Music and the Effect it has on the Motor Learning of a Serial Task in Children, Ages Seven and Eight

Karen L. Kurncz  
Grand Valley State University

Tara K. Nielsen  
Grand Valley State University

Follow this and additional works at: http://scholarworks.gvsu.edu/theses

Part of the Physical Therapy Commons

Recommended Citation
http://scholarworks.gvsu.edu/theses/410

This Thesis is brought to you for free and open access by the Graduate Research and Creative Practice at ScholarWorks@GVSU. It has been accepted for inclusion in Masters Theses by an authorized administrator of ScholarWorks@GVSU. For more information, please contact scholarworks@gvsu.edu.
Music and the Effect it has on the Motor Learning of a Serial Task in Children, Ages Seven and Eight

by

Karen L. Kunecz
Tara K. Nielsen

THESIS

Submitted to the Department of Physical Therapy
at Grand Valley State University
Allendale, Michigan
in partial fulfillment of the requirements
for the degree of

MASTER OF SCIENCE IN PHYSICAL THERAPY

1998
Abstract

Purpose: To study the hypothesis that music will improve the motor learning of a serial task in seven and eight year old children.

Design: Acquisition - Retention Design

Intervention: The twenty-one subjects were randomly divided into two conditional groups, those who received musical intervention and those who did not. Each subject performed the serial task eleven times during the acquisition session. During the acquisition session, the only difference between the groups was the addition of music to the verbal cues in the experimental group. Approximately twenty-four hours later, each subject returned for a retention session to assess the motor learning that occurred. During the retention session, the subjects were asked to perform the serial task one time without music, verbal cues, or videotape demonstration.

Results: No statistically significant results were found between the two conditional groups, secondary to a ceiling effect that occurred with the subjects’ scores.
Acknowledgements

The authors would like to express their appreciation to the following individuals for their time and support in the completion of our research project:

*Mrs. Linda Kurncz*, for allowing her students to take part in our study and patiently dealing with the interruptions that our study caused in the normal routine of the classroom.

*Ms. Pam Pyper*, for taking the time to help us with the vocal portion of our videotapes.

*Thesis Committee: Barbara Baker (Chair), Mary Green, and Paul Stephenson*, for without their assistance, completion of this research project would not have been possible.
Definition of Terms

**Attention Deficit Hyperactivity Disorder (ADHD):** disorder characterized by varying degrees of developmentally inappropriate inattention, impulsiveness, and hypersensitivity; may also occur without hyperactivity and is then referred to as attention deficit disorder (ADD) (Long, T., 1995, p. 257).

**Autism:** severe communication disorder accompanied by apparent lack of social interaction and varied play skills; frequently associated with self-stimulatory behaviors such as hand-flapping, rocking, or spinning; onset during infancy or childhood; most severe form of pervasive developmental disorder (Long, T., 1995, p. 257).

**Electromyography (EMG):** the recording and study of the electrical activity of muscle; it is commonly used to refer nerve conduction studies as well; the electromyograph is the instrument used to record and display the electromyograph (O’Sullivan, S., 1994, p. 164).

**Motor Control:** An area of study dealing with the understanding of the neural, physical, and behavioral aspects of movement (Schmidt, 1988).

**Motor Learning:** an area of study focusing on the acquisition of skilled movements as a result of practice (Schmidt, 1988).

**Motor Performance:** a temporary change in motor behavior seen during a practice session (Schmidt, 1988).

**Sensory Integration:** reception, organization, and synthesis of sensory and environmental stimuli to support appropriate motor responses (Long, T., 1995, p. 270).

**Sensory Integration Therapy:** treatment approach for individuals with sensory integration dysfunctions; use of vestibular, proprioceptive, and tactile stimulation interventions to promote improved processing of sensory information for adaptive responses to environmental demands (Long, T., 1995, p. 270).

**Spatiotemporal:** having both spatial and temporal qualities; of or relating to space and time (Webster’s Intercollegiate Dictionary).
# Table of Contents

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Abstract</td>
<td>ii</td>
</tr>
<tr>
<td>Acknowledgements</td>
<td>iii</td>
</tr>
<tr>
<td>Definition of Terms</td>
<td>iv</td>
</tr>
<tr>
<td>Chapter</td>
<td></td>
</tr>
<tr>
<td>1. Introduction</td>
<td>1</td>
</tr>
<tr>
<td>Background Information</td>
<td>1</td>
</tr>
<tr>
<td>Purpose of the Study</td>
<td>2</td>
</tr>
<tr>
<td>2. Literature Review</td>
<td>4</td>
</tr>
<tr>
<td>The Arts as Therapy</td>
<td>4</td>
</tr>
<tr>
<td>Dance Therapy</td>
<td>5</td>
</tr>
<tr>
<td>Music Therapy</td>
<td>6</td>
</tr>
<tr>
<td>Music and its Effect on Mind and Body</td>
<td>8</td>
</tr>
<tr>
<td>Music and the Human Brain</td>
<td>9</td>
</tr>
<tr>
<td>Music's Effect on Motor Activity</td>
<td>11</td>
</tr>
<tr>
<td>Motor Learning Literature Review</td>
<td>14</td>
</tr>
<tr>
<td>Motor Learning Theories and Physical Therapy</td>
<td>14</td>
</tr>
<tr>
<td>Feedback</td>
<td>17</td>
</tr>
<tr>
<td>Forms of Extrinsic Feedback</td>
<td>18</td>
</tr>
<tr>
<td>Frequency of Feedback</td>
<td>19</td>
</tr>
<tr>
<td>Timing of Feedback</td>
<td>22</td>
</tr>
<tr>
<td>Music, Motor Learning, and Physical Therapy</td>
<td>23</td>
</tr>
<tr>
<td>3. Methodology</td>
<td>29</td>
</tr>
<tr>
<td>Experimental Design</td>
<td>29</td>
</tr>
<tr>
<td>Subjects</td>
<td>30</td>
</tr>
<tr>
<td>Site and Facilities</td>
<td>32</td>
</tr>
<tr>
<td>Instruments</td>
<td>32</td>
</tr>
<tr>
<td>Procedure</td>
<td>33</td>
</tr>
</tbody>
</table>
CHAPTER ONE
INTRODUCTION

