Coen, 1994).

Bolton (2000) reports that some students and faculty at Hudson Valley Community College in upstate New York believe that people learn better while listening to the music of Mozart and other composers from the same period. In order to take advantage of these claims, the school has established a Mozart Effect Study Area. A peaceful room in the campus library features background music composed from approximately 1700 to 1825. "A test run for a few weeks last spring showed a profound improvement in many students' performances" (Bolton, 2000, p. 1). Freshman Ryan Naylor (as cited in Bolton, 2000, p. 2) said he: "seeks out the Mozart Effect Study Area because it is quiet, relaxing, and there isn't a lot of disturbing activity. The music is there but it's just in the background." The librarian at the school agreed that the calm, quiet environment induced students to really work.

Three groups of high school students volunteered to participate in a study to see if listening to Mozart would bring about an improvement in test scores. Ten minutes prior to taking the same test, one group listened to pop music, a second group listened to Mozart, and a third sat in total silence. The group that listened to Mozart scored higher (Online Math Applications, 2000).

Gardiner, Fox, Knowles, and Jeffrey (1996) investigated if learning in first grade children improved by arts training. Ninety-six first graders aged 5-7 years participated in the study. Students were divided into two groups based upon First-Grade Metropolitan Achievement Test scores. The control group had the higher scores, and the test group had scores lower than the control group. The test group received 7 months of training in a music and visual arts curriculum that emphasized sequenced skill development on visuospatial reasoning. At the end of the treatment period, the test group had caught up on reading and was ahead in mathematics. The authors (Gardiner et. al., 1996) suggest that the pleasure of arts promotes the acquisition of skills which in turn motivates the acquisition of other difficult skills.

A study by Botwinick (1997) found that there was a gain on the spelling test scores of first grade students when they listen to music just prior to receiving instruction in the spelling of phonetically generalized words. The students in this study listened to the classical music of Mozart, the baroque music of Vivaldi, and five symphonically arranged Disney tunes over a six-week period. Even though the results were statistically insignificant, students showed greater achievement when they listened to the music of Mozart than when they listened to Vivaldi or symphonically arranged Disney tunes. The findings of the Botwinick study suggested that student motivation and interest were increased when a musical listening period was provided prior to a spelling lesson. The greatest improvement came when students listened to the music of Mozart. In her conclusions, Botwinick (1997) suggests that achievement in spelling test scores may be improved if students listen to the music of Mozart prior to instruction in spelling. She recommends additional studies conducted over a longer period of time to test whether or not a statistically significant improvement in spelling test scores might be found.

In his book, *Frames of Mind: The Theory of Multiple Intelligences*, Howard Gardner (1983) posits that the brain is intended to process seven distinct forms of intelligence. He has subsequently acknowledged an eighth intelligence, the naturalist intelligence that refers to the ability to recognize and classify plants, minerals, and animals. Gardner (1999, p. 8) defines intelligence as, "... the human ability to solve problems or to make something that is valued in one or more cultures." These intelligences allow innate cognitive capabilities to focus on the important problem areas that confront the brain. As in most brain functioning, Gardner (as cited in Sylwester, 1995) argues that the seven systems are highly interrelated and yet each system is also autonomous in that distinct brain areas are dedicated to processing its function. As the problems encountered in life contain temporal, spatial, and personal elements, Gardner contends the brain (primarily the cortex) can effectively process these three types of challenges. According to Gardner

(1983, p. 123), " . . . the localization of musical capacities in the right hemisphere has suggested that certain musical abilities may be closely tied to spatial capacities."

Gardner (1983) draws upon the work of Noam Chomsky to illuminate the significant parallels between music and language. Gardner (1983) compares Chomsky's analysis of the generative structure of language to the generative aspects of musical perception and production. Although not all aspects of language are directly analogous to music, according to Gardner (1983, p. 125), "there do seem to be nontrivial parallels in the modes of analysis which seem appropriate for natural language on the one hand, and for Western classical music (1700-1900), on the other." Gardner (1983) contends that competence in one of the seven spheres of intelligence need not be related to competence in others. He suggests that students who are having difficulty in a certain subject might rely on their strengths in other areas to overcome difficulties encountered in learning. He advocates linking the multiple intelligences with a curriculum focused on understanding in an effort to catapult students to a higher level of comprehension and skill.

In an interview with Scherer (1999), Gardner said: "I advocate teaching those disciplines that will present to students their culture's image of what is true and not true, beautiful and not beautiful, ethical and immoral." Three topics he would choose to focus on are the Holocaust, evolution, and Mozart. As a child, Gardner was a serious piano player whose favorite music was that of Mozart. In his new book, *The Disciplined Mind*, Gardner (1999) makes reference to what he calls the existentialist intelligence. Gardner explains to Scherer (1999) that: " . . . this term denotes the human proclivity to ask fundamental questions about life: Who are we? Where do we come from? Why do we die? What are some of the wonderful things of which humans are capable?" His answer to the last rhetorical question is the music of Mozart.

Why the music of Mozart? Drs. Rauscher and Shaw (as cited in Campbell, 1997, pp. 28-29) selected Mozart's music for their research because, "Mozart was composing at a young age and was exploring the inherent repertoire of spatial-temporal firing patterns in the cortex." The researchers also suggest that the complexity of the music is the key to higher test scores (Miller & Coen, 1994).

In the 1950's Dr. Alfred A. Tomatis, a French Ear Nose and Throat specialist, developed a training method with the lofty purpose of being able to "reeducate the way we listen and to improve learning, language abilities, communication, creativity and social behavior" (Sollier, 1996, p 2). He established numerous centers in which his method continues to be offered today, and claims for proven results abound. The Mozart Effect, so named by Tomatis, can be defined as the increase in spatial-reasoning performance immediately after exposure to a Mozart piano sonata" (Steele, Bass, & Crook, 1999, p. 1). According to Tomatis (as cited in Campbell, 1997), the music of Mozart calms listeners, improves spatial perception, and facilitates clear, expressive communication. In an attempt to explain why the music of Mozart seems to have unique properties that elicit improved brain functioning, Tomatis points to the music's pure simplicity and high frequencies. He states that high-frequency sound energizes the brain, releases muscle tension, and balances the body (Ostrander, Schroeder, & Ostrander 1994). Campbell credits Tomatis with demonstrating that Mozart's music, above all, was the most effective in calming, improving spatial perception, and allowing the listener to "communicate with both heart and mind." Tomatis's theory evolved around the neurophysiology of the listening process in a complex way that describes a connection with the function of the ear and its connection with the voice. He claimed that high-frequency sounds energize the brain, whereas low frequencies were draining. Much of his work dealt with voice and ear training; such luminaries as Maria Callas came to him for help (Sollier, 1996). Though Sollier claims the Tomatis method to be very effective and quotes a number of studies as substantiation, it is not clear whether he has simply included the "Mozart Effect" in a broader statement, or if he considers it significantly established as a proven method for gaining long-term improvement in learning.

Long before Tomatis began his research, physiological research conducted in Bulgarian and Soviet laboratories charted exceptional mental and physical benefits from classical music. They found that the music of Mozart yielded high-power results in facilitating learning. Lozanov developed a method of using music to accelerate learning and enhance memory and called it "Suggestology." He made a comprehensive study of suggestion, imagery, and relaxation. Music was used to create external conditions that placed " . . . the students in the same state of mental pseudopassivity that they would be at a concert—listening serenely to the musical program and to the new material being given them to learn" (Lozanov, 1995, p. 269). He found that the use of background music facilitated the learner's ability to assimilate new material and demonstrated this with the memorization of spelling, poetry, and foreign words. Lozanov found that the best music for learning was that of the violin and other string instruments rich in harmonic overtones and pulsing at 64 beats per minute. He found that certain music could slow down brainwave activity to the alpha level of 7-13 cycles a second and bring body rhythms to a more restful level. With his method of breaking up information into

4-second data chunks against a background of instrumental string music, reciting the data chunks improved overall memory and accelerated learning. Through the course of his research, Lozanov discovered that brainwaves receive concrete information in both highly stimulated and extremely relaxed states. Lozanov (as cited in Campbell, 1997, p.183-184) concluded, "When information is coded in both the conscious and unconscious minds access to memory is far greater." Students find *Suggestopedic* sessions to be a source of aesthetic pleasure.

Ostrander, Schroeder, and Ostrander (1994) capitalized on the earlier physiological research in Bulgarian and Soviet labs and developed their own "Superlearning" techniques to accelerate learning and enhance performance. To maximize learning the "Superlearning" program advocates the following techniques:

1. Get into a stress-free, "best" mind body state for what is to be done.
2. Absorb information in a paced, rhythmic way.
3. Use music to expand memory, energize the mind, and link to the subconscious.
4. Engage the whole brain, senses, emotions, and imagination for peak performance.
5. Become aware of blocks to learning and change, and then flood them away.

Lozanov noticed that music helped to regulate heart beat and blood pressure. Like Lozanov, the "Superlearning" technique advocates slow Baroque music with a 60 beat per minute tempo to open a communication link to the subconscious mind, expand memory, and harmonize right and left brain. To the contrary, up-tempo high frequency music gives a powerful energy boost to the cerebral cortex to help charge up and rebalance the brain and body. "Research shows that after listening to high-frequency music for a certain length of time, the brain seems to become harmonized, energized, and sharpened" (Ostrander et al., 1994, p. 127). When reading textbooks and noting key material, Lozanov advocates the music of Mozart and Beethoven because meshing text material with this particular music linked right and left hemispheres of the brain and gave the data a global imprint in memory (Ostrander et. al., 1994). Relying upon the research of Lozanov, the "Superlearning" technique advocates learning with these two specific kinds of music to speed learning 2 to 10 times.

Research conducted by Iwanga, (1995) indicates that subjects tend to prefer tempos close to those of their own heart rates. Burke and Gridley (1990) conducted a study to ascertain the relation between listeners' musical sophistication and musical preferences. The data they obtained corroborated the findings of others that familiarity contributes to musical preferences. Listeners who had greater exposure demonstrated greater fondness for the musical stimuli in the experiment.

Today more than ever, music is being credited with the power to raise performance levels and productivity by reducing stress and tension. Campbell, who championed the idea, is greatly responsible for the rapid spread of this popular notion. In his book, "The Mozart Effect" Campbell (1997) suggests exercises for using music to strengthen memory and learning, boost productivity and performance, and even enhance romance and sexuality. He further points to ways in which music has historically fostered endurance, generated the feeling of well-being, promoted a sense of safety, and enhanced unconscious receptivity to symbolism. It would appear that Campbell's training is that of a classical musician; there is little indication that his training in scientific discipline goes to more depth than careful review of the literature. However, he has done his homework. He draws from Plato's *Symposium* as well as from Socrates to demonstrate that his theories have been drawn from the ancients and have deep historic roots. His review of work done at the University of Washington indicates positive effects of listening to light classical music. He states that the specific rhythms, melodies, and high frequency qualities of the music of Mozart stimulate and "charge the creative and motivational regions of the brain" as well as promote greater concentration for extended time periods. It is clear that his research of existing support for his theses has been thorough. Campbell quotes work of Tomatis extensively for his basis for proving causality between long-term improvement and exposure to music. This new craze for the Mozart effect relies on its purported remedial powers to quickly improve intellectual skills. In his book, *The Raising of Intelligence*, Spitz (as cited in Steele, Bass & Crook, 1999), demonstrates how difficult it is to produce even a small, short-lived intellectual gain. Upon consideration of the duration and depth of interventions typically implemented to improve IQ, Spitz questions the potential of brief music listening to affect a significant improvement in IQ.

In 1996 Goehegan and Mitchelmore compared two small groups of preschool children at school entry. Thirty-five were already involved in a "music program treatment" and 39 had no musical experience. In both the initial study and a more refined repeat of the study (that divided the group of children with prior musical experience into those with and without home music), the positive effect of music was indicated. The children were compared on the Test of Early Mathematics Ability-2 (TEMA-2). "Initial results indicated that the music group had higher TEMA-2 mean scores than children without musical experience." In the follow-up study:

> There were no differences in mathematics achievement between the comparison group and the experimental group without music at home. The experimental group with music at home scored higher in mathematics achievement than the experimental group without music at home. Two home music activities were related to

mathematics achievement: listening to their own music collection, and listening to a family member sing to them. (Goeghegan & Mitchelmore, 1996).

In 1997 Cash, El-Mallakh, Chamberlain, Bratton and Li studied 34 adult subjects administering a series of cognitive tasks in a fixed order (letter cancellation, Trails A & B, Digit-Symbol, and Digit-Span recall). One group listened to 9 minutes of Canon in D by Pachelbel and the other to Celeste, Movement Two by Bartok. "While the mean performance improved after music, the change was not statistically significant but was consistently greater after the music by Pachelbel than by Bartok. These data suggest that one of the musical variables that affect cognitive performance may be the structure of the piece. Longer exposure is likely necessary" (Cash et al., 1997).

Music and the ADD/ADHD Paradigm

Over the past 20 years, a paradigm has emerged in the United States and Canada to try to explain why 3% to 5% percent of children in today's schools have trouble paying attention, concentrating, or sitting still. The paradigm suggests that such children have a biological disorder called attention-deficit-hyperactivity-disorder (ADHD) or attention-deficit-disorder (ADD). Many strategies have been developed to assist regular and special education teachers in addressing the needs of children who have specific attention or behavior difficulties. These strategies encompass all domains of the child's world: cognitive, educational, physical, emotional, interpersonal, ecological, behavioral, and biological (Armstrong, 1999).

Of particular concern in this study is the effect that listening to music might have on the learning of a student with ADD/ADHD disorder. According to Armstrong (1999, p.

94), music may prove to enhance the learning environment for children with attention and behavior difficulties." He quotes studies, which report that background recordings can serve as a sort of "musical Ritalin," providing the extra stimulation required by some students who have been diagnosed with ADD/ADHD (Armstrong, 1999, p. 94). Previous mention was made of the important effect music can have on mood, behavior, and learning.

Armstrong advocates classroom experimentation to determine what music produces the best effect on behavior and attention. He offers several suggestions for classroom teachers to incorporate music into the educational environment to facilitate learning not only by ADD/ADHD students, but all students. Armstrong (1999, p. 95) is quoted as saying, ". . . by choosing the right sounds for the classroom, you can help 'soothe the hyperactive beast' and create a harmonious learning environment."

Commercialization of the Mozart Effect

The researchers that led to the conclusion that Mozart makes you smarter were professionally circumspect with their conclusions (Linton, 1999). However, the media that sensationalized them were not. The impetus for this remarkable, wildfire spread of the Mozart Effect notion was the original experiment performed by researchers Rauscher, Shaw and Ky at the University of California at Irvine. According to Robert Todd Carroll (2000) the enhancement this group had demonstrated was temporary, and the research has never been replicated. Though it appears that Shaw and Rauscher presented their initial (1993) results in a modest and qualified way, they continued the research and as Carroll describes it, "created an industry." The Music Intelligence Neural Development

Institute, as well as a book and a compact disc on the Mozart effect, is just a part of that industry. According to Carroll (2000, p 2): "Shaw and Rauscher may have spawned an industry, but the mass media and others have created a kind of alternative science which supports the industry. Exaggerated and false claims about music have become so commonplace that it is probably a waste of time to try to correct them." Regarding Campbell specifically, Carroll (2000, p. 2) calls him the " . . . Carlos Castaneda and P.T. Barnum of the Mozart Effect."