Music is a multicultural medical intervention that has been used since the time of the ancient Greeks (Aldridge, 1993; Cook, 1981; Standley, 1988). Research supports that humans are rhythmical beings. The beating of the heart, circulation of the blood, and individual muscle activity during movement all follow an internal rhythm (Aldridge, 1993; Cook, 1981; Standley, 1988). Music, therefore, can be used as an extrinsic factor to motivate the re-establishment of internal rhythm in persons with physical or mental impairments (Aldridge, 1993; Cook, 1981; Lee, 1989; Safranek, 1982; Standley, 1988).

In addition, current research has shown that music can have an effect on two components of motor learning: motor activity and spatial-temporal reasoning. Skillful movement involves the coordination of appropriate muscle activity in time and space (Singer, 1980). By strengthening the spatial-temporal connections within the cortex, the performance and learning of movement skills may be directly affected through musical application (Rauscher, 1995; Rauscher 1993). Research available supports the connection of music and motor learning. The linking of music and motor learning could be especially useful in pediatric physical therapy. Music has been shown to be the “substance of children’s playful exploration of and experimentation in the world around them.”(Campbell, P., 1995, p. 2) Motor learning, a large component of pediatric physical therapy, may not occur without this exploration of the environment (Campbell, S., 1995).
Survival rates of premature infants and children with disabilities are increasing, leading to a new population of children needing physical therapy services. In dealing with children with disabilities, the creativity of the therapist is crucial to the success of the treatment sessions due to the child’s shorter attention span, increased energy level, as well as impairments (Zillgitt, 1997). The therapist must interact at a level that the child can understand. Often musical intervention can bridge the gap between child and therapist. Many children love music and respond very well to it (Staum, 1988b). Music may give children a reason to move, help them forget the pain, and allow them to laugh, smile, and express themselves just as a child without any physical or mental impairments might (Campbell, P., 1995; Staum, 1988b). While the reason may be unclear, pediatric physical therapists consistently see successful results with the use of music, and therefore continue to use it as an adjunct to their treatment sessions.

If physical therapy is going to continue to be successful in today’s changing healthcare field, more research needs to be done in order to provide solid rationale for the treatment methods that are being implemented. In addition, healthcare reform is also requiring therapists to provide the most time and cost efficient care. Experiments promoting the use of current motor learning research along with creative therapeutic methods, such as music, will establish creditability for the use of these methods. Therefore, support for methods that can promote an increased rate of skill acquisition, such as the combination of music and current motor learning strategies, will help to strengthen the position physical therapy has in the healthcare field.

Research provides strong evidence of the physiological and psychological effects of music; however, limitations exist concerning the use of music to promote motor learning. The purpose of this study will be to support the hypothesis that music will enhance the motor learning
of a serial task in children, ages seven and eight. The definition of serial task that will be used throughout this research is “a number of discrete tasks strung together with the order of actions being important” (Schmidt, 1988, p.47). The results of this study may encourage the use of music in pediatric physical therapy as well as encourage further physical therapy research with regard to specific pediatric populations in the area of motor learning and music.
CHAPTER TWO
LITERATURE REVIEW

Our literature review will focus on current research in the areas of music and motor learning and their relevance to physical therapy practice. First, the use of the creative arts in therapy will be discussed with an emphasis on the intervention of dance and music in rehabilitation. Secondly, a review of motor learning theories and strategies involved in designing practice sessions will be provided. We will conclude with a discussion of the possible ways in which music, when used in conjunction with extrinsic feedback scheduling, can affect motor learning in children.

The Arts as Therapy

Creative therapies, which are based on “the timeless, and ever-changing relationship between culture, artistic activity, and social development” (Warren, 1984 p. 3), have gradually made their way into educational and rehabilitation settings. The use of music, dance, poetry, painting, and drama continues to grow as research in this area illustrates success. Creative therapies are able to remove the language barrier via cultural intervention and emphasize self-expression. Furthermore, “the arts require the involvement of primal elements found in the connection of the mind and body” (Fleshman, 1981, p. 6).

Music and dance therapy, creative therapy disciplines, will be reviewed due to their similarity and relevance to this study. These alternative forms of intervention attach fun and meaning to treatment sessions, not allowing the boredom of repetition to develop (Fleshman, 1981; Warren, 1984).
Dance Therapy

In dance therapy, individuals communicate through the use of the entire body. Normal physical activities performed daily, such as dressing, bathing, etc. consist of sequences of many muscle actions that resemble dance. Consequently, the use of dance to promote movement helps in the organization and sequencing of many functional activities (Warren, 1984). Dance therapy can be used in many patient populations, including the geriatric population. Inactivity, a common finding in the elderly, can promote an increase in the physiological changes normally associated with aging and can lead to decreased function. By motivating the elderly to engage in movement with dance, the effects of immobility can be decreased and feelings of psychosocial well being will be enhanced (Guccione, 1993).

Dance therapy has also been found to be especially useful with the pediatric population. It can be used to encourage movement which facilitates learning about the environment and body image (Campbell, S., 1995; Couper, 1981; Staum, 1988b; Warren, 1984). Couper (1981) studied the effects that dance therapy has on motor performance in children with sensory integration dysfunction. In this study, dance therapy was compared to a typical vestibular sensory integration program. The amount of change in the performance of four gross motor tasks was measured with pre- and post tests. After four weeks of treatment intervention, the dance group showed significantly greater improvement in all four tasks than did the control group. Couper states that the activities performed in both groups of the study were similar, with the only real difference being the addition of rhythm. Therefore "dance therapy provides an exciting and enjoyable option for therapists to the play activities usually designed for vestibular sensory integrative therapy" (Couper, 1981, p.26).
Dance therapy has been utilized in a variety of other pediatric patient populations as well. It has been used with cerebral palsy patients as a creative way to decrease spasticity and increase gross and fine motor control (Warren, 1984). With autistic children, who are typically withdrawn from their environment, have a limited repertoire of movement, and are emotionally isolated, dance therapy can be used as a way for them to "experience spontaneous movement, touch, and sharing of space" (Fleshman, 1981, p. 102). Individuals with hearing impairments can benefit from dance therapy much in the same way that autistic patients do, by increasing avenues to explore the environment and express one's self (Baker, 1982; Campbell, S., 1995; Fleshman, 1981; Warren, 1984).

In summary, dance therapy has been proven to be a successful therapeutic intervention for many patient populations. Music and dance are often thought of as going hand in hand. However, research has proven that music alone can also have a powerful effect. Therefore, music and the effect it has on the body and movement will be discussed to provide the theoretical construct for this study.

Music

Music is communication, like verbal language, with its own set of rules. Organized sound patterns are processed through the auditory pathways instead of words and sentences (Sergent, 1993). It has been used for centuries to aid in the ailments of mind and body. The historical use of music dates back to primitive times when incantations and rhythmic chants were used to ward off evil spirits (Cook, 1981). The Hebrews, in Samuel I 16:23, noted that King Saul had David play his harp to remove the evil spirit of God from his body (Aldridge, 1993; Cook, 1981). However, the Greeks were reportably the first to analyze the use of music as a way to restore mental and physical harmony (Cook, 1981; Standley, 1988). Aristotle believed that the
soul ruled the body; and since music was able to reach the soul, "appropriate melodies, harmonies, and instruments will affect both body and soul" (Cook, 1981, p.254). The positive effect of music was further supported in the 1700's, when researchers began to evaluate the specific effects that music has on the body. This research continued in labs and clinics of the 20th century, providing evidence of the physiological and psychological effects of music on the human body. The results of the research have been responsible for the increasing acceptance of music as a successful multidisciplinary intervention in the treatment of variety of physical and mental impairments (Cook, 1981).

Michael Thaut, a well-known music therapy researcher, stated that "the primary clinical importance of music is not the emotional or the motivational value, but the neurological effects that improve motor control" (Marwick, 1996, p. 268). Positron emission tomography has been used to assess which areas of the brain are responsible for the processing of musical stimuli. Results from a study performed by Phelps and Mazziota (Hachinski, 1994) show that simple melodic tones demonstrate activity in the frontotemporal areas of the brain with greater activation noted on the right side of the cortex. Complex musical stimuli resulted in a similar pattern of activity in the left frontotemporal areas of the cortex as well. Studies performed by Shapiro, Grossman, and Gardner (Prior, 1990) also suggest that there is bilateral hemispheric processing of musical stimuli, the right hemisphere dealing with the processing of global harmonics (e.g. pitch) and the left hemisphere with rhythm processing. The fact that different areas of the brain are activated by music or rhythmic stimuli suggests that music has the capability to excite alternative neural pathways (Weiss, 1994). Music may be the gate used to access an individual's mind and influence motor behavior, thus providing support for the integration of creative therapies into traditional therapeutic settings.
Music and its Effect on Mind and Body

Altshuler described man as a "rhythmical being" due to the nature of activities in the body that follow an inherent rhythm (Cook, 1981; Staum, 1988). Based on this fact, music has been noted to facilitate a change in many biological functions. Music, depending on the tempo and individual reaction, can elicit changes in respiration rate, heart rate, muscle tension, internal secretions, metabolism, anxiety level, and blood pressure and volume (Aldridge, 1993; Cook, 1981; Lee, 1989; Safranek, 1982; Standley, 1988). Individuals with varying impairments may benefit from external rhythmic stimuli to restore and synchronize the necessary rhythmic components that direct natural processes of every day living (Aldridge, 1993; Cook, 1981; Lee, 1989; Safranek, 1982; Standley, 1988). Research by Bason and Celler (Aldridge, 1993) found that heart rate can be manipulated when synchronizing the sinus rhythm with an auditory stimulus. In their study when an audible click was presented to the subjects within the QRS duration of the cardiac cycle, it was found that "the heart rate could be increased or decreased up to twelve percent in a period of three minutes or less (Aldridge, 1993, p.19)." It was also shown that clicks presented outside the QRS duration did not produce any change in heart rate.