The widely reported findings of Rauscher and Shaw's 1993 study have generated an industry of supposedly mind-enhancing recordings as well. The original researchers theorized that the music of Mozart primes higher brain functions because of its complex, highly structured, and non-repetitive nature. Campbell has made a huge business of marketing of CD sets with specially selected music composed by Mozart. He claims the music has been designed to help listeners benefit from the transformative powers found in Mozart's compositions. Several "Mozart Effect" CDs have been on the Billboard classical charts since January 1998 (Will Mozart make you smarter? 1999).

Educators, apprised of the psychological work of Piaget and Erickson, are aware of the existence of developmental stages which exist in early childhood. "These stages are windows of opportunity during which children, ages birth to six years old, are extremely receptive to certain types or modalities of learning such as the preschool child's incredible ability to learn language" (Clark, 1999, p. 1). Recent discussions in popular media, such as *Time* and *Newsweek*, emphasize the importance of listening to music and early music training to develop long-term connections and pathways inside the brain as an effective means to improve the ability to learn throughout life. In 1998 former Georgia Governor

Zell Miller gave a free compact disc or cassette tape of classical music to the parents of all babies born in his state's 100 public hospitals (Bond, 2000). His goal was to capitalize on the purported life-long, developmental benefit of active association with music early in life. Governor Miller enlisted the expert knowledge of Atlanta Symphony Orchestra conductor Yoel Levi to help select the pieces for the recordings. The $105,000 initiative was voted down by the Georgia legislature. Governor Miller was able to get the Sony Corporation to fund the project. The states of South Dakota and Tennessee, as well as the National Academy of Recording Arts and Sciences, also give away classical CD's to new mothers. They point to research claims that there are a number of extra-musical benefits from active involvement with music during the early developmental stages. It is held that early musical experience has a positive effect on the acquisition of upper level math and science reasoning skills and the development of analytical thinking in general.

Many are of the mind-set that listening to music can have more broad-sweeping benefits. These include the enhancement of self-confidence, growth in physical coordination, greater poise, improved concentration, increased ability to focus one's attention, greater facility in following directions, and an increase in the ability to listen attentively (Clark, 1999, p.1). An owner and avid user of such CDs plays them because she likes the music and listening to it makes her happy. "I was intrigued by it because it was a nice compilation. Who knows if it raises my children's IQ? Even if it doesn't, I'm still happy with it" (Will Mozart make you smarter? 1999, p.3).

Failure to Replicate the Mozart Effect

Jon Bruer, president of the James S. McDonnell Foundation, and a specialist in cognitive science (as cited in Bond, 2000) points out that neuroscientists do not know enough about how the brain works to explain the temporary IQ improvement found in the Rauscher and Shaw study. Bruer goes on to say that researchers are beginning to work together to question the assumptions we have about the brain. Future findings may have great implications for parents and educators about how to best facilitate learning.

Band & Orchestra Product News published challenges of the validity of the Mozart effect in October 1999. The magazine reviewed two articles published in the British science journal *Nature*. Christopher Chabris of Harvard refuted the findings of Rauscher, et al. He combined results of 16 related studies and found only a 1.5 IQ point increase which he states is not statistically significant. According to Chabris: "There's no reason to believe that that wasn't just caused by a randomness or statistical noise or due to chance." A second group of detractors, Steele, Bass, and Crook (1999) attempted to replicate the 1995 Rauscher et al. study as closely as possible. The results differed drastically as Steele et al. were unable to produce the Mozart effect. Rauscher responded by pointing out the differences in tasks and the fact that none of the Steele et al. studies were actual replications of the original (B&O Product News, Oct, 1999). Even though cognitive task performance did not improve after listening to the music of Mozart, participants did experience mood elevation upon hearing Mozart as compared to the amelodic, repetitive selection by Glass. Based upon these results, Steele et al. (1999 p. 5) suggest, " . . . production of a performance difference indirectly through differences in mood or arousal must be differentiated from the direct neurophysioilogical priming effect hypothesized by Rauscher el al. (1993)."

Rideout and Taylor (1997) speak to the inability of a 1994 replication of the Rauscher et al. study conducted by Stough, Kerkin, Bates, and Mangan to produce an enhanced performance on the Raven's Advanced Progressive Matrices test after listening to the *Mozart Sonata in D major, K448* for two pianos. Another attempt by these researchers using the Revised Minnesota Paper Form Board Test also indicated no enhanced performance following exposure to the same Mozart composition.

Rideout and Taylor conducted a replication study using 16 subjects with the dependent measure of paper folding and cutting, tasks with some of the items taken from the Stanford-Binet Scale of Intelligence with the remaining items created to be similar. Ten minutes of progressive relaxation was the control procedure and the treatment the same Mozart Sonata used in the Rauscher et al. study. Subjects rotated through relaxation and listening to music. The effect of the music was consistent with the findings of the original Rauscher et al. study; however, the influence of the music was relatively subtle. Rideout and Taylor concluded that the Mozart effect was persistent but not powerful.

The inability to produce a Mozart effect has taken place in many laboratories. In defense of their findings, Rauscher and Shaw have "... suggested that failure to produce a Mozart effect may be from carryover effects of the spatial reasoning pretest which may interfere with the effect of listening to Mozart" (Steele, Brown & Stoecker, 1999). According to Rauscher and Shaw, an unpublished study found that when a verbal distracter was inserted between the pretest and the listening, the Mozart effect was substantiated. Steele, Brown, and Stoecker attempted to confirm the results of this unpublished study. When 206 college students were exposed to 1 of 3 sequences involving pretest, verbal distracter, and Mozart, an immediate posttest indicated no significant difference on solution of paper folding and cutting items among the 3 groups. Thus the researchers failed to support the findings of the original or unpublished studies.

Another attempt to replicate the Mozart Effect failed at the University of Western Ontario. Psychology professor Keith Humphrey and his team of researchers found no marked improvement in performance after brief periods of exposure to the Mozart *Sonata in D major K488* for two pianos compared to students who listened to relaxation music or no music at all. He discredits Rauscher et al. in their claim that " . . . listening to the Sonata and its two pianos weaving in and out activated the same neural circuitry in the brain that is involved in spatial reasoning" (Western Today, 1999 p.1). They summarize their efforts by saying the long-term effect of listening to Mozart has yet to be studied.

In an attempt to replicate and extend the findings of Rauscher et al.'s Mozart Effect, Nantais (1997) conducted 3 experiments. The first replication took place in a highly controlled environment in which subjects listened to Mozart or sat in silence prior to engaging in a spatial-temporal task. In this experiment the subjects who listened to Mozart performed better than those who sat in silence. In the second experiment, a piece by Schubert was substituted for the Mozart. Participants who listened to the Schubert piece outperformed those who sat in silence. In the third experiment one group listened to Mozart, and in the other group the silence was replaced with a narrated short story. Spatial-temporal task performance increased based upon the listener's preference for

Mozart or the short story. Nantais concluded that the Mozart Effect " . . . can be explained by participant's motivation and emotional state" (Nantais, 1997, p. 1).

Not only did Newman et al. (1995) fail to replicate the Mozart Effect as found in the Shaw et al. study, they point out several shortcomings in the design, method, and interpretation of the study. According to Newman et al., the original study's sample size of 36 was inadequate to allow full rotation of subjects throughout the 3 experimental conditions. They also suggested that the posttest-only design permitted ambiguous interpretation of the results. They say it is unclear whether the silence and relaxation music depressed performance compared to the Mozart having no effect at all or depressed performance less. As there are only 18 different Paper Folding and Cutting items on the Stanford-Binet subtest, Newman et al. found it unclear how a sufficient number of items could have been generated for the pretests and posttests. They go on to say: "The data presented do not support the conclusions described by the authors; the enhancing effect of music occurred only after the first day of treatment and was not apparent during the remainder of the 5 day period of study" (Newman et al., 1995, pp. 1380-1381).

In an effort to resolve the apparent contradictions in the Rauscher et al. (1993) experiment, Newman et al. repeated the experimental conditions of the original study and sought to improve its design. They utilized a between-subjects design for the listening condition and carefully administered standardized procedures. The sample size was increased to 114 subjects and Raven' Progressive Matrices-Advanced Form replaced the Stanford-Binet subtest to avoid repetition of items. Subjects listened to 8 minutes of Mozart, relaxation instructions, or sat in silence prior to taking a posttest. The subjects also provided background information about their musical training and preferences to find out if there was a correlation of musical preference or training to test performance.

A practice effect was present in all 3 groups, but it was unrelated to the treatment received. "There was no evidence that the brief music had a different effect on subsequent problem solving according to listeners' musical background" (Newman et al., 1995, p. 1379). Therefore, the authors concluded that brief listening to a Mozart piano sonata does not enhance the spatial problem-solving capabilities of college students.

Spelling

"It is suggested that the pleasure of arts promotes the acquisition of skills which in turn motivates the acquisition of other difficult skills" (Gardiner et al., 1996, p. 8). Campbell (1997), author of *The Mozart Effect*, claims that he has used music for years as a strategy to reduce learning time and increase students' memory of the material. Along with others, he maintains that music activates the whole brain for the maximum learning and retention effect. Shaw and Rauscher (as cited in Carroll, 1999, p. 2) assert that their research demonstrates "that there are patterns of neurons that fire in sequences, and that there appear to be pre-existing sites in the brain that respond to specific frequencies." Research continues to test the suspicion that the symmetries and patterns characteristic of music might be fundamentally connected to the symmetries and patterns of brain waves. Ostrander et al. (1994) contend that learning factually based information is a left-brain activity, and when the music of Mozart is added, the right brain becomes simultaneously engaged bringing about an energy boost and balance to brain and body.

The act of spelling must be examined, as the purpose of this research was to determine if there was a relationship between listening to music and improved spelling abilities in fourth grade public school students, the act of spelling must be examined. Spelling can be defined as writing or naming (in the appropriate order) the letters of a word. A primary objective of language arts instruction is to elicit in students the capacity to spell. Correct spelling, like correct speaking is a desired outcome of education as it facilitates the ability of an individual to communicate thoughts in writing as a way of conveying meaning to others. The study and systemic design of spelling are called orthography. According to *The World Book Dictionary* (Barnhardt, 1968): "The function of orthography is to identify the phonemes, or distinctive vowels and consonants, of a language. *The World Book Encyclopedia* (1991, p. 775) defines spelling as "simply the method of writing letters of spoken sounds."

The English language has only 26 letters, but these letters can combine to form several hundred thousand words. Being made up of words from many other languages such as Greek, Latin, French, German, Old Norse, Old Icelandic, and Old English or Anglo Saxon, the historical development of the English language has resulted in numerable spellings that fail to align with the way a word is pronounced. The basis for English spelling can be traced back to the 15th Century. However, today's word pronunciation has changed drastically which helps explain why so many words are not spelled the way they sound.

Because English syntax can readily accept words from other languages, it is a rich and versatile language, but many of its words fail to comply with a predictable, systematic spelling system rendering it a complex language to learn and to spell. Indeed, spelling competency is an elusive skill for many English-speaking people regardless of their intelligence. The difference between good spellers and poor spellers can often be traced to the mental strategies they use to encode accurate spellings into their long-term memory. Herein lies the need for a teaching approach that encompasses the breadth of the English language in such as manner as to facilitate the accurate spelling of predictable as well as unpredictable words. Over the years many strategies have been tried to assist the learner of English to encode accurate spellings into long-term memory.

Summary

A number of studies have demonstrated a relationship between music and other higher cognitive functions. Because the spelling of English is complex and elusive to many English-speaking people, the use of music to facilitate correct spelling into long-term memory is worthy of consideration. Inspired by the findings of previous research and recommendations for further study, this study evaluated the relationship between listening to music and spelling facilitation in fourth grade public school students.

CHAPTER 3

PROCEDURES AND METHODOLOGIES

Introduction

This study was designed to determine if there was a relationship between listening to the music of Mozart and spelling performance in fourth grade public school students as measured by posttest gain/loss scores on the TWS-3. This chapter discusses the population, sample, spelling instruction, instrumentation, research design, data analysis, and procedures that were used in this study.

Cast-A-Spell

The students in this study were in their second year of the *Cast-A-Spell Process Spelling Program* developed by Fontenault and Salter (1993). The Cast-A-Spell Program integrates auditory, visual, and kinesthetic processes necessary to develop spelling competency. The program encourages students to take charge of their own learning by becoming conscious of their own visual memory. Students are taught how to visualize letters in their minds so they can be recalled. They are taught to hear words in chunks and pronounce words in a way that assists spelling. They write the spelling words on white boards to engage their kinesthetic learning powers. According to Fontenault and Salter, these strategies make encoding specific words easy. Fontenault and Salter (1993) lay out six presuppositions in their Cast-A-Spell Program:

1. Spelling requires the ability to use the visual, auditory, and kinesthetic sensory systems flexibly and appropriately.
2. By learning appropriate mental strategies, all students can learn to spell.
3. Student beliefs about and attitudes toward spelling will affect long-term memory of written words.
4. Visual memory can be trained.
5. Teachers can learn how to analyze, train, and alter student-spelling strategies.
6. The best time to begin teaching the spelling process is in the first grade.

The Cast-A-Spell approach takes into consideration that information is not stored in a specific location in the brain but rather in multiple locations such as the visual, auditory, and motor cortices. Evidence from current brain research indicates that each time recall takes place, the same circuits used to store it are reconstructed to bring forth the information. Thus, it seems that the more modalities that are used to store information or experience, the more pathways there are available to access it. New information or experiences are chunked with existing information and will be stored along the same neural network.

Beginning spellers are taught phonemic awareness and are trained in phonetic spelling. Combined with visual memory training, students learn strategies to spell phonetically irregular words with accuracy. Once conventional spelling has been mastered, students can incorporate accurate spelling into their writing.

It is intended that Cast-A-Spell training take place daily for a minimum of 15 minutes and a maximum of 25 minutes without exception. It is the role of the teacher to establish a quick, steady rhythm to assure maximum student attention and focus on the learning strategies.

Population

The population for this study was all fourth grade elementary students enrolled in the Bozeman Public School District during the 1999-2000 school year.

Sample

The sample for this study was two classes of fourth grade students from Emily Dickinson Elementary School located in northwest Bozeman. The school serves a socioeconomically diverse population. It draws students from neighborhoods of the upper middle class, middle-class, lower middle-class, a lower class trailer court, a moderate-income housing development, as well as from upper class country estates. Students from this school are primarily from two-parent homes in which both parents work. Some students live with a single, usually working parent, and a few students come from families on welfare. Parental employment varies from white-collar to blue-collar.

Of the 496 students enrolled at Emily Dickinson as of October 1, 1999, 13 students were listed as having an ethnic origin to be other than Caucasian. This information was garnered from the student enrollment cards filled out by parents at the beginning of the school year. This means that 98% of the student body at Emily Dickinson was Caucasian. All of the students in the control group and the experimental group were listed as being Caucasian on their enrollment cards. Therefore ethnic background was not a factor in this study.