Aside from the physiological effects, music also has psychological effects. Music has the ability to motivate and alter moods "by stimulating the imagination and intellect" (Cook, 1981, p. 259). For example, soothing music has the ability to promote relaxation by decreasing levels of stress and situational anxiety (Aldridge, 1993; Cook, 1981; Fischer, 1990). Decreasing the stress levels in patients with cardiac conditions is imperative to the prevention of future cardiac complications (Aldridge, 1993). A study by Guzzetta (1989) showed that lower apical heart rates, increased peripheral temperature (due to vasodilation), and fewer cardiac incidents
occurred with music therapy and relaxation techniques incorporated into the treatment plans of individuals post acute myocardial infarction. Other research in this area demonstrates that the majority of coronary patients report feelings of heightened mood and decreased anxiety through the use of music; however, there is lack of scientific evidence to support this notion (Aldridge, 1993; Standley, 1988).

Music's use with the chronically ill can promote relaxation, as well as have an analgesic effect (Aldridge, 1993; Standley, 1988; Staum, 1988). Pain is subjective in nature and contains "physiological, social, cultural, and spiritual components" (Zimmerman, 1989, p. 298). It is proposed that music may play a role in the gate theory of pain acting as a "diversional stimulus that refocuses the attention given to pain on something more pleasant" (Zimmerman, 1989, p.299). Research done with individuals with chronic pain from cancer has found that music decreased the emotional and physical sensation of pain and in some cases decreases the amount of pharmacological medications administered to relieve the pain (Fischer, 1990; Zimmerman, 1989). Sedative, slow music can relax and calm individuals, whereas lively music has been used to increase activity and levels of socialization among apathetic or psychologically impaired individuals (Cook, 1981; Fischer, 1990).

Music and the Human Brain

Music has been shown to affect human brainwaves. Research by Furman (1978) demonstrated the effects of musical stimulation, with and without text, and a silence condition on the frequency of brainwave production in children. "Alpha waves signify relaxation, or inwardly directed attention," whereas "beta waves are usually associated with alertness" (Furman, 1978, p.109). Thirty children, ranging in age from 8.00 to 9.92 years, were monitored using an Alphaphone Brainwave Analyzer during each of the three conditions, thus serving as their own
control. The results based on the research by Furman (1978) were then compared to a similar study, with adult subjects. The results demonstrated that children experienced increased alpha duration during silence, as compared to the two musical conditions, and that there were no significant differences between adult and child alpha times. It is also important to note that there was no significant difference in the alpha wave duration between the two musical conditions. The relevance of this research is that music has the ability to block alpha wave production and elicit attention.

Research by Rauscher, Shaw, and Ky (1995; 1993) has shown that music training, specifically music composed by Mozart, can enhance spatial-temporal task performance. In this study, thirty-six college students were tested on the effects of Mozart, a relaxation tape, and silence on standard IQ spatial reasoning tasks. Each of the three conditions were conducted ten minutes before the task was measured by the Stanford-Binet Intelligence Scale. Those subjects who listened to the Mozart music prior to assessment scored “eight to nine points above their IQ scores in the other two conditions” (Rauscher, 1993, p.611). The researchers’ proposed theory for these results is that listening to music helps “organize the cortical firing patterns” and that music acts as an “exercise for exciting and priming the common repertoire and sequential flow of the cortical firing pattern responsible for higher brain functions” (Rauscher, 1995, p.47). One limitation to this study is that only one composer, Mozart, was investigated, thus highlighting the need to explore other musical styles. The authors suggest that more research is needed to determine whether other areas of higher cognitive functioning, such as short term memory, could be stimulated by music as well (Rauscher, 1995; Rauscher, 1993).

Temporal and spatial perception are components of cognition that directly influence mobility. The ability to correctly time and coordinate muscular activity in space is crucial to
task performance (Campbell, S., 1995; Schmidt 1991; Singer, 1980; Thaut, 1988). Music is described as a "complex temporal organization of acoustic events" (Thaut, 1988, p. 127), and therefore requires the mind to recognize organized patterns of sound over time which can strengthen neural pattern development. Research by Rauscher (1995) has shown that music has the ability to strengthen the neural spatial-temporal connections responsible for higher brain functions, and because of the spatial-temporal elements involved in movement (Campbell, 1995; Schmidt, 1991; Singer, 1980) it is hypothesized, by the authors of the current study, that music can enhance motor learning as well.

Music's Effect on Motor Activity

There has been limited research about music's effect on motor activity in humans. However, pioneer research in this area has proposed that music can influence motor behavior and enhance many aspects of motor rehabilitation. This research has provided information that auditory rhythm can influence the onset, duration, and variability of muscle activity (Pal’tsev, 1967; Safranek, 1982; Thaut, 1991).