As is the case with all elementary schools in Bozeman, every attempt is made by Emily Dickinson Elementary School to maintain well-balanced classrooms with an even mix of socioeconomically and intellectually divergent students. Most classes have about half girls and half boys. Each classroom had a few intellectually advanced students, a few low performing students, with the majority in the middle which is the case in the two classes that participated in this study. In addition, each classroom in this study had one student receiving special education services and a few students serviced by the Title I program, which addressed learning deficiencies in various areas.

Because the student population at Emily Dickinson School is balanced in regards to gender, intellectual capability, socioeconomic advantage or disadvantage, and represents a good sample of the city's elementary school population, the findings of this study may be generalized to be reflective of the city's entire elementary school student population. This generalization extends specifically to the 2 classes of Emily Dickinson fourth graders who participated in this study.

The experimental class had 25 students, 12 boys and 13 girls. The control group had 24 students, 13 boys and 11 girls. Competent, experienced and well-respected teachers taught both classes. Both teachers have a number of years of experience and Master's degrees in Education with an emphasis on curriculum. Both teachers were administered a survey (see Appendices B) to evaluate their equivalency.

The teacher of the control group was in her 21st year of teaching and has taught kindergarten, first grade, second grade, and math lab, with most of her experience at the third, fourth, and fifth grade level. Her undergraduate degree was in elementary education with a minor in psychology. She received the Presidential Award for Exceptional Montana Mathematics teaching. When asked what professional strengths she brings to the classroom, she pointed to her psychology minor which she says enables her to understand how children learn and has given her ways to inspire and motivate them to realize their full potential. She also has taken full advantage of additional training in order to keep current in elementary curriculum methodologies.

The teacher of the experimental group was in her 12th year of teaching and has taught third and fourth grade exclusively. In her undergraduate work she pursued a math option and received a reading certificate as part of her Master's degree. This teacher also has frequently engaged in additional study to maximize her teaching potential. This teacher considers all of the extra training she has undertaken to be of considerable advantage for her students.

Both teachers reported that, based upon their experiences their classes are average to above average in academic capability. The teacher of the control group commented that her class was highly creative and very right-brained. The teacher of the experimental group reported that her class, as a whole, excels in logical, mathematical-type thinking. Classroom management was not an issue in either classroom as both teachers have demonstrated the ability to focus all students on the task at hand.

A noteworthy distinction between the two classes was that the experimental group was a cycling class, which meant they were in their second year with the same teacher. However, this was not a factor in their academic performance especially as it pertained to spelling, but rather reflected a different structural model.

During the treatment period both teachers reported that nothing changed in their classes. No students left; no new students joined. There were no paraprofessionals or student teachers in either room during spelling instruction for the duration of the treatment period. Neither classroom experienced any sort of extraneous event that could have changed the classroom dynamic. Both classes experienced the same disruptions to routine, such as the annual holiday program and other school assemblies.

Both teachers placed a high priority on spelling instruction as a part of the overall fourth grade curriculum. Both were conscientious in following the procedures laid out in the Cast-A-Spell manual. Both classes received daily spelling instruction. The teacher of the experimental group was as teacher mentor, trained to teach other teachers how to implement the program and serve as a liaison between the school and the developers of the program. The teacher of the control group did not feel this placed her students at any disadvantage because she attended every in-service and workshop offered by the school district when the program was adopted. With her many years of classroom experience, she rated herself as highly competent in implementation of the program.

Both the teachers scored the TWS-3 on both the pretest and the posttest. They were trained to score both the pretest and the posttest of the TWS-3. They reported that they considered that their scoring reflected an accurate reporting of the data.

The control group received 22 minutes of spelling instruction daily from approximately 10:30 a.m. to 11:00 a.m. as prescribed by the Cast-A-Spell program. This instructional time was directly after a 15 minute morning recess period.

The experimental group began their instructional day after the morning/arrival recess time with a 30 minute silent reading period followed by the daily spelling routine. As with the control group, the teacher of this class was effective in handling playground issues so as not to allow them to interfere with instruction and learning. For the duration of the 12-week treatment period, the teacher played the music of Mozart throughout the silent reading period. This was followed by a 22 to 25 minute spelling lesson as prescribed by the Cast-A-Spell program.

Thus both groups were taught spelling after an active recess period. The difference being that the experimental group was exposed to the music of Mozart during a silent reading session prior to spelling instruction. The control group began spelling instruction immediately after the morning recess period.

Independent Variable

For the purposes of this study, the independent variable was the treatment, which was listening to the music of Mozart for 30 minutes during a silent reading period prior to engaging in spelling instruction.

Dependent Variable

The dependent variable in this study was the score on the TWS-3.

Research Questions and Hypotheses

This study tested the following research hypotheses and sub-hypotheses. All were tested at the 0.05 α level.

Question 1: Is there a difference in spelling achievement as measured by the TWS-3 between the control group and the experimental group after the 12-week treatment period?

<u>Question 2</u>: Is there a difference in spelling gains as measured by the TWS-3 among fourth grade students with below average, average, and above average total CTBS scores?

<u>Question 3</u>: Is there an interaction between treatment and achievement level as measured by gain scores determined by the difference between TWS-3 posttest and pretest scores?

In order to answer the research questions the following hypotheses and sub-hypotheses were conducted to establish the equality of the two groups.

<u>Hypothesis 1</u>: There is no difference between the control and experimental group in gender, knowledge of spelling, academic achievement level, or age at the beginning of the study. This hypothesis was tested by one comparison and three subhypotheses.

Comparison: There is no difference in the number of males and females in the control group and the experimental group.

Hypothesis 1.1: There is no difference in spelling achievement as measured by the TWS-3 between the control group and experimental group prior to the treatment.

Hypothesis 1.2: There is no difference in academic achievement between the control group and experimental group as measured by their third grade CTBS total scores.

Hypothesis 1.3: There is no difference in mean age between students in the control group and students in the experimental group.

<u>Hypothesis 2</u>: There is no difference in gain scores between the groups at the end of the study. This hypothesis was tested by two sub-hypotheses.

Hypothesis 2.1: There is no difference in spelling achievement from the pretest to the posttest as measured by the TWS-3 in the control group.

Hypothesis 2.2: There is no difference in spelling achievement from the pretest to the posttest as measured by the TWS-3 in the experimental group.

Instrument

Educators are well aware that many forms of scientific inquiry require, among other things, the use of standardized measures that adequately tap the ability being studied. To conduct research in spelling, instruments with demonstrated high reliability and validity are needed. Such devices permit comparison of a student's score with those of age and grade level peers. Without their use, research in spelling is often random and haphazard.

The Test of Written Spelling (TWS) was first published in 1976, and it has gained wide acceptance as an accurate testing instrument for assessing the spelling abilities of school-age children and adolescents (Larsen & Hammill, 1994). It is used throughout the country and is probably the most popular individually administered, norm-referenced test of spelling in common use. Now in its third addition, the TWS-3 is administered in the dictation format, and the words are related to currently used curricula. It has two subtests, each of 50 words. One subtest measures predictable words; the other subtest measures unpredictable words. The division of spelling words into these two subtests presents a departure from other tests and should present educators with information that will help them identify students who have spelling problems. In addition, the TWS-3 documents gender, age at test time, score for predictable words, score for unpredictable words, total score, and percentage score. The recording sheet catalogues this information for both the pretest and the posttest. In addition, the TWS-3 allows for the determination of a gain or loss in spelling achievement form the pre-test to the posttest.

The subtests and total score were normed on a large sample of students in Grades 1 through 12. Appropriate demographic characteristics of the sample were keyed to the Statistical Abstract of the United States (U.S. Bureau of the Census, 1990). Test results are reported as standard scores, percentiles, spelling ages, and grade equivalents. In addition to being extensively normed, the TWS-3 also has consistently high reliability and a demonstrated high degree of validity. This feature is particularly noteworthy because it demonstrates that the TWS-3 does indeed measure written spelling. By using a dictated-word test procedure, the TWS-3 yields a more valid estimate of how well an examinee can actually spell words in written form.

The results of the TWS-3 are typically used for four specific purposes:

1. to identify students whose scores are significantly below those of their peers and who might need interventions designed to improve spelling proficiency;
2. to determine areas of relative strength and weakness in spelling;
3. to document overall progress in spelling as a consequence of intervention programs; and
4. to serve as a measure for research efforts designed to investigate spelling.

The TWS-3 permits the examiner to quantify the spelling abilities of students by comparing their scores with those of their peers. The technical adequacy of the TWS-3 provides assurance that it is a reliable source of data to use in making decisions about the identification of persons who are deficient in spelling ability. In the case of this study, the TWS-3 was used to measure the correlation of an intervention to determine whether or not it was an effective means of improving spelling in fourth grade students.

Validation

The TWS-3 has undergone examination for the three types of validity: content, criterion-related, and construct. There are two demonstrations of content validity for the TWS-3. The first is a rationale for the subtests' content. Second, the validity of the items can be noted through the examination of the results of item analysis procedures used during item selection in the developmental stages of test construction.

When the test was first constructed in 1976, two guidelines had to be met in order for a word to make it onto the test. The rationale for selecting test items was governed by two principles. First, to be included in the list of words to be spelled, a word had to be typically taught in school and readily identifiable as rule governed or irregular in its spelling. Second, it was determined that a word was typically taught in classrooms if it appeared in ten basal spelling series commonly used in schools at the time of test construction. Words selected for the "predictable" category had to follow the rule governing their spelling 50% of the time. A word was determined to be "unpredictable" if it could not be spelled correctly even when the more than 2000 spelling rules were applied.

Items were scrutinized to insure content validity in regard to item discrimination and item difficulty. Utilizing the point biserial correlation technique, each item was correlated with the total test score to determine its discriminating power. Statistically significant coefficients of .2 or .3 were considered acceptable. Item difficulty was determined by distribution between 15% and 85%. The item analysis procedure was applied to many student samples to eliminate inappropriate items from inclusion on the test. Further reinforcement of the TWS-3's discriminating powers and percentages was added by using the entire normative sample as subjects. The final published version of the TWS-3 satisfies all previously mentioned requirements.

The TWS-3 withstood scrutiny in regards to concurrent validity as well. The 1976 TWS cites several studies pointing to the test's concurrent validity. The newer TWS-3 underwent equivalency testing with the 1976 version. The results were well above the range necessary to support the validity of the TWS-3 scores.

The concurrent validity of the TWS was studied by correlating it with four other respected tests. The resulting coefficients were significant beyond the .01 level of confidence and of high magnitude verifying concurrent validity. A second study of concurrent validity correlated the TWS-3 with two other spelling tests as well as with actual spelling tests given by teachers. The results of this correlation provided additional evidence that the TWS-3 has criterion-related validity. The final type of validity, construct validity, examined the seven basic, underlying constructs considered in the TWS-3.

1. Age Differentiation. As is typical with school taught skills, scores increase with age and then level off about the time that the subject ceases to be taught. This is the case with the TWS-3. The correlations of predictable words, unpredictable words, and total words scores with the ages of the students in the normative sample demonstrated highly significant coefficients at .62, .63, and .64 respectively.
2. Relation Between the TWS-3 Subtests. Construct validity is tested using the normative sample as subjects. Raw scores from the predictable words and unpredictable words subtest were correlated yielding a coefficient of .87 after age effects were partialled from the coefficient. A similar study on fifth graders reported a highly significant coefficient of .83.
3. Relationship of TWS-3 to Tests of Achievement. The coefficients dealing with the TWS-3 subtests and totals to achievement test scores in reading, math, language, and the composite were tested and found to be .55, .54, and

.62. These coefficients indicate a moderate relationship and provide evidence of the TWS-3's construct validity.

4. Relationship to Tests of Aptitude/Intelligence. As expected, the TWS-3 is influenced by basic aptitude. This was tested by correlating the scores on the TWS-3 with the School Ability Index from the *Otis-Lennon School Ability Test*. With resulting corrected coefficients of .53, .47, and .56, the magnitude of which indicated that the TWS-3 can differentiate between those known to be average and those known to be below average in cognitive ability.
5. Influence of Instruction. Preliminary research reveals TWS-3 posttest scores to be significantly higher than pretest scores. As this investigation used no control group, this evidence must be considered as tentative.
6. Group Differentiation. The TWS-3 discriminated between groups of spellers. A study of protocols of students with identified learning disabilities found mean scores on the TWS-3 to be significantly below the mean values expected for typical students.
7. Item Validity. A test to examining the correlation between individual items and total test results found values of high magnitude demonstrating good construct validity.

Reliability

The TWS-3 has undergone sufficient scrutiny to exceed minimum reliability requirements. In order for a test of this nature to be considered a reliable testing instrument, reliability coefficients must approximate or exceed .80 in magnitude. There are three types of errors that can affect the reliability of the TWS-3: content sampling, time sampling, and interscorer.

The internal consistency reliability of the items in the TWS-3 was tested to determine the correlation between items. Using Cronbach's coefficient alpha method, data from the entire normative sample were used to calculate coefficient alphas. The alphas were averaged using the z-transformation technique. The mean alphas for both the subtests were .95 and the mean alpha for Total Words was .97.

The standard errors of measurement (SEM) were used to estimate a confidence interval of a particular test score. The standard deviation for the standard scores is always 15 on the TWS-3. The mean SEM on the two subtests and for total words was 3.

Time sampling was measured using the test-retest technique. Morris studied 160 students in grades two through eight. This researcher administered the TWS-3 twice with a 2-week period between testings. The scores were correlated with 23 of the 224 coefficients, exceeding .9 in size. All scores were significant at the .01 confidence interval. These results demonstrate that the TWS-3 is stable over time.

J. Jeffrey Grill conducted a second test-retest for reliability. He tested 391 students of above average intellect in grades one through eight. The testing interval ranged from 13 to 18 days. His results confirmed the findings reported by Morris.

The TWS-3 has proven to be reliable when it comes to scoring. Unreliable scoring is usually the result of clerical errors or caused by illegible student handwriting. To study the interscorer reliability of the TWS-3, two research staff independently scored the TWS-3 protocols of 108 students in grades 1 through 8. The gender division between subjects was equal. Fifty-six percent of the sample was Hispanic and 44% percent were Anglo-European. The scorings of the two scorers correlated. The effects of age were partialled from the resulting coefficients. The scores were in near agreement, differing only on those few occasions where the student's handwriting was difficult to decipher. The TWS-3 has undergone two evaluations to determine if the test content covers a representative sample of spelling items covered in a spelling curriculum. The first is a rationale for test content. The second is demonstrated by the results of item analysis procedures used to select items for inclusion in the test

Research Design

This study employed a quasi-experimental design involving intact groups. Because this study was a field study conducted in an elementary school using school children, the researcher had to agree to use existing classrooms. The two classrooms selected were deemed to be as equivalent as possible from those available in the school so as to control sources of invalidity to the greatest posssible extent. Both groups were administered the TWS-3 as pretest of the dependent variable. One class was randomly designated as the treatment group and administered a 12-week treatment, which was listening to the music of Mozart for 30 minutes during a silent reading period prior to engaging in instruction in the Cast-A-Spell spelling program. The other fourth grade class, hereafter referred to as the control group, engaged in regular Cast-A-Spell spelling lessons without listening to music. Both groups were administered the TWS-3 as a posttest the week immediately following the treatment period in order to minimize the threat to external validity. Data were collected and analyzed to determine the effectiveness of the treatment. Posttest scores were directly compared using a t-test.

All fourth grade students throughout the Bozeman School District were administered the TWS-3 in the fall and receive the same test in the spring, so a possible interaction between the pretest and the treatment was not an issue. Therefore, the results of the treatment may be generalizable to all other fourth grade students in the Bozeman School District.

Data Analysis Strategy

The first step in the analysis was to determine if the control group and the treatment group were demographically and academically equivalent at the beginning of the study. The two groups were compared on the basis of gender equity. Comparison of means and t-tests were used to find out if the two groups were equal in their knowledge of spelling, in overall academic achievement, and in age at the beginning of the study.

In order to establish that the groups were the same at the end of the study, two subhypotheses tested whether or not there was a difference within each group in spelling achievement as determined by comparing the means from the TWS-3 pretest to the means of the TWS-3 posttest. To test for a statistically significant difference, t-tests were conducted.

To find out if the treatment had an effect on spelling test scores, posttest means of the two groups were compared. A t-test was performed to determine if the treatment made a difference.

Students in both groups were classified according to achievement as above average, average, or below average based upon their third grade total CTBS score. Means were compared and an F-test conducted to determine if the treatment made a difference based upon achievement level. The means of the gain scores for the three achievement classifications of the control group and the treatment group were compared and an F-test was conducted to determine if there was an interaction between the treatment and achievement in the two groups.

Alpha Level

An α level of 0.05 was set prior to the execution of the study. This level was adopted rather than a more conservative 0.01 because the researcher determined that it was more important to guard against a Type II error than a Type I error. The consequences for committing a Type I error (rejecting the null hypothesis when it is true) would result in motivations for public school to incorporate music listening into their curriculums to improve student achievement when in fact it would not be of any benefit to do so. Interest would be generated to conduct further research, which could be unwarranted. A Type II error (failure to reject a true null) would mean public schools would miss the opportunity to improve student achievement by having students listen to music prior to engaging in instruction. Considering that most classrooms are already equipped with devices with which to listen to music, incorporating music listening into the curriculum would not be a costly endeavor. Therefore, this researcher is not as concerned about committing a Type I error as missing the opportunity to improve learning by committing a Type II error.

Summary

The purpose of this study was to determine if there was a relationship between fourth grade spelling scores as measured by the TWS-3 between students who listened to the music of Mozart prior to engaging in instruction in the Cast-A-Spell spelling program and those who did not. Data were garnered from a TWS-3 pretest and posttest administered to the control group and the treatment group. Mean comparisons, t-tests for independent samples, and F-tests were used to determine specified differences between groups and find out if there was a correlation in listening to the music of Mozart and improved knowledge of spelling as indicated by posttest performance on the TWS-3.

CHAPTER 4

DATA ANALYSES AND FINDINGS

Introduction

The research conducted in this study investigated the effect of listening to the music of Mozart on fourth grade spelling test scores. Many researchers including Rauscher et al. (1993, 1994), Linton (1999), Rideout et al. (1998), Winner and Hetland (1999), Bolton (2000), Gardiner et al. (1996), Botwinick (1997), Sollier (1996), Lozanov (1995), Goehegan and Mitchelmore (1996), and Cash et al. (1997) have discovered that musical activity and other higher cognitive functions share inherent neural firing patterns encoded in a highly structured format over a large region of the cortex. Using music to improve verbal memory may enhance the mnemonic and compensatory techniques currently implemented for memory training.

In the Rauscher et al. (1993) study, the beneficial effects of listening to music endured for only a 10 to 15 minute period during which the subjects were involved in a spatial task. Data were collected in this study to test if there was a relationship between listening to the music of Mozart over an extended period of 12 weeks in a typical public school classroom and long-term improvement in spelling. In order to test the research hypotheses, two public school fourth grade classes were selected to participate in the study.

This chapter is organized to present the data and statistical results related to the specific hypotheses stated in this study. All hypotheses were tested using an α level of 0.05.

Data Analysis Findings

Comparison of the Groups:

The first step in the analysis was to determine if the control group and the experimental group were demographically and academically equivalent at the beginning of the study.

Hypothesis 1: There is no difference between the control and experimental group in gender, knowledge of spelling, academic achievement level, or age at the beginning of the study.

This hypothesis was tested by one comparison and 3 subhypotheses and the following tests resulted in **hypothesis 1 being retained.**

Comparison: There is no difference in the number of males and females in the control group and the experimental group.

In Table 1 it can be seen that the control group had 24 students, 11 females and 13 males. The experimental group had 25 students, 13 females and 12 males also visible in Table 1.

Table 1. Group gender demographics.

Group	Females	Males	Total
Control	11	13	24
Treatment	13	12	25
Total	24	25	49

Although they were not exactly the same, the two classes were very close in respect to total number of students as well as in the number of males and females in each class. This reflects as realistic a gender balance as could be expected in a typical public school setting as the classes are developed with balance in mind. As such, it was determined that the two groups were matched in regard to gender for this study.

It was also necessary to determine if the control group and the experimental group were equal in their knowledge of spelling at the beginning of the study. This was tested by a comparison of the means of the two classes, on the basis of their pretest percentage of correct answers on the TWS-3.

Hypothesis 1.1: There is no difference in spelling achievement as measured by the TWS-3 between the control group and experimental group prior to the treatment.

In Table 2 a comparison of the means of the two groups, based upon their pretest percentage scores on the TWS-3 is presented. The mean for the control group was 41.9 and the mean for the experimental group was 53.92.

Table 2. Pretest means of spelling achievement.

Pretest %	N	Mean	Std. Deviation
Control Group	24	41.92	33.10
Experimental Group	25	53.92	31.47

A t-test was used to determine whether the means were significantly different at the 0.05 α level. In Table 3 it is demonstrated that a statistically significant difference was not found in spelling achievement as measured by the TWS-3 between fourth grade students in the control group and the experimental group on the pretest. The p-value of .200 exceeds the established α of 0.05.

Table 3. t-test for equality of means between the control and experimental groups.

	t	df	Sig. (2-tailed)	Mean Difference
Pretest % Equal Variances Assumed	-1.301	47	.200	-12.00

Although not exactly equal, this test confirms that there was not a statistically significant difference between the two groups on the basis of their pretest performance on the TWS-3. As such, it was determined that on average, the two groups were equal in spelling knowledge at the beginning of the study. **Hypothesis 1.1 was retained.**

Comparison of Achievement Levels of the Groups:

To further assure that the two groups were equivalent at the onset of the study, the means of the total scores on third grade CTBS tests were compared. A t-test was used to determine whether or not the control group and experimental group were equal on the basis of overall academic achievement.

Hypothesis 1.2: There is no difference in academic achievement between the control group and experimental group as measured by their third grade CTBS total scores.

The mean score for the control group was 69.58 and the mean score for the treatment group was 71.16 as seen in Table 4.

Table 4. Mean CTBS total scores for the control group and the experimental group.

Group	Mean	N	Std. Deviation
Control	69.58	24	23.22
Experimental	71.16	25	24.30
Total	70.39	49	23.54

The results of the t-test between the mean scores of the CTBS test of the groups resulted in a t-value of .232. The significance level of the statistic equals .818, indicates that there was not a statistically significant difference between the two groups on the CTBS test (see Table 5). Therefore it was determined that the two groups on average were equal in achievement as based upon their third grade CTBS total score at the beginning of the study. **Hypothesis 1.2 was retained.**

Table 5. t-test to test achievement levels between groups.

	t	df	Sig. (2-tailed)	Mean Difference
CTBS Total Score Equal Variances Assumed	.232	47	.818	1.58

It was also necessary to ascertain whether or not the two groups were equivalent in age at the beginning of the study. Comparing the mean age of students in both groups accomplished this. Mean ages were compared and a t-test conducted.

Hypothesis 1.3: There is no difference in mean age between students in the control group and students in the experimental group.

The mean age at the time of the pretest was 9.463 for the control group and 9.485 for the experimental group as can be seen in Table 6.

Table 6. Mean age for control group and experimental group.

Class	N	Mean	Std. Deviation
Pretest Age Control Group	24	9.463	.420
Pretest Age Treatment Group	25	9.485	.476

A t-test, comparing the means of the groups determined that there was not a statistically significant difference in mean age between the two groups. As can be seen in Table 7, the significance or the t value of .866 is greater than .05. This finding indicates that the results exceeded the probability that the results were found strictly by chance.

Table 7. t-test to test for difference in age between the two groups.

	t	df	Sig. (2-tailed)	Mean Difference
Pretest Age (Equal Variances Assumed)	-.170	47	.866	-2.187E-02

As such, it was determined that on average the students of the control group and the experimental group were the same age at the time of the pretest. Because, statistically the mean age of the students was the same for both groups, neither group had an age advantage over the other. **Hypothesis 1.3 was retained.**

Comparison of Growth in Spelling Knowledge of the Groups at the End of the Study:

Having demonstrated that the two groups were equal at the beginning of the study, the next step was to determine whether or not they were equal in spelling knowledge at the end of the study.

Hypothesis 2: There is no difference in gain scores between the two groups on the TWS-3.

This hypothesis was tested by two sub-hypotheses and the following tests resulted in the **hypothesis 2 being retained.**

Hypothesis 2.1: There is no difference in spelling achievement from the pretest to the posttest as measured by the TWS-3 in the control group.

The pretest and posttest means from the TWS-3 can be seen in Table 8.

Table 8. Pretest and posttest means for the TWS-3 in the control group.

Control Group	Mean	N	Std. Deviation	Std. Error Mean
Posttest %	54.00	24	30.18	6.16
Pretest %	41.92	24	33.10	6.76

A t-test was conducted to determine if there was a statistically significant gain in spelling knowledge from the TWS-3 pretest to the TWS-3 posttest in the control group. The results of the test can be seen in Table 9. For each student, he pretest percentage score was subtracted from the posttest percentage score comparing the average difference score with 0. This yielded a t-value of 2.881.

Table 9. Comparison of pretest and posttest scores for the control group.

	Paired Differences					
Control Group	Mean	Std. Deviation	Std. Error Mean	t	df	Sig. (2-tailed)
Post % – Pret %	12.08	20.55	4.19	2.881	23	.008

The significance of the t-score equals .008 indicating growth in the control group's spelling achievement from the pretest to the posttest. The strength of this statistic demonstrates that the growth was substantial. **Hypothesis 2.1 was rejected.**

Hypothesis 2.2: There is no difference in spelling achievement from the pre-test to the posttest as measured by the TWS-3 in the experimental group.

The pretest and posttest means from the TWS-3 can be seen in Table 10.

Table 10. Pretest and posttest means for the TWS-3 in the experimental group.

Treatment Group	Mean	N	Std. Deviation	Std. Error Mean
Posttest %	68.64	25	27.31	5.46
Pre-test %	53.92	25	31.47	6.29

A t-test was conducted to determine if there was a statistically significant gain in spelling knowledge from the TWS-3 pretest to the TWS-3 posttest in the experimental group. The results of the test can be seen in Table 11.

Table 11. Comparison of pretest and posttest scores for the experimental group.

	Paired Differences					
Treatment Group	Mean	Std. Deviation	Std. Error Mean	t	df	Sig. (2-tailed)
Post % – Pret %	14.72	15.47	3.09	4.79	24	.000

The results of the t-test between the mean percentage in scores of the pretest and posttest in the experimental group resulted in a t-value of 4.79. The significance level of the statistic equals .000 indicating that there was statistically significant difference between the pretest and the posttest in the experimental group. **Hypothesis 2.2 was rejected.**

Although both the control group and the experimental group demonstrated statistically significant growth, it can be noted that growth of the control group was not as great as that of the experimental group.

Comparison of Spelling Achievement Between Groups at the End of the Treatment Period:

In order to determine if the treatment had an effect on spelling test scores, posttest means of the two groups were compared. A t-test was performed to determine if the treatment made a difference.

Hypothesis 3: There is no difference in spelling achievement as measured by the TWS-3 between the control group and the experimental group after the twelve-week treatment period.

It can be seen in Table 12 that at the end of the 12-week treatment period, the mean of the control group was 54.00 and the mean of the experimental group was 68.64. This was determined on the basis of TWS-3 posttest scores.

Table 12. Posttest means for the experimental and control group.

Posttest %	N	Mean	Std. Deviation
Control group	24	54.00	30.18
Treatment group	25	68.64	27.31

The mean posttest score was higher in the experimental group than in the control group. Although the difference approached significance, it failed to reach statistical significance. The results of a t-test established that there was not a statistically significant difference between the two groups in fourth grade spelling test scores as measured by TWS-3 posttest percentage scores. The resulting p-value of .081 as seen in Table 13 exceeds the established α level of 0.05.

Table 13. t-test for equality of means between the control and experimental groups.

	t	df	Sig. (2-tailed)	Mean Difference
Posttest % Equal Variances Assumed	-1.782	47	.081	-14.64

It can be concluded that students who listened to the music of Mozart prior to receiving instruction in spelling did not make significant gains in spelling knowledge compared to those who did not listen to Mozart prior to spelling instruction. **Hypothesis 3 was retained.**

Comparison of Spelling Achievement in Relationship to TWS-3 Gain/Loss Scores:

The students in both groups were classified as above average, average, or below average in achievement on the basis of their third grade CTBS total score. The categories were as follows: above average students scored total 81 or above, average achieving students scored 66 and 80, and low achieving students scored below 66. The distribution of students can be seen in Table 14.

Table 14. Achievement distribution between above average, average, and below average students.

	N
Control Group	24
Treatment Group	25
Above Average	22
Average	13
Below Average	14

The mean gain scores for students in the control group and the experimental group based upon achievement classification can be seen in Table 15.

Table 15. Mean gain scores on the TWS-3 by achievement classification and group.

Class	Achievement	Mean	Std. Deviation	N
Control	Above Average	9.25	15.85	8
Control	Average	15.25	28.46	8
Control	Below Average	9.13	9.91	8
Control	Total	11.21	19.01	24
Experimental	Above Average	8.43	8.53	14
Experimental	Average	8.80	10.55	5
Experimental	Below Average	32.33	18.21	6
Experimental	Total	14.24	15.32	25
Total	Above Average	8.73	11.36	22
Total	Average	12.77	22.81	13
Total	Below Average	19.07	17.95	14
Total	Total	12.76	17.11	49

In order to determine if the treatment made a difference based upon achievement level, an F-test was conducted. The dependent variable was gain/loss as determined by the TWS-3, and the independent variables were treatment and achievement.

Hypothesis 4: There is no difference in spelling gains as measured by the TWS-3 gain score among fourth grade students with below average, average, and above average total CTBS scores.

When examined independently, the treatment appeared to have no effect between the achievement levels. The F-test between above average, average, and below average achievement yielded an F-value of 2.296, with significance level of .115 as can be seen in Table 16.

Therefore, it can be concluded that there was not a statistically significant difference in achievement on the TWS-3 between the three different achievement levels. **Hypothesis 4 was retained.**

Table 16. F-test comparing means of groups by achievement level.