Pal’tsev and El’ner (1967), in a series of two experiments, found that in response to sound stimuli there is a decreased latency period in the initiation of muscle action when measuring electromyographic (EMG) activity. In both experiments the latency period was recorded by an oscilloscope and at each intensity the subjects (N=5) performed the task 150-200 times with a 15-20 minute rest period in-between trials.

In their first experiment, the researchers chose to assess the knee reflex following a sound stimulus of differing intensities. An electromagnetic hammer was used to elicit the reflex in order to assure that the taps to the knee were of constant strength and a Diza electromyograph was used to record the reflex response of the quadriceps muscle. In the second experiment, the
latency period of voluntary knee extension following sound stimuli of differing intensities was measured.

Results of these experiments showed that following a sound signal of 70 or 100 decibels (dB) above the auditory threshold, latency periods of 60-70 milliseconds (msec) occurred. In contrast, when sound signals of an intensity of only 20 dB above the auditory threshold were used a significant change in EMG response did not occur.

Phelps and Mazziota (Hachinski, 1994) in accordance with Pal’tsev and El’ner (1967) state that a sound stimulus produces responses in different areas of the cerebral cortex. However, the research by Pal’tsev (1967) also supports the notion that auditory information travels to the cerebral cortex as well as directly to the spinal cord by way of alternate pathways, thus explaining the decrease in latency time. The functional change that occurs at the segmental level of the spinal cord is connected with supraspinal influences in that as the auditory information, if of sufficient intensity, ascends towards the cortex, “the excitation through the stem formations raises in an unspecific way the excitation of the motor nuclei of the spinal cord” (Pal’tsev, 1967, p. 1223) and speeds up the initiation of muscular response. Based on this neurophysiological response, Michael Thaut states that auditory cues, or sound events, if rhythmically organized, are predictable timing cues...that facilitate the anticipation of a motor response” (Thaut, 1988, p.129).

In research by Safranek, Koshland, and Raymond (1982) and Thaut, Schleiffers, and Davis (1991), the EMG activity of the biceps and medial triceps was assessed during a gross motor task. In these studies, the task was hitting a target with the ulnar side of the hand using a flexion-extension movement at the elbow. In both studies, the addition of rhythmic stimuli evidenced earlier onset times of opposing muscle groups, co-contraction of biceps and triceps
prior to target contact, and decreased variability in muscle activity. For example, during the extension moment of the task, the biceps were activated prior to hitting the target, whereas without rhythm the biceps were activated after target contact. As previously stated, rhythm can change the sensitivity of motor neurons and speed up the activity of the antagonist muscle. In this instance, the early onset of the biceps results in a co-contraction of the opposing muscle groups. In learning a novel task, co-contraction is utilized “when accurate spatial or temporal adjustments in the movement are necessary” (Thaut, 1991, p. 81) and to steady the limb during movement (Safranek, 1982; Thaut, 1991). The authors suggest that by adding rhythm the task is now considered novel to the individual and can facilitate very different characteristics in the response of the muscle (Safranek, 1982; Thaut, 1991; Thaut 1988). Research (Safranek, 1982) has also shown that biceps activity performed to an even beat resulted in an increased duration as well as a decreased variation in EMG activity. Instances where the same activity was accompanied by an uneven tempo, duration and variation in the muscle activity was increased. It is assumed that skilled motor performance is the result of efficient motor recruitment. “The addition of a rhythmic beat as a pacemaker for a gross motor task helped to focus lower motor neuron activity by producing a more consistent and regular recruitment of motor units” (Thaut, 1991, p. 83). The results of these studies document that auditory rhythm can have an impact on human motor activity and thus can promote successful outcomes when incorporated into rehabilitation programs.

Motor Learning Literature Review

Motor learning, more than music, is traditionally associated with the success of rehabilitation programs. Schmidt defines motor learning as, “a set of processes associated with
practice or experience leading to relatively permanent changes in the capability for skilled performance" (Schmidt, 1991, p. 285). This section of our literature review will demonstrate the relevance of motor learning to physical therapy, through the discussion of current motor learning theories and successful feedback strategies that can be used to enhance physical therapy sessions.

Motor Learning Theories and Physical Therapy

Research clearly demonstrates the need for the integration of motor learning principles in the practice of physical therapy. Carolee Winstein states that, "many if not most of the practice of physical therapy involves some form of movement training" (Winstein, 1991, p. 141). Therefore, it is important that the most efficient teaching methods be used to promote motor skill acquisition. The importance of motor learning in physical therapy dates back twenty years in research. However, research is still lacking in this area (Winstein, 1991). Recent research is beginning to challenge therapists in their use of certain teaching strategies. Researchers are asking therapists to reexamine their teaching strategies in order to provide the most optimal learning environment for their patients (Croce, 1989; Lee, 1991; Winstein, 1991). Croce and DePaepe (1989) suggest that therapists turn to the "empirically derived motor learning concepts" (Croce, 1989) in developing these strategies in order to be most effective.

Motor Learning Theories

The research regarding motor learning contains many different theories. All of these theories contain one similar concept, namely that the learner is an active participant in the process of skill acquisition (Croce, 1989; Winstein, 1991b). This participation may be of various forms such as, "interacting with the environment, comparing intrinsic and extrinsic error information, solving problems and processing relevant sensory cues" (Winstein, 1991b, p.
The understanding of how and why these processes occur is what distinguishes the theories from each other.

The Adam’s Closed Loop Theory is based on the understanding that the process of motor learning occurs as a result of feedback from the responding limbs, and the visual, auditory, and vestibular systems (Croce, 1989). The need for sensory input, sensory feedback and rewards during practice is emphasized. The use of this sensory input and feedback then creates a perceptual memory trace of the movement. The more the movement is practiced, the more defined the memory trace becomes (Campbell, S., 1995). Unfortunately, this theory does not clearly explain how an open-loop movement, movement without sensory feedback, can occur (Shumway-Cook, 1995).

The theories that were developed in response to the weaknesses found in Adam’s Closed Loop Theory added a new dimension to motor learning. The “Motor Program” theorists believed that in addition to the feedback discussed in Adam’s Theory there was also a central program present (Campbell, S., 1995; Croce, 1989). Central programs are defined as hardwired neural connections that contain the essential details of a motor task. (Campbell, S., 1995; Croce, 1989; Schmidt, 1991). These programs help in the production of a novel task by providing the essential details of the motor task before it is even attempted for the first time. The disadvantage of the programming notion was that it required the existence of an infinite amount of storage of the information for every movement an individual made (Croce, 1989).

As a result of the limitations of the above theories, Schmidt’s Schema Theory, including both central programs and a generalization of movement concept, was developed (Croce, 1989; Kerr, 1978). Schmidt’s Schema Theory suggests that “the memory for movement entails two fundamentally different representations” (Lee, 1991, p. 151). The first representation is the
recall schema. This schema gives the rules for movement production. The recall schema is used in cases of rapid ballistic movements in which memories and motor experiences can aid in the production of movement. The second representation is the recognition schema. The recognition schema is responsible for developing the relationship between the initial conditions and the specific movement that is going to be performed (Campbell, S., 1995). These details supply information about what exactly is required of the body for the correct movement to occur. Such details include what muscles are needed, the exact force and time of muscle activation, and the body’s position in space at the time of the movement (Lee, 1991). The recall and recognition schemas allow for the generalization of movement. Therefore, a given central program can be varied slightly without having to produce a whole new central program in the production of a novel task (Croce, 1989). In conclusion, the formation of the Schema Theory combined the “strong points of various theoretical positions and modified [ing] them so that the schema concept would be able to circumvent some of the limitations of existing theories (e.g., storage and novelty problems)” (Croce, 1989, p. 11).

Finally, the most current research is being done in the area of the Dynamical Theory approach. These theorists believe that “motor behavior emerges from the dynamic cooperation of all subsystems within the context of a specific task: central nervous system [CNS], biomechanical, psychological and social environmental components” (Campbell, S., 1995, p.160). This theory emphasizes function more than instruction as the most important part of motor learning. Further research is needed on these concepts in order to establish a strong theoretical base for the development of the best interventions in facilitating skill acquisition.

Currently research is lacking in the area of motor learning. Consequently, caution needs to be taken when using strategies derived from the motor learning theories (Winstein, 1991).
The area of motor learning that has received the most attention in the research is the role of feedback in skill acquisition. The results from this research are very relevant to physical therapy. Therefore, the remainder of this literature review on motor learning will focus on the research describing the most current strategies for feedback in skill acquisition.

**Feedback**

There are two distinct forms of feedback, intrinsic and extrinsic. Intrinsic feedback is “feedback that comes to the individual simply through the various sensory systems as a result of the normal production of movement” (Shumway-Cook, 1995). Extrinsic feedback, on the other hand, is “feedback provided artificially over and above that received naturally from a movement” (Schmidt, 1991). Extrinsic feedback is what physical therapists have the most control over during treatment sessions. A physical therapist uses feedback throughout each treatment session; therefore, the benefits of specific extrinsic feedback strategies will be the focus in this portion of the literature review. Feedback functions to provide a learner with information on the results from the previous trial, corrections that may need to be made before the next trial, and motivation to attempt another trial (Croce, 1989; Schmidt, 1991). Numerous researchers have reported that feedback is essential to the process of motor learning (Barclay, 1980; Campbell, S., 1995; Croce, 1989; Gable, 1991; Schmidt, 1991). Consequently, specific guidelines have developed from various researchers on the appropriate use of feedback in skill acquisition (Campbell, S., 1995; Croce, 1989; Gable, 1991; Sherwood, 1988; Swinnen, 1990; Vander Linden, 1993; White, 1990; Winstein, 1991; Winstein, 1990; Yao, 1994).