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	2893.624*	5	578.725	2.229	.069
Intercept	8510.763	1	8510.763	32.882	.000
Treatment	312.368	1	312.368	1.203	.279
Achievement	1181.664	2	590.832	2.276	.115
Treatment + Achievement	1712.126	2	856.063	3.297	.047
Error	11163.437	43	259.615		
Total	22029.000	43			
Corrected Total	14057.061	48			

* R squared = .206 (Adjusted R Squared = .114)

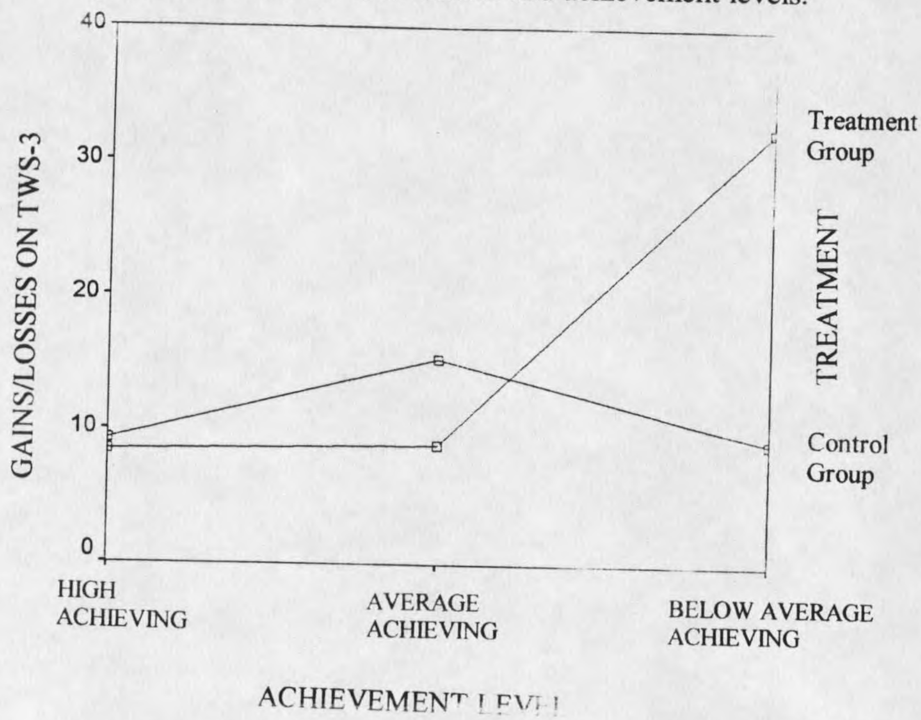
<u>Comparison of the Treatment and Achievement Level by Gain/Loss Scores</u>:

Examination of the interaction between the treatment and achievement levels was conducted by first comparing the means between groups and achievement levels as seen in Table 16 and second by using an F-test to look at the interaction of the treatment with the three achievement levels in the two classes.

<u>Hypothesis 5</u>: There is no interaction between treatment and achievement level as measured by gain scores determined by the difference between TWS-3 posttest and pretest scores.

The means of the gain scores for the three achievement classifications of the control group and the treatment group can be seen in Table 16. An F-test was conducted to examine the interaction between the treatment and achievement in the two groups among so designated high achieving, average achieving, and low achieving students. Across the groups and across the achievement levels, when looked at independently, the treatment appeared to have no effect. However, when the interaction between treatment and achievement levels was examined, lower achieving students in the treatment group had significantly greater gains than the other students. This is readily visible in Figure 1.

Figure 1: Interaction of treatment and achievement levels.



As can be seen in Figure 1, below average achieving students in the experimental group had gain scores that were greater than the other groups. This resulted in a significant interaction as measured by an F ratio of 3.2937, significant at the .047 level. **Hypothesis 5 was rejected.**

Summary

This research tested five research hypotheses and five subhypotheses. A gender comparison between the two groups determined that they were gender equitable at the beginning of the study. Comparison of means using t-tests established that the groups were equal in regard to spelling achievement as determined by the TWS-3 pretest score, overall academic achievement levels based upon the third grade total CTBS score of the students, and age at the time of the TWS-3 pretest. A t-test was used to test the effect of listening to the music of Mozart prior to engaging in spelling instruction. F-tests, tested the relationship between spelling gain among the three achievement levels and the effect of the treatment on the three achievement levels. Two of the hypotheses were rejected while four were retained.

CHAPTER 5

SUMMARY, CONCLUSIONS, DISCUSSION, IMPLICATIONS, AND RECOMMENDATIONS

Summary of the Study

This study was designed to investigate if there was a relationship between listening to the music of Mozart prior to engaging in spelling instruction and spelling test scores in fourth grade students as determined by TWS-3 pretest and posttest scores. Two comparable fourth grade classes received daily spelling instruction in the Cast-A-Spell spelling program. The study was conducted during the 1999-2000 school year at Emily Dickinson Elementary School in Bozeman, Montana. The study was limited to two fourth grade classrooms at Emily Dickinson Elementary School in Bozeman, Montana. One class designated as the control group received spelling instruction directly after an active period (morning recess) without listening to music before the spelling lesson. The second class, the experimental group, listened to the music of Mozart for 30 minutes during a silent reading period after an active period (before school recess) prior to engaging in spelling instruction. Both classes were administered the third edition of the Test of Written Spelling (TWS-3), in September 1999, prior to a 12-week designated treatment period. The same test was administered in February 2000, one week after the treatment period.

The TWS-3 is designed to record both pretest and posttest data. It records gender, age at test time, score for predictable words, score for unpredictable words, a total score, and a percentage score for the pretest and posttest. When both tests have been administered a loss or gain is calculated. In addition, general achievement for the students in both groups was evaluated on the basis of the students' third grade total CTBS achievement test scores. As determined by their CTBS total scores, students in both groups were categorized as high achieving, average achieving, or below average achieving. The data obtained were analyzed using the SPSS statistical analysis program at Montana State University. The findings were used to answer the study's research questions.

Conclusions

This study sought to answer the question "Is there a relationship between listening to the music of Mozart prior to engaging in spelling instructions and spelling test scores in fourth grade students as measured by the TWS-3?" Inspired by the finding of previous studies, Rauscher et al. (1993, 1994), Leng and Shaw (1991), Rideout and Laubach (1996), Nantais and Schellenberg (1999), Pantev et al. (1998), Chan et al. (1998), Schlaug et al (1995), and others, the data collected in this study capitalized on existing research and were used to determine if improvement in spelling test scores would be found in fourth grade students who listen to the music of Mozart over a 12-week period prior to receiving instruction in spelling compared to fourth grade student who received spelling instruction without listening to music.

The first step in the analysis was to determine if the groups were demographically and academically equivalent at the beginning of the study. Descriptive statistics provided evidence that the two groups were equal on the basis of gender. Mean comparisons and t-tests validated their equality in age, knowledge of spelling as measured by the TWS-3 pretest, and overall academic achievement as measured by the third grade CTBS total score. Once it was proven that there was not a statistically significant difference between the groups at the beginning of the study, the remaining research hypotheses were tested.

Because the two groups tested out to be equal at the beginning of the study, mean comparisons and t-tests were conducted to determine if they were also equal in spelling knowledge at the end of the study. When tested individually, as anticipated, it was found that both the control group and the treatment group made significant gains in spelling knowledge from the pretest to the posttest as measured by TWS-3 scores.

For the reason that initial testing proved that the two groups were equal at the beginning of the study, they were merged together to analyze gain/loss in spelling achievement from the TWS-3 pretest to the posttest at the end of the study. On average, all students across both groups demonstrated statistically significant growth from the pretest to the posttest. It is a natural educational expectation that growth would occur over a 12-week period, treatment or no treatment.

At the end of the 12-week treatment period, a comparison of spelling achievement between groups was conducted. Data analysis yielded no statistically significant difference between the control group and the experimental group in spelling loss or gain scores. This was measured by calculating the difference between the TWS-3 pretest and posttest scores. An F-test indicated there was not a significant difference between the control group and the experimental group on the posttest percentage. Therefore, it can be concluded that listening to the music of Mozart prior to engaging in spelling instruction did not serve to facilitate growth in knowledge of spelling in the fourth graders who participated in this study.

To further scrutinize the relationship between listening to the music of Mozart and the learning of spelling, students were assigned to one of three academic classifications. Students were classified as above average achieving, average achieving, or below average achieving according to their third grade CTBS total score. An F-test comparing spelling gains as measured by the TWS-3 posttest with the achievement classifications yielded no statistically significant difference in improved spelling knowledge among students in the 3 designated achievement classifications.

However, when the effects of the treatment were examined in relation to achievement classification and TWS-3 gain scores, an interaction between the treatment and TWS-3 spelling gain was found for those fourth graders that were designated below average on the basis of their third grade CTBS total score. No significant difference was found for students in the control group or for students designated above average and average as determined by their third grade CTBS total score in the treatment group.

Discussion

Because the groups were found to be equal at the beginning of the study and at the end of the study, the findings are relevant and worthy of consideration. The fact that the treatment had an effect on low achieving students is of critical importance. Educational programs seek to provide curricula and instruction that enhances learning for all students. Below average achieving students are usually encumbered with a myriad of learning hindrances that are difficult for the student to overcome. Teachers make use of multiple strategies to help the underachieving student experience success. If, in fact, as found in this study that listening to the music of Mozart prior to engaging in spelling instruction can elicit a positive effect, it is worth serious consideration as a strategy to augment the learning capacity of these students.

Because this study was conducted in a public school setting, the researcher had to agree to use existing classrooms. Therefore the subjects in the two groups were not randomly assigned to the control and experimental groups. This is an inherent flaw of a quasi-experimental design. According to Gay (1996, p. 369), an advantage of this design is that " . . . since classes are used 'as-is,' it is possible effects from reactive arrangements are minimized." The subjects in this study were not aware that they were involved in a study so their participation can be considered unfettered. Although the same teacher did not teach both groups, a background survey provided some assurance that they were both highly competent, skilled instructors able to deliver the Cast-A-Spell spelling curriculum effectively.

Another consideration in this study was that even though the two groups received spelling instruction after an active period, the control group received its spelling instruction 75 minutes later in the instructional day compared to the treatment group. As physical activity is also associated with the ability to perform with greater concentration, a strength of this study lies in the fact that both groups received spelling instruction after a recess period. Since both groups experienced this active time, recess need not be considered a variable.

Because the treatment (listening to the music of Mozart) coincided with a silent reading period, it may have been the reading, not the music that accounted for any difference in spelling performance on the posttest. Student preference for listening to music verses silent reading was not tested in this study. Poor reading skills are commonly associated with low achieving students. Thus it is more likely that these students did not engage in silent reading as vigorously as high achieving students. Because high achieving students typically read with ease, they are more likely to garner pleasure from it and therefore engage more whole-heartedly in reading. In either case, it remains unknown if reading, listening to music, or a combination of both contributed to the results of this study.

There is no way of knowing if the students really listened to the music or if they were just in the room while the music was being played. It is also unknown if the students who listened with great attention perform differently than those who just sat back and let the music wash over them.

Implications

Since improving instruction and learning is the goal of every educational program, the findings presented in this study deserve consideration by those in roles of academic leadership. Teachers are constantly striving to develop strategies to assist all students in the assimilation of knowledge and skills contained in school curricula. To the extent that research finds that music has as substantial a biological basis as language, and is an inherent part of human nature, it makes educational sense to insure it is utilized in public school curricula. Considering the neural effect of music on cognition and behavior, attention must be given to the well-balanced role music can play in influencing educational philosophy and practical decisions about curricula. In this age of brain discovery, understanding the substrates of music should illuminate both music itself and the working of the brain and mind. The possible benefits of music listening are well worth consideration. On the basis of the findings of this study, specifically, the following recommendations are offered regarding having students listen to the music of Mozart prior to engagement in spelling instruction:

1. Since the designated low achieving students made statistically significant improvement in spelling and no harm was done to others, it would befit teachers to play this music for all students prior to the delivery of spelling instruction.

2. In this time of budgetary constraints, administrators will find that most contemporary classrooms are equipped with audio equipment. Outside of the purchase of a few audiocassettes or compact discs, minor budgetary allocations would be required to implement a music listening element into classrooms.

3. It has been suggested that the pleasure of listening to music promotes the acquisition of skills that consequently motivate the acquisition of other difficult skills. Listening to music may enhance the ability of students to learn standard curricula, such as mathematics and science, as well as those subjects such as spelling which require the encoding of information into long-term memory.

4. Research literature suggests that background music, though itself not a part of a conscious learning task, correctly integrated into the learning experience may serve as an agent of facilitation.

Recommendations for Future Research

It is recommended that further research be conducted to achieve a more complete understanding of the role of music in daily memory and its implications. The studies to date reveal that memories are complex constructions consisting of many strands. It remains unknown to what extent the use of music can impact learning. Music may be a useful tool for the understanding of higher brain function and its relationship to cognition.

Additional research may be able to determine the extent to which music can access inherent brain patterns, enhance the ability of the cortex to do pattern development, and thereby improve other related higher cognitive functions. Because musical activities help systematize the cortical firing patterns in the brain, which enhances pattern development, it is recommended that the study be replicated and extended to include a larger sample.

Future studies have the potential to capitalize on the role music can play in public education, particularly with at-risk students. This study has shown that music's effect in stimulating brain activity may be a valuable tool for the enhancement of intellectual development. The results of this study have provided the impetus for public school officials to apply the findings to instructional programs and include music as an integral part of elementary school education.

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APPENDICES

APPENDIX A

TEACHER INVENTORY

TEACHER INVENTORY

How many years and at what grade levels have you taught?

What is your educational level?

How many years have you been in your current position?

Professionally, what strengths do you bring to the classroom?

When do you teach spelling in your daily classroom routine?

In relationship to other curricular areas, how much importance/emphasis do you place on spelling?

Is there anything unique about your classroom that deserves consideration?

In your opinion, how would you rank your class's academic capability?

How consistent are you at doing spelling daily for 20 – 25 minutes as required by the Cast-A-Spell program?

In your opinion, do you feel you received adequate training in the Cast-A-Spell program to have acquired to skills to implement the program?

How accurate do you think your test scoring is?

Has anything changed in you class during the twelve-week treatment period?

Was the treatment consistently administered as prescribed?

APPENDIX B

TESTING INSTRUMENT

Test of Written Spelling
Record Sheet

Teacher:
School:
Grade:

Student	Gender	Age	Pre-test			% Score	Post-test			% Score	+/- Gain
		(Y-M)	Pred. Words	Unpred. Words	Total		Pred. Words	Unpred. Words	Total		
1.											
2.											
3.											
4.											
5.											
6.											
7.											
8.											
9.											
10.											
11.											
12.											
13.											
14.											
15.											
16.											
17.											
18.											
19.											
20.											
21.											
22.											
23.											
24.											
25.											
26.											
27.											
28.											
29.											
30.											

TWS-3

Test of Written Spelling
Third Edition

SUMMARY/RESPONSE FORM

Section I. Identifying Information

Name ____________ Female ___ Male ___
School ____________
Examiner ____________
Referred by ____________
Reason for Referral ____________

	Year	Month
Date of Testing	___	___
Date of Birth	___	___
Test Age	___	___

Section II. Record of TWS-3 Scores

TWS-3 Scores	Raw Scores	Std. Scores	%iles	Spelling Ages	Grade Equivalents
Predictable Words					
Unpredictable Words					
Total Words					

Section III. Other Test Scores

	Name	Date	Std. Score	TWS-3 Equiv.
1.				
2.				
3.				
4.				

Section IV. Profile of Scores

Standard Scores	Total Words	Predictable Words	Unpredictable Words	1.	2.	3.	4.	Standard Scores
150	·	·	·	·	·	·	·	150
145	·	·	·	·	·	·	·	145
140	·	·	·	·	·	·	·	140
135	·	·	·	·	·	·	·	135
130	·	·	·	·	·	·	·	130
125	·	·	·	·	·	·	·	125
120	·	·	·	·	·	·	·	120
115	·	·	·	·	·	·	·	115
110	·	·	·	·	·	·	·	110
105	·	·	·	·	·	·	·	105
100	—	—	—	—	—	—	—	100
95	·	·	·	·	·	·	·	95
90	·	·	·	·	·	·	·	90
85	·	·	·	·	·	·	·	85
80	·	·	·	·	·	·	·	80
75	·	·	·	·	·	·	·	75
70	·	·	·	·	·	·	·	70
65	·	·	·	·	·	·	·	65
60	·	·	·	·	·	·	·	60
55	·	·	·	·	·	·	·	55

Section V. Test Conditions

A. Place Tested ____________

	Interfering				Not Interfering
B. Noise Level	1	2	3	4	5
C. Interruptions	1	2	3	4	5
D. Distractions	1	2	3	4	5
E. Light	1	2	3	4	5
F. Temperature	1	2	3	4	5

G. Notes and other considerations ____________

Additional copies of this form (#6725) may be purchased from PRO-ED. 8700 Shoal Creek Blvd., Austin, TX 78757. 512/451-3246.

Section VI. Response Form

Predictable Words

____ 1. ____________________
____ 2. ____________________
____ 3. ____________________
____ 4. ____________________
____ 5. ____________________
____ 6. ____________________
____ 7. ____________________
____ 8. ____________________
____ 9. ____________________
____ 10. ____________________
____ 11. ____________________
____ 12. ____________________
____ 13. ____________________
____ 14. ____________________
____ 15. ____________________
____ 16. ____________________
____ 17. ____________________
____ 18. ____________________
____ 19. ____________________
____ 20. ____________________
____ 21. ____________________
____ 22. ____________________
____ 23. ____________________
____ 24. ____________________
____ 25. ____________________
____ 26. ____________________
____ 27. ____________________
____ 28. ____________________
____ 29. ____________________
____ 30. ____________________
____ 31. ____________________
____ 32. ____________________
____ 33. ____________________
____ 34. ____________________
____ 35. ____________________
____ 36. ____________________
____ 37. ____________________
____ 38. ____________________
____ 39. ____________________
____ 40. ____________________
____ 41. ____________________
____ 42. ____________________
____ 43. ____________________
____ 44. ____________________
____ 45. ____________________
____ 46. ____________________
____ 47. ____________________
____ 48. ____________________
____ 49. ____________________
____ 50. ____________________

Total Raw Score ____________

Unpredictable Words

_____ 1. ______________________________

_____ 2. ______________________________

_____ 3. ______________________________

_____ 4. ______________________________

_____ 5. ______________________________

_____ 6. ______________________________

_____ 7. ______________________________

_____ 8. ______________________________

_____ 9. ______________________________

_____ 10. ______________________________

_____ 11. ______________________________

_____ 12. ______________________________

_____ 13. ______________________________

_____ 14. ______________________________

_____ 15. ______________________________

_____ 16. ______________________________

_____ 17. ______________________________

_____ 18. ______________________________

_____ 19. ______________________________

_____ 20. ______________________________

_____ 21. ______________________________

_____ 22. ______________________________

_____ 23. ______________________________

_____ 24. ______________________________

_____ 25. ______________________________

_____ 26. ______________________________

_____ 27. ______________________________

_____ 28. ______________________________

_____ 29. ______________________________

_____ 30. ______________________________

_____ 31. ______________________________

_____ 32. ______________________________

_____ 33. ______________________________

_____ 34. ______________________________

_____ 35. ______________________________

_____ 36. ______________________________

_____ 37. ______________________________

_____ 38. ______________________________

_____ 39. ______________________________

_____ 40. ______________________________

_____ 41. ______________________________

_____ 42. ______________________________

_____ 43. ______________________________

_____ 44. ______________________________

_____ 45. ______________________________

_____ 46. ______________________________

_____ 47. ______________________________

_____ 48. ______________________________

_____ 49. ______________________________

_____ 50. ______________________________

Total Raw Score ________________

PREDICTABLE WORDS

Pronunciation*	Word	Sentence	Word
'stäp	stop	1. Stop talking now.	stop
'bed	bed	2. She slept on a bed.	bed
'let	let	3. Please let me go.	let
'plant	plant	4. The plant needed some water.	plant
(')him	him	5. She touched him on the arm.	him
(')went	went	6. Jim went to the store.	went
(')nekst	next	7. He is next in line.	next
'spriŋ	spring	8. Flowers bloom in the spring.	spring
'sto(ə)rm	storm	9. The storm passed quickly.	storm
'spend	spend	10. Did you spend the money?	spend
'shāk	shake	11. Did the baby shake the rattle?	shake
'hwen	when	12. I laughed when I saw the clown.	when
'härd-lē	hardly	13. The extra point hardly mattered.	hardly
'stroŋ	strong	14. The man was strong.	strong
'ā-bəl	able	15. Carol was able to play.	able
'pī(ə)l	pile	16. The boys played on a pile of dirt.	pile
'tärd-ē	tardy	17. Alan was tardy for school.	tardy
'strānj	strange	18. Bob heard a strange noise.	strange
'sek-shən	section	19. The farmers worked one section of land.	section
'häs-pit-ᵊl	hospital	20. The injured player went to the hospital.	hospital
'sig-nᵊl	signal	21. The cars stopped at the traffic signal.	signal
'bran-dish	brandish	22. When you brandish your sword, the battle will begin.	brandish
ik-'spekt	expect	23. We expect them to be on time.	expect
'fort-ē	forty	24. He is forty years old.	forty
'dis-(ˌ)trikt	district	25. The congressman campaigned in his district.	district
'lē-gəl	legal	26. The judge has legal authority.	legal
pə-'lit-i-kəl	political	27. He joined a political party.	political
in-'tī(ə)r	entire	28. The entire football team went to the game.	entire
sə-'lüt	salute	29. The soldiers will salute the officers.	salute
ˌin(t)-stə-'t(y)ü-shən	institution	30. The school is sometimes called an institution of learning.	institutior
ˌō-vər-'hwelm	overwhelm	31. It is not always necessary to overwhelm the opponent.	overwhel
'vizh-(ə-)wə-līz	visualize	32. It is not always possible to visualize a dream.	visualize
'bāst	baste	33. It's time to baste the turkey.	baste
ri-'tal-e-ˌāt	retaliate	34. General Davis wanted to retaliate against the enemy.	retaliate
'wist-fəl	wistful	35. Susan led a wistful life.	wistful
'traŋ-kwəl	tranquil	36. The tranquil scene helped calm his thoughts.	tranquil

PREDICTABLE WORDS, continued

Pronunciation*	Word	Sentence	Word
ăm-bĭg-ˊu-ŭs	ambiguous	37. The debater's arguments were ambiguous.	ambiguous
ˌkänt-ən-ˊ(y)ü-et-ē	continuity	38. There is little continuity in the stock.	continuity
ˊnōt-ə-rē	notary	39. The lawyer was also a notary.	notary
ləˊbor-ē-əs	laborious	40. The laborious task took four hours.	laborious
ˊnav-i-gə-bəl	navigable	41. The channel was navigable.	navigable
liŋˊgwis-tik	linguistic	42. John's linguistic competence was well recognized.	linguistic
ˌpan-əˊram-ə	panorama	43. The wall contained a panorama of the grand canyon.	panorama
niˊgō-shē-ˌāt	negotiate	44. We tried to negotiate the dispute.	negotiate
ˊkrej-ə-ləs	credulous	45. Children are often credulous persons.	credulous
ˊgȯnt-let	gauntlet	46. The group had its new members run the gauntlet.	gauntlet
fəˊnes	finesse	47. The game of bridge requires finesse.	finesse
ˊver-ē-ən(t)s	variance	48. There was little variance between the two points.	variance
griˊgar-ē-əs	gregarious	49. Sheep are gregarious creatures.	gregarious
ˊtər-shē-ˌer-ē	tertiary	50. The tertiary battalion was as well disciplined as the first.	tertiary

*From *Webster's Ninth New Collegiate Dictionary* (1984).

UNPREDICTABLE WORDS

Pronunciation*	Word	Sentence	Word
'yes	yes	1. Yes, I am going to John's house today.	yes
(')shē	she	2. She won the spelling bee.	she
(')əs	us	3. Please come with us to the puppet show.	us
'nām	name	4. What is your name?	name
'tü	two	5. There are two birds in the tree.	two
'məch	much	6. You didn't eat much of your breakfast.	much
mī-'self	myself	7. I saw myself in the mirror.	myself
'pē-pəl	people	8. The people were riding in the car.	people
(')hü	who	9. Who did you see?	who
'āt	eight	10. The boys had eight books.	eight
'nīf	knife	11. The knife was sharp.	knife
'ev-rē-(ˌ)wən	everyone	12. Everyone finished on time.	everyone
'əŋ-kəl	uncle	13. Bob's uncle took us to the park.	uncle
'nü	knew	14. Kathy knew the right answer.	knew
(')nīn(t)-'ēn	nineteen	15. My brother is nineteen years old.	nineteen
'shu̇(ə)r	sure	16. Be sure to write the letter.	sure
'i-'nəf	enough	17. Joan had enough to eat.	enough
'kan-yən	canyon	18. The canyon is very deep.	canyon
'fau̇nt-ᵊn	fountain	19. There was water in the fountain.	fountain
i-ˌlek-'tris-ət-ē	electricity	20. Benjamin Franklin discovered electricity.	electricity
'pärd-ᵊn	pardon	21. I beg your pardon.	pardon
'ȯ-fəl	awful	22. The medicine tasted awful.	awful
'ter-ə-bəl	terrible	23. Dorothy saw the terrible storm.	terrible
'bī-ˌsik-əl	bicycle	24. Paul received a bicycle for his birthday.	bicycle
kə-'myü-nət-ē	community	25. They lived in a small community.	community
'yü-nə-ˌfī	unify	26. Discord does little to unify a group.	unify
'ag-ri-ˌkəl-chər	agriculture	27. Agriculture is an important part of the economy.	agriculture
ə-'rij-ən-ᵊl	original	28. The art exhibit featured original paintings.	original
'n(y)ü-klē-əs	nucleus	29. The returning lettermen form the nucleus of a strong team.	nucleus
'fal-(ˌ)ō	fallow	30. The field was left fallow.	fallow
'käl-ər	collar	31. She buttoned her collar.	collar
(')kam-'pān	campaign	32. They planned the campaign carefully.	campaign
hī-'päth-ə-səs	hypothesis	33. Our hypothesis was confirmed by the study.	hypothesis
'ȯd-ə-bəl	audible	34. The music was barely audible.	audible
'tan-jə-bəl	tangible	35. No tangible results came from the survey.	tangible
'lü-mə-nəs	luminous	36. The luminous sign was an effective advertising tool.	luminous

UNPREDICTABLE WORDS, continued

Pronunciation*	Word	Sentence	Word
′ver-ə-′fī	verify	37. The research team could not verify its earlier findings.	verify
sə-′fīs	suffice	38. A passing grade will suffice.	suffice
′sist	cyst	39. A cyst was found in the dog's leg.	cyst
ō-′pāk	opaque	40. The new fingernail polish was opaque.	opaque
′zel-əs	zealous	41. Dan was zealous in his beliefs.	zealous
′ha-vək	havoc	42. The tornado wreaked havoc upon the village.	havoc
sham-′pān	champagne	43. Champagne was used to toast the new bride and groom.	champagne
ă-frŭnt′	affront	44. The speaker's comments were an affront to his listeners.	affront
′vər-sət-ᵊl	versatile	45. Susan was a very versatile dancer.	versatile
′rek-wə-zət	requisite	46. The introductory course is a prerequisite for enrolling in the advanced class.	requisite
fak-′sim-ə-lē	facsimile	47. Todd's painting was a reasonable facsimile of the original.	facsimile
ˌaf-ə-′dā-vət	affidavit	48. After signing the affidavit, Tom left.	affidavit
′lē-ə-ˌzän	liaison	49. The company's liaison spoke to the general.	liaison
′fān	feign	50. Those who feign injury may not later be believed.	feign

*From *Webster's Ninth New Collegiate Dictionary* (1984).