**Forms of Extrinsic Feedback**

The discussion of feedback will start with a definition of the two most common forms of extrinsic feedback, knowledge of results (KR) and knowledge of performance (KP). KR is
defined as, "extrinsic feedback relating to the outcome of an action with respect to the environmental goal" (Winstein, 1991, p. 142). KR in many instances is identical to the intrinsic feedback the body provides (Schmidt, 1991). For example, the KR of moving from sit to stand would be the amount of time it takes to perform the activity. KP, on the other hand is defined as, "extrinsic feedback which provides information about the nature of the movement pattern underlying the goal outcome" (Winstein, 1991, p. 142). In the sit to stand example, KP would be the amount of knee flexion the patient attained in the attempt to move to stand. KP is the form of feedback that is most often given in a clinical setting. Unfortunately, as a result of the ease of which KR can be tested in a lab it has been researched most heavily, whereas the research on KP is somewhat lacking. The limited research on KP available suggests that it is much more powerful in motor learning than KR (Schmidt, 1991). In addition, Winstein states that, "the existing studies indicate that KP variables behave similarly to KR variables with regard to motor learning" (Winstein, 1991, p. 142). Unfortunately, the lack of research, does not allow for this assumption to be made without further scientific backing.

Frequency of Feedback

One variable of feedback that can have a substantial effect on learning is the frequency of the feedback. The frequency of KR can be defined as either absolute or relative. Absolute frequency is the total number of trials that KR is presented in a practice session. Relative frequency, on the other hand, is defined as the ratio of the number of KR presentations to the total number of trials (Campbell, S., 1995; Schmidt, 1991; Winstein, 1990). The importance of absolute frequency to learning is well supported. (Winstein, 1990) In initial studies performed by Thorndike, it was believed that the more feedback given, the more substantial the learning would be (Thorndike, 1927). In other words, the higher the absolute frequency of feedback the
more learning that would occur. There were two major limitations to this study. First of all, current research suggests that Thorndike actually tested performance and not the learning of a skill. Secondly, research suggests that the use of high absolute frequencies of feedback may actually be detrimental to learning even though it enhances performance (Lee, 1990).

Current research, performed by Vander Linden, Cauraugh, & Green (1993), supports that a decreased frequency of feedback enhances learning. These researchers examined the effect of frequency on the learning of an isometric force production task. Three conditions were compared. Group one received feedback concurrently with and after each trial, group two received feedback after each trial (100%), and group three received feedback only after 50% of the trials. The results demonstrated that if permanent changes in movement are desired, concurrent feedback can be detrimental to the learning even though it may enhance performance. Furthermore, lower frequencies, 50%, of feedback following a trial, produced the most beneficial results when permanent changes in task performance are desired (Vander Linden, 1993).

The guidance hypothesis can be used to support the explanation of why increased frequency of KR enhances performance but not learning. High frequency KR has a positive effect on performance because it guides the learner to the correct skill, but at the same time can have a detrimental effect on learning by allowing dependency to develop in the learner. The learner does not learn how to utilize intrinsic error detection mechanisms. Therefore, in situations where KR is not given, the skill cannot be performed (Lee, 1990; Winstein, 1990). The support for relative frequency schedules of KR is increasing; consequently, many new schedules are currently being developed in the research (Gable, 1991; Lee, 1991; Schmidt 1991; Sherwood, 1988; Winstein, 1990; Yao, 1994).
One schedule of relative frequency of feedback that is being suggested to facilitate improved retention on motor skills is bandwidth feedback (Campbell, S., 1995; Sherwood, 1988; Schmidt, 1991). Bandwidth feedback is defined as feedback that requires a “preset band of accuracy” (Campbell, S., p.173) on the part of the therapist. The feedback given can either be motivating when the patient performs a trial within the bandwidth, or it can provide information on the errors of trials that fell outside the bandwidth (Campbell, S., 1995; Schmidt, 1991; Winstein, 1991; Winstein, 1991b). Research done by Sherwood (1988) provided support for the use of bandwidth in skill acquisition. He examined the effect of bandwidth KR on the performance and retention of a timed elbow flexion-extension movement. The goal was to perform the movement in 200ms. Three groups were compared: Group A received feedback according to a 5% bandwidth schedule, with feedback given only if the their absolute error was greater than 10 ms; Group B received feedback according to a 10% bandwidth schedule, with feedback given only if their absolute error was greater than 20 ms; and Group C acted as a control group receiving feedback after each trial (0% bandwidth), where no band of accuracy was set. Results from this study found that the group which received the 10% bandwidth schedule performed the task most consistently and accurately on the retention test (Sherwood, 1988). Based on research by Sherwood (1988) and Lee and Carnahan (in press), Carol Winstein made the suggestion that “the beneficial learning effects of bandwidth KR variations over a pure relative frequency condition appear to be in the terms of movement consistency”(Winstein, 1991b, p.70). More research is needed to determine the optimal bandwidth for simple and complex skills (Sherwood, 1988); however, research in this area is promising and provides strategies for promoting successful skill acquisition.
Two other feedback schedules that have been found useful through analysis of the current research are summary feedback and average feedback. Summary feedback is given at the conclusion of a set number of trials. Average feedback is also given at the conclusion of a set of trials, but only provides the learner with a average of the trial block (Campbell, S., 1995; Gable, 1991; Yao, 1994). Research performed by Yao, Fischman, and Wang (1994) compared not only the effect that average and summary feedback have on retention, but also the differences between the effects of average and summary feedback. The experiment involved learning an aiming task that required both spatial and temporal accuracy. The subjects practiced under one of three conditions: summary feedback, average feedback or every trial feedback. Results of the experiment showed that the condition that received KR after every trial performed with less absolute error during the acquisition portion of the experiment than the average or summary feedback groups. However, when given a delayed no KR retention test, performance of the average and summary groups far surpassed the every trial group. These results suggest that both average and summary feedback schedules can enhance the retention of a motor task. Furthermore, a comparison between the results of the summary and average feedback groups suggest that these two feedback schedules have very similar influences on motor learning, both schedules being more effective than feedback after every trial (Schmidt, 1991; Yao, 1994).