TABLE A

PREDICTABLE WORDS

Converting Raw Scores to Standard Scores

Number of Items Passed	6-0 to 6-5	6-6 to 6-11	7-0 to 7-5	7-6 to 7-11	8-0 to 8-5	8-6 to 8-11	9-0 to 9-5	9-6 to 9-11	10-0 to 10-5	10-6 to 10-11	11-0 to 11-5	11-6 to 11-11	12-0 to 12-5	12-6 to 12-11	13-0 to 13-5	13-6 to 13-11	14-0 to 14-5	14-6 to 14-11	15-0 to 15-5	15-6 to 15-11	16-0 to 16-5	16-6 to 16-11	17-0 to 17-5	17-6 to 17-11	18-0 to 18-5	18-6 to 18-11	Number of Items Passed
0	70	70	69	68	67	66	65	64	63	62	61	60	60	≤60	≤60												0
1	76	74	70	70	69	68	67	66	65	64	63	62	61	60	60	≤60	≤60										1
2	81	78	75	74	70	70	69	68	67	66	65	64	63	62	61	60	60	<60	<60								2
3	85	82	77	76	74	73	70	70	69	68	67	66	65	64	63	62	61	60	60	<60	<60						3
4	89	85	80	78	76	75	74	73	70	70	69	68	67	66	65	64	63	62	61	60	60	<60	<60				4
5	93	87	82	80	78	77	76	75	74	73	70	70	69	68	67	66	65	64	63	62	61	60	60	<60			5
6	97	90	85	82	80	79	78	77	76	75	73	72	70	70	69	68	67	66	65	64	63	62	61	60	<60	<60	6
7	100	93	88	85	82	81	80	79	78	77	75	74	72	71	70	70	69	68	67	66	65	64	63	62	60	60	7
8	103	97	89	87	85	82	81	80	79	78	77	75	74	73	71	71	70	70	69	68	67	66	65	64	62	61	8
9	105	100	92	89	87	83	82	81	80	79	78	76	75	74	73	72	71	71	70	69	68	67	66	65	64	63	9
10	107	102	96	91	89	85	83	82	81	80	79	77	76	75	74	73	72	72	71	70	69	68	67	66	65	64	10
11	111	105	100	94	91	87	85	83	82	81	80	78	77	76	75	74	73	73	72	71	70	70	69	68	67	66	11
12	115	108	103	97	93	89	87	85	83	82	81	79	78	77	76	75	74	74	73	72	71	71	70	69	69	68	12
13	119	111	106	100	95	90	88	86	84	83	82	80	79	78	77	76	75	75	74	73	72	72	71	70	70	69	13
14	123	113	108	102	97	92	90	88	85	84	83	81	80	79	78	77	76	76	75	74	73	73	72	71	71	70	14
15	127	115	111	105	100	94	91	89	86	85	84	82	81	80	79	78	77	77	76	75	74	74	73	72	72	71	15
16	130	119	113	107	101	96	93	90	88	86	85	83	82	81	80	79	78	78	77	76	75	75	74	73	73	72	16
17	133	123	115	109	103	98	95	91	89	87	86	84	83	82	81	80	79	79	78	77	76	76	75	74	74	73	17
18	136	127	118	111	105	100	97	92	90	88	87	85	84	83	82	81	80	80	79	78	77	77	76	75	75	74	18
19	139	130	121	113	107	102	98	93	92	89	88	86	85	84	83	82	81	81	80	79	78	78	77	76	76	75	19
20	141	133	124	115	110	105	100	94	93	90	89	87	86	85	84	83	82	82	81	80	79	79	78	77	77	76	20
21	>141	136	127	118	113	108	103	96	94	91	90	88	87	86	85	84	83	83	82	81	80	80	79	78	78	77	21
22		139	130	120	115	110	105	98	96	92	91	89	88	87	86	85	84	84	83	82	81	81	80	79	79	78	22
23		141	133	122	117	112	107	100	97	93	92	90	89	88	87	86	85	85	84	83	82	82	81	80	80	79	23
24		>141	136	124	119	115	110	102	98	94	93	92	91	90	89	88	87	86	85	84	83	83	82	81	81	80	24
25			139	128	121	117	113	104	100	95	94	93	92	91	90	89	88	87	86	85	84	84	83	82	82	81	25
26			141	130	123	118	115	107	102	97	96	95	94	93	92	91	90	89	88	87	85	85	84	83	83	82	26
27			>141	133	125	119	116	110	105	100	98	97	96	95	94	93	92	91	90	89	87	86	85	84	84	83	27
28				136	127	121	117	112	107	103	100	98	97	96	95	94	93	92	91	90	88	87	86	85	85	84	28
29				138	129	122	118	115	110	106	102	100	98	97	96	95	94	93	92	91	90	89	88	87	86	85	29
30				140	130	124	120	117	113	109	104	101	100	98	97	96	95	94	93	92	91	90	89	88	87	86	30
31				141	132	125	121	119	115	111	107	103	102	100	98	97	96	95	94	93	92	91	90	89	88	87	31
32				>141	134	126	122	120	116	113	109	105	104	101	100	98	97	96	95	94	93	92	91	90	89	88	32
33					136	128	124	121	117	115	111	107	106	103	102	100	98	97	96	95	94	93	92	91	90	89	33
34					138	130	125	122	118	116	113	109	108	105	104	101	100	98	97	96	95	94	93	92	91	90	34
35					140	132	127	123	119	117	115	111	110	107	106	103	102	100	98	97	96	95	94	93	92	91	35
36					141	134	129	124	120	118	117	113	112	109	108	105	104	101	100	98	97	96	95	94	93	92	36

TABLE A. Continued

Number of Items Passed	6-0 to 6-5	6-6 to 6-11	7-0 to 7-5	7-6 to 7-11	8-0 to 8-5	8-6 to 8-11	9-0 to 9-5	9-6 to 9-11	10-0 to 10-5	10-6 to 10-11	11-0 to 11-5	11-6 to 11-11	12-0 to 12-5	12-6 to 12-11	13-0 to 13-5	13-6 to 13-11	14-0 to 14-5	14-6 to 14-11	15-0 to 15-5	15-6 to 15-11	16-0 to 16-5	16-6 to 16-11	17-0 to 17-5	17-6 to 17-11	18-0 to 18-5	18-6 to 18-11	Number of Items Passed
37					>141	136	130	125	121	120	119	115	114	111	110	107	106	103	102	100	99	97	96	95	94	93	37
38						138	132	127	123	122	121	117	115	113	112	109	108	105	104	101	100	98	97	96	95	94	38
39						140	134	130	125	124	123	119	117	115	114	111	110	107	106	103	102	100	99	97	96	95	39
40						141	136	132	127	126	125	121	119	117	115	113	112	109	108	105	104	101	100	98	97	96	40
41						>141	138	134	129	128	127	123	121	119	117	115	114	111	110	107	106	103	102	100	98	97	41
42							140	136	130	129	128	125	123	121	119	117	115	113	112	109	108	105	104	101	100	99	42
43							141	138	132	130	129	127	125	123	121	119	117	115	114	111	110	107	106	103	102	100	43
44							>141	140	134	132	130	129	127	125	123	121	119	117	115	113	112	109	108	105	104	102	44
45								141	136	134	132	130	129	127	125	123	121	119	117	115	114	111	110	107	106	104	45
46								>141	138	136	134	132	130	129	127	125	123	121	119	117	115	113	112	109	108	106	46
47									140	138	136	133	131	130	129	127	125	123	121	119	117	115	114	111	110	108	47
48									141	140	137	135	132	131	130	129	127	125	123	121	119	117	115	113	112	110	48
49									>141	141	139	137	133	132	131	130	129	127	125	123	121	119	117	115	114	112	49
50										>141	141	139	134	133	132	131	130	129	127	125	123	121	119	117	115	114	50

TABLE B

UNPREDICTABLE WORDS

Converting Raw Scores to Standard Scores

Number of Items Passed	6-0 to 6-5	6-6 to 6-11	7-0 to 7-5	7-6 to 7-11	8-0 to 8-5	8-6 to 8-11	9-0 to 9-5	9-6 to 9-11	10-0 to 10-5	10-6 to 10-11	11-0 to 11-5	11-6 to 11-11	12-0 to 12-5	12-6 to 12-11	13-0 to 13-5	13-6 to 13-11	14-0 to 14-5	14-6 to 14-11	15-0 to 15-5	15-6 to 15-11	16-0 to 16-5	16-6 to 16-11	17-0 to 17-5	17-6 to 17-11	18-0 to 18-5	18-6 to 18-11	Number of Items Passed
0	78	70	<68	66	64	62	60	<60																			0
1	83	75	70	68	66	64	62	60	<60																		1
2	85	80	79	70	68	66	64	62	60	<60	<60																2
3	89	85	81	76	70	68	66	64	62	60	60	<60	<60														3
4	94	89	84	80	78	70	68	66	64	62	61	60	60	<60	<60												4
5	96	92	85	83	80	72	70	68	66	64	63	62	61	60	60	<60	<60										5
6	100	95	89	85	82	74	72	70	68	66	65	64	63	62	61	60	60	<60	<60								6
7	101	97	92	88	85	78	75	72	70	68	67	66	65	64	63	62	61	60	60	<60	<60						7
8	105	100	95	89	87	81	79	75	73	70	69	68	67	66	65	64	63	62	61	60	60	<60	<60				8
9	110	103	98	92	89	85	81	78	75	73	70	70	69	68	67	66	65	64	63	62	61	60	60	<60	<60		9
10	115	107	100	95	90	86	83	81	79	76	72	71	70	70	69	68	67	66	65	64	63	62	61	60	60	<60	10
11	118	110	103	97	93	88	85	83	81	78	75	74	72	71	70	70	69	68	67	66	65	64	63	62	61	60	11
12	120	115	107	100	95	90	86	85	82	80	78	77	74	73	72	71	70	70	69	68	67	66	65	64	63	62	12
13	124	118	111	104	98	92	87	86	84	82	80	78	76	75	74	73	72	71	70	70	69	68	67	66	65	64	13
14	127	120	115	109	100	95	89	87	85	83	82	80	79	77	76	75	74	73	72	71	70	70	69	68	67	66	14
15	130	124	118	111	104	97	90	88	86	85	84	81	80	79	78	77	76	75	74	73	72	71	70	70	69	68	15
16	133	127	120	115	108	100	93	90	87	86	85	83	82	81	80	79	78	77	76	75	74	73	72	71	70	70	16
17	136	130	123	118	111	104	96	91	88	87	86	85	85	83	82	81	80	79	78	77	76	75	74	73	72	71	17
18	139	133	126	120	113	107	100	94	91	89	88	87	86	85	85	84	83	81	80	79	78	77	76	75	74	73	18
19	141	136	128	121	115	110	104	97	93	91	90	89	88	87	86	85	85	84	83	81	80	79	78	77	76	75	19
20	>141	139	130	122	118	113	109	100	95	93	92	91	90	89	88	87	86	85	85	83	82	80	79	78	77	76	20
21		141	133	124	120	115	111	103	97	96	95	94	93	92	90	89	88	87	86	85	85	83	81	80	79	77	21
22		>141	135	126	121	117	113	107	100	98	97	96	95	94	93	92	91	90	89	87	86	85	85	83	82	80	22
23			137	128	122	119	115	110	103	100	98	97	96	95	94	93	92	91	90	89	88	87	86	85	83	81	23
24			139	130	124	121	117	113	106	103	99	98	97	96	95	94	93	92	91	90	89	88	87	86	85	83	24
25			141	133	126	123	119	115	109	105	100	99	98	97	96	95	94	93	92	91	90	89	88	87	86	85	25
26			>141	135	128	124	120	116	111	107	103	100	99	98	97	96	95	94	93	92	91	90	89	88	87	86	26
27				137	130	126	122	118	113	109	105	103	100	99	98	97	96	95	94	93	92	91	90	89	88	87	27
28				139	133	127	123	120	115	111	107	105	103	100	99	98	97	96	95	94	93	92	91	90	89	88	28
29				141	135	129	124	121	116	113	109	107	105	103	100	99	98	97	96	95	94	93	92	91	90	89	29
30				>141	137	130	125	122	118	115	111	109	107	105	103	100	99	98	97	96	95	94	93	92	91	90	30
31					139	133	127	123	119	116	113	111	109	107	105	103	100	99	98	97	96	95	94	93	92	91	31
32					141	135	129	125	121	118	115	113	111	109	107	105	103	100	99	98	97	96	95	94	93	92	32
33					>141	137	130	127	123	119	116	115	113	111	109	107	105	103	100	99	98	97	96	95	94	93	33
34						139	133	129	125	121	118	116	115	113	111	109	107	105	103	100	99	98	97	96	95	94	34
35						141	135	130	127	123	120	118	116	115	113	111	109	107	105	103	100	99	98	97	96	95	35
36						>141	137	133	129	125	122	120	118	116	115	113	111	109	107	105	103	100	99	98	97	96	36

TABLE B. Continued

Number of Items Passed	6-0 to 6-5	6-6 to 6-11	7-0 to 7-5	7-6 to 7-11	8-0 to 8-5	8-6 to 8-11	9-0 to 9-5	9-6 to 9-11	10-0 to 10-5	10-6 to 10-11	11-0 to 11-5	11-6 to 11-11	12-0 to 12-5	12-6 to 12-11	13-0 to 13-5	13-6 to 13-11	14-0 to 14-5	14-6 to 14-11	15-0 to 15-5	15-6 to 15-11	16-0 to 16-5	16-6 to 16-11	17-0 to 17-5	17-6 to 17-11	18-0 to 18-5	18-6 to 18-11	Number of Items Passed
37							139	135	130	127	124	122	120	118	116	115	113	111	109	107	105	103	100	99	98	97	37
38							141	137	133	130	126	124	122	120	118	116	115	113	111	109	107	105	103	100	99	98	38
39							>141	139	135	133	128	126	124	122	120	118	116	115	113	111	109	107	105	103	100	99	39
40								141	137	135	130	128	126	124	122	120	118	116	115	113	111	109	107	105	103	100	40
41								>141	139	137	133	130	128	126	124	122	120	118	116	115	113	111	109	107	105	103	41
42									141	139	135	133	130	128	126	124	122	120	118	116	115	113	111	109	107	105	42
43									>141	141	137	135	133	130	128	126	124	122	120	118	116	115	113	111	109	107	43
44										>141	139	137	135	133	130	128	126	124	122	120	118	116	115	113	111	109	44
45											141	139	137	135	132	130	127	126	124	122	120	118	116	115	113	111	45
46											>141	141	139	137	134	132	130	128	126	124	122	120	118	116	115	113	46
47												>141	141	139	136	134	132	130	128	126	124	122	120	118	116	115	47
48													>141	141	138	136	134	132	130	128	126	124	122	120	118	116	48
49														>141	140	138	136	134	132	130	128	126	124	122	120	118	49
50															141	140	138	136	134	132	130	128	126	124	122	120	50

TABLE C

TOTAL WORDS

Converting Raw Scores to Standard Scores

Number of Items Passed	6-0 to 6-5	6-6 to 6-11	7-0 to 7-5	7-6 to 7-11	8-0 to 8-5	8-6 to 8-11	9-0 to 9-5	9-6 to 9-11	10-0 to 10-5	10-6 to 10-11	11-0 to 11-5	11-6 to 11-11	12-0 to 12-5	12-6 to 12-11	13-0 to 13-5	13-6 to 13-11	14-0 to 14-5	14-6 to 14-11	15-0 to 15-5	15-6 to 15-11	16-0 to 16-5	16-6 to 16-11	17-0 to 17-5	17-6 to 17-11	18-0 to 18-5	18-6 to 18-11	Number of Items Passed
0	68	66	62	60																							0
1	70	68	64	60	60																						1
2	73	70	66	62	60																						2
3	76	72	68	64	62	<60																					3
4	79	74	70	66	64	60	<60																				4
5	81	76	72	68	66	62	60																				5
6	83	78	74	70	68	64	62																				6
7	85	78	76	71	70	66	64	<60																			7
8	87	82	78	72	71	68	66	60	<60																		8
9	89	85	80	73	72	70	67	62	60																		9
10	91	87	82	74	73	71	68	64	62	<60																	10
11	93	88	84	76	74	72	69	65	63	60	<60																11
12	95	90	85	78	75	73	70	66	64	62	60	<60															12
13	97	91	87	80	76	74	71	67	65	63	62	60	<60														13
14	99	93	88	82	77	75	72	69	66	64	63	61	60	<60													14
15	100	95	89	85	78	76	73	70	67	66	64	63	61	60	<60												15
16	102	96	91	86	79	77	74	71	68	67	65	64	62	61	60	<60											16
17	104	98	92	88	83	78	75	72	69	68	66	65	63	62	61	60	<60										17
18	105	99	93	89	85	80	76	73	70	69	67	66	64	63	62	61	60	<60									18
19	107	100	95	90	86	82	77	74	71	70	68	67	65	64	63	62	61	60	<60	<60							19
20	108	102	96	91	88	85	78	75	72	71	69	68	66	65	64	63	62	61	60	60	<60						20
21	110	104	97	93	89	86	79	76	74	73	70	69	68	67	66	65	64	63	62	61	60	<60					21
22	112	106	98	94	90	87	82	78	77	74	71	70	70	69	68	67	66	65	64	63	62	60	<60				22
23	114	108	100	95	91	88	84	81	78	76	73	72	71	70	70	69	68	66	65	64	63	61	60	<60			23
24	115	110	102	96	92	89	85	82	79	78	76	74	73	72	71	70	69	67	66	65	64	62	61	60	<60		24
25	117	112	104	97	93	90	86	83	80	79	77	75	74	73	72	71	70	68	67	66	65	63	62	61	60	<60	25
26	119	114	106	98	95	91	87	84	82	80	78	77	76	74	73	72	71	70	68	67	66	64	63	62	61	60	26
27	121	115	108	100	96	92	88	85	83	81	79	78	77	75	74	73	72	71	70	68	67	65	64	63	62	61	27
28	123	117	110	101	97	93	89	86	84	82	80	79	78	76	75	74	73	72	71	70	68	67	66	65	64	63	28
29	125	118	112	103	98	94	90	87	85	83	81	80	79	77	76	75	74	73	72	71	70	68	67	66	65	64	29
30	127	120	114	104	99	95	91	88	85	83	81	80	79	78	77	76	75	74	73	72	71	70	68	67	66	65	30
31	129	122	115	106	100	96	92	89	86	84	83	81	80	79	78	77	76	75	74	73	72	71	69	68	67	66	31
32	130	124	116	107	101	97	93	90	87	84	83	81	80	79	78	77	76	75	74	73	72	71	70	70	68	67	32
33	133	125	118	109	103	98	94	90	88	85	84	82	81	80	79	78	77	76	75	74	73	72	71	71	69	68	33
34	136	126	120	110	104	99	95	92	89	86	84	82	81	80	79	78	77	76	75	74	73	72	71	71	70	70	34
35	139	128	122	112	105	100	96	93	89	87	85	83	82	81	80	79	78	77	76	75	74	73	72	72	71	71	35
36	141	130	123	114	106	101	97	94	90	88	85	83	82	81	80	79	78	77	76	75	74	73	72	72	71	71	36

TABLE C. Continued

Number of Items Passed	6-0 to 6-5	6-6 to 6-11	7-0 to 7-5	7-6 to 7-11	8-0 to 8-5	8-6 to 8-11	9-0 to 9-5	9-6 to 9-11	10-0 to 10-5	10-6 to 10-11	11-0 to 11-5	11-6 to 11-11	12-0 to 12-5	12-6 to 12-11	13-0 to 13-5	13-6 to 13-11	14-0 to 14-5	14-6 to 14-11	15-0 to 15-5	15-6 to 15-11	16-0 to 16-5	16-6 to 16-11	17-0 to 17-5	17-6 to 17-11	18-0 to 18-5	18-6 to 18-11	Number of Items Passed
37		133	124	115	108	102	98	95	91	89	86	84	83	82	81	80	79	78	77	76	75	74	73	73	72	72	37
38		136	125	117	110	104	100	96	92	90	87	85	83	82	81	80	79	78	77	76	76	75	74	73	72	72	38
39		139	126	118	112	106	101	97	93	91	88	85	84	83	82	81	80	79	78	77	77	76	75	74	73	73	39
40		141	127	119	114	108	103	98	93	92	89	86	85	84	83	82	81	80	79	78	78	76	76	75	74	73	40
41		>141	128	120	115	109	105	99	94	93	90	87	85	84	83	82	81	80	79	78	78	77	76	76	75	74	41
42			130	121	117	111	106	99	95	93	90	87	86	85	84	83	82	81	80	79	79	78	77	77	76	75	42
43			132	122	118	112	108	100	96	94	91	88	87	86	85	84	83	82	81	80	80	79	78	78	77	76	43
44			134	123	119	114	110	101	97	95	92	89	88	87	86	85	84	83	82	81	81	80	79	79	78	77	44
45			136	126	120	115	111	102	98	96	93	90	89	88	87	86	85	84	83	82	82	81	80	80	78	77	45
46			138	128	121	117	112	104	99	96	93	90	89	88	87	86	85	85	84	83	83	82	81	81	79	78	46
47			140	130	122	118	113	106	100	97	94	91	90	89	88	87	86	86	85	84	84	83	82	81	80	79	47
48			141	132	123	119	114	107	102	98	95	92	91	90	89	88	87	86	86	85	85	84	83	82	81	80	48
49			>141	134	125	120	115	108	103	99	96	93	92	91	90	89	88	87	86	86	85	84	83	82	81	80	49
50				136	126	121	116	109	104	100	97	94	93	92	91	90	89	88	87	87	86	85	84	83	82	81	50
51				138	127	122	117	111	105	102	97	94	93	92	91	90	89	88	87	87	86	85	84	83	82	81	51
52				140	128	123	118	112	107	103	98	95	94	93	92	91	90	89	88	88	87	86	85	84	83	82	52
53				141	130	124	119	113	109	104	99	96	95	94	93	92	91	90	89	88	87	86	85	84	83	82	53
54				>141	132	125	120	114	110	105	100	97	96	95	94	93	92	91	90	89	88	87	86	85	84	83	54
55					134	126	121	115	111	107	102	97	96	95	94	93	92	91	90	89	88	87	86	85	84	83	55
56					136	127	122	116	112	108	103	98	97	96	95	94	93	92	91	90	89	88	87	86	85	84	56
57					138	128	123	117	114	109	104	99	97	96	95	94	93	92	91	90	89	88	87	86	85	84	57
58					140	130	124	118	115	110	105	100	98	97	96	95	94	93	92	91	90	89	88	87	86	85	58
59					141	132	125	119	116	111	106	101	99	98	97	96	95	94	93	92	91	90	88	87	86	85	59
60					>141	134	126	120	117	112	107	102	100	99	98	97	96	95	94	93	92	91	89	88	87	86	60
61						136	127	121	118	114	108	104	101	100	99	98	97	96	95	94	93	92	90	89	88	87	61
62						138	128	122	119	115	110	105	102	101	100	99	98	97	96	95	94	93	91	90	89	88	62
63						140	129	123	120	116	111	106	103	102	101	100	99	98	97	96	95	94	92	91	90	89	63
64						141	130	124	121	117	112	107	104	103	102	101	100	99	98	97	96	95	93	92	91	90	64
65						>141	132	125	122	118	113	108	105	104	103	102	101	99	98	97	96	95	93	92	91	90	65
66							134	126	123	119	114	109	106	105	104	103	102	100	99	98	97	96	94	93	92	91	66
67							136	127	124	120	115	111	107	106	105	104	103	101	99	98	97	96	94	93	92	91	67
68							138	128	125	121	116	112	108	107	106	105	104	102	100	99	98	97	95	94	93	92	68
69							140	129	125	122	117	113	109	108	107	106	105	103	101	100	99	98	96	95	94	93	69
70							141	130	126	123	118	114	110	109	108	107	106	104	102	101	100	99	97	96	95	94	70
71							>141	132	126	124	118	115	111	110	109	108	107	105	103	102	101	100	99	98	96	95	71
72								134	127	124	119	116	112	111	110	109	108	106	104	103	102	101	100	99	97	96	72
73								136	128	125	119	116	113	112	111	110	109	107	105	104	103	102	101	100	99	98	73
74								138	129	125	120	117	114	113	112	111	110	108	106	105	104	103	102	101	100	99	74

TABLE C. Continued

Number of Items Passed	6-0 to 6-5	6-6 to 6-11	7-0 to 7-5	7-6 to 7-11	8-0 to 8-5	8-6 to 8-11	9-0 to 9-5	9-6 to 9-11	10-0 to 10-5	10-6 to 10-11	11-0 to 11-5	11-6 to 11-11	12-0 to 12-5	12-6 to 12-11	13-0 to 13-5	13-6 to 13-11	14-0 to 14-5	14-6 to 14-11	15-0 to 15-5	15-6 to 15-11	16-0 to 16-5	16-6 to 16-11	17-0 to 17-5	17-6 to 17-11	18-0 to 18-5	18-6 to 18-11	Number of Items Passed
75								140	130	126	120	118	115	114	113	112	111	109	107	106	105	104	103	102	101	100	75
76								141	132	126	121	119	116	114	113	112	111	109	107	106	105	104	103	102	101	100	76
77								>141	134	127	121	120	117	115	114	113	112	110	108	107	106	105	104	103	102	101	77
78									136	127	122	121	118	116	115	114	113	111	109	108	107	106	105	104	103	102	78
79									138	128	123	122	119	117	116	115	113	112	110	109	108	107	106	105	104	103	79
80									140	129	124	123	120	118	117	116	114	113	111	110	109	108	107	106	105	104	80
81									141	130	125	123	121	119	118	117	115	114	112	111	110	109	108	107	106	105	81
82									>141	132	126	124	122	120	119	118	117	115	113	112	111	110	109	108	107	106	82
83										134	127	125	123	121	120	119	118	117	114	113	112	111	110	109	108	107	83
84										136	128	126	124	123	122	120	119	118	115	114	113	112	111	110	109	108	84
85										138	129	127	125	124	123	121	120	119	117	115	114	113	112	111	110	109	85
86										140	130	128	126	125	124	122	121	120	119	117	115	114	113	112	111	110	86
87										141	132	129	127	126	125	124	123	122	120	119	115	114	113	112	111	110	87
88										>141	134	130	128	127	126	125	124	123	122	121	117	115	114	113	112	111	88
89											136	132	129	128	127	126	125	124	123	122	119	117	115	114	113	112	89
90											138	134	130	129	128	127	126	125	124	123	121	119	116	115	114	113	90
91											140	136	132	130	129	128	127	126	125	124	122	121	117	115	114	113	91
92											141	138	134	132	130	129	128	127	126	125	123	122	120	117	115	114	92
93											>141	140	136	134	132	130	129	128	127	126	124	123	122	119	117	115	93
94												141	138	136	134	132	130	129	128	127	125	124	123	120	119	117	94
95												>141	140	138	136	134	132	130	129	128	126	125	124	122	120	119	95
96													141	140	138	136	134	132	130	129	127	126	125	124	123	121	96
97													>141	141	140	138	136	134	132	130	129	127	126	126	124	123	97
98														>141	141	140	138	136	134	132	130	128	127	127	126	125	98
99															>141	141	140	138	136	134	132	130	128	128	127	126	99
100																>141	141	140	138	136	134	132	130	129	128	127	100

TABLE D
Converting Standard Scores to Percentiles

Standard Scores	Percentile	Standard Scores	Percentile
>140	>99	97	42
140	>99	96	39
139	>99	95	37
138	>99	94	34
137	>99	93	32
136	>99	92	30
135	99	91	27
134	99	90	26
133	99	89	24
132	98	88	21
131	98	87	19
130	98	86	17
129	97	85	16
128	97	84	14
127	96	83	13
126	96	82	12
125	95	81	10
124	95	80	9
123	94	79	8
122	93	78	7
121	92	77	6
120	91	76	5
119	90	75	5
118	88	74	4
117	87	73	4
116	86	72	3
115	84	71	3
114	83	70	2
113	81	69	2
112	79	68	2
111	76	67	1
110	74	66	1
109	73	65	1
108	70	64	<1
107	68	63	<1
106	66	62	<1
105	63	61	<1
104	61	60	<1
103	58	59	<1
102	55	58	<1
101	52	57	<1
100	50	56	<1
99	48	55	<1
98	45	<55	<1

TABLE E
Spelling Ages and Grade Equivalents

Number of Items Passed	Predictable Words Spelling Ages	Predictable Words Grade E.	Unpredictable Words Spelling Ages	Unpredictable Words Grade E.	Total Words Spelling Ages	Total Words Grade E.
<1			<5-3			
1	<5-0		5-3			
2	5-0		5-6			
3	5-3		5-9			
4	5-6		6-0		<5-0	
5	5-9		6-3	.5	5-0	
6	6-0		6-6	.8	5-3	
7	6-3	.5	6-9	1.0	5-4	
8	6-6	.8	7-0	1.2	5-6	
9	6-9	1.0	7-3	1.5	5-7	
10	7-0	1.2	7-6	1.8	5-9	
11	7-3	1.5	7-9	2.0	5-10	
12	7-6	1.8	8-0	2.2	6-0	.5
13	7-9	2.0	8-3	2.5	6-1	.6
14	8-0	2.2	8-6	2.7	6-3	.8
15	8-3	2.5	8-9	3.0	6-4	.9
16	8-6	2.8	9-0	3.2	6-6	1.0
17	8-9	3.0	9-3	3.5	6-7	1.1
18	9-0	3.2	9-6	3.7	6-9	1.2
19	9-3	3.5	9-9	4.0	6-10	1.3
20	9-6	3.8	10-0	4.2	7-0	1.5
21	9-9	4.0	10-3	4.5	7-1	1.6
22	10-0	4.2	10-6	4.8	7-3	1.8
23	10-3	4.5	10-9	5.0	7-4	1.9
24	10-6	4.8	11-0	5.2	7-6	2.0
25	10-9	5.0	11-3	5.5	7-7	2.1
26	11-0	5.2	11-6	5.8	7-9	2.2
27	11-3	5.5	12-3	6.0	7-10	2.3
28	11-6	5.8	13-0	6.2	8-0	2.5
29	11-9	6.0	14-0	6.5	8-1	2.6
30	12-0	6.2	14-9	7.5	8-3	2.8
31	12-3	6.5	15-6	8.5	8-4	2.9
32	13-0	6.8	16-6	9.5	8-6	3.0
33	14-0	7.8	17-3	10.5	8-7	3.1
34	14-9	8.8	18-0	11.5	8-9	3.2
35	15-9	9.8	>18-0	>11.5	8-10	3.3
36	16-6	10.8			9-0	3.5
37	17-3	11.5			9-1	3.6
38	18-3	>11.5			9-3	3.8
39	>18-3				9-4	3.9
40					9-6	4.0
41					9-7	4.1
42					9-9	4.2
43					9-10	4.3
44					10-0	4.5
45					10-1	4.6
46					10-3	4.8
47					10-4	4.9
48					10-6	5.0
49					10-7	5.1
50					10-9	5.2
51					10-10	5.3

TABLE E. Continued

Number of Items Passed	Predictable Words Spelling Ages	Predictable Words Grade E.	Unpredictable Words Spelling Ages	Unpredictable Words Grade E.	Total Words Spelling Ages	Total Words Grade E.
52					11-0	[illegible]
53					[illegible]	[illegible]
54					11-3	5.8
55					11-4	5.9
56					[illegible]	[illegible]
57					12-0	[illegible]
58					12-3	6.3
59					12-9	6.4
60					13-0	[illegible]
61					13-6	7.0
62					14-0	7.5
63					14-6	8.0
64					14-9	[illegible]
65					15-3	9.0
66					15-9	9.5
67					16-3	10.2
68					16-6	10.5
69					17-0	[illegible]
70					17-3	11.5
71					17-9	>11.5
72					18-0	
>72					>18-0	

APPROVAL

Of a thesis submitted by

Laurie Jo Howard

This thesis has been read by each member for the thesis committee and has been found to be satisfactory regarding content English usage, format, citations, bibliographic style, and consistency. It is ready for submission to the College of Graduate Studies.

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Dr. Bruce McLeod ______________________________ __________
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