In conclusion, there are various types of feedback schedules being researched that may prove to be very beneficial to physical therapy. Therapists have a responsibility to their patients to keep updated on the most successful schedules, and also to perform research in this area to develop the most successful feedback schedules for physical therapy populations.
Timing of Feedback

The final aspect of feedback to be discussed is the timing of feedback in skill acquisition. There are different names for the interval found between the trial and feedback in research. For clarity, in this discussion it will be referred to as the feedback delay (Campbell, S., 1995; Schmidt, 1991; Winstein, 1991). It was once believed that any period of time that was allowed to elapse between the action and feedback would be detrimental to the learning process. Therefore, the faster feedback could be given the better the results would be. However, recent research has found this is not true (Swinnen, 1990). In a study done by Swinnen, Nicholson, Schmidt, and Shapiro (1990), three groups were compared in the performance of a linear movement task. Group A received feedback instantaneously, Group B received feedback after a 8-second unfilled interval, and Group C received feedback after an 8 second interval in which the subjects were required to orally estimate their movement time. It was found that there was no difference in performance between the groups in the skill acquisition phase. However, Group A demonstrated a significant deterioration in skill performance in the 10 minute and 2 day retention tests, when compared to Group B and Group C. The results of this study suggest that instantaneous feedback may be detrimental to learning by interfering with the processing of intrinsic error detection mechanisms (Swinnen, 1990).

In conclusion, research has found that the area of feedback delay is frequently misused by practitioners (Campbell, S., 1995; Winstein, 1991; Schmidt, 1991). Winstein states that current research on methods of providing KR is in “direct contrast to that of some practitioners who advocate the provision of feedback immediately or continuously” (Winstein, 1991, p. 146). She warns therapists that “although the provision of instantaneous feedback may be beneficial
for performance during practice, it can be detrimental for learning and retention" (Winstein, 1991, p. 146).

Although this literature review involved only one aspect of motor learning, the use of extrinsic feedback, it clearly demonstrates the need for physical therapists to pay close attention to motor learning research. The fields of motor learning and physical therapy can benefit a great deal from working together to help increase the skill acquisition in a variety of patient populations. Patients are depending on therapists to have the most effective teaching methods, and by reviewing motor learning research therapists will be able to attain this goal. Furthermore, physical therapists need to continue researching to bridge the gap between motor learning in normals and in the disabled population.

Music, Motor Learning and Physical Therapy

There is little scientific research regarding the effect music has on motor learning in rehabilitation settings (Thaut, 1988). However, based on the extensive literature of the powerful influence that music has on the body and mind, one can hypothesize that it would have a positive effect on motor learning. Furthermore, the hypothesis of this study is that music will enhance motor learning and had the potential for significant clinical success.

The need for more effective treatment techniques in physical therapy has increased over the past few years as a result of changes in health care. Consequently, therapists have turned to alternative treatment techniques, such as music, to meet these demands (Marwick, 1996). The main goal in physical therapy is to promote or enhance functional motor activity. Research shows that not only can music be used to motivate patients, it can also be used to directly affect motor activity (Marwick, 1996; Pal’tsev, 1967; Safranek, 1982; Staum, 1983; Thaut, 1991; Thaut, 1988). In fact, research has shown that “the auditory modality produces motor rhythmic
responses less variable than the visual, tactile, or combined auditory/visual presentation mode” (Thaut, 1988, p. 128). Music may also function to “facilitate quicker recovery of motor control and skill, e.g., through improved anticipation and timing of muscular effort” (Thaut, 1991, p. 85). Research assessing music and the effect it has on gait patterns in humans supports the effects of music on muscular activity mentioned above, and suggests additional benefits of the use of music. Myra Staum (1983) and Michael Thaut (1988) both used rhythm to facilitate a more normal gait pattern in patients with Parkinson’s disease and hemiplegia. The researchers believe that the patients’ improvements in stride length, foot placement, and step cadence occur as a result of the rhythmical element’s ability to “override poorly established motor patterns” (Staum, 1992, p. 267) required for locomotion (Marwick, 1996; Thaut, 1988). The gait pattern can be further improved by music’s ability to increase the duration of muscle activity resulting in increased antagonist muscular co-contractions. As a result, a patient’s gait pattern improves because of increased stabilization around the lower extremity joints during stance phase (Safranek, 1982; Thaut 1991). Thaut has also shown in his research that music has an “entraining effect.” That is, even after the rhythmic stimulation is removed the gait improvements made during training have remained (Marwick, 1996). Finally, music has proven successful in the rehabilitation setting due to its ability to block pain and increase endurance by stimulating the auditory pathways and suppressing the afferent pathways carrying the more adverse sensory information (Fischer, 1990; Standley, 1988; Thaut, 1988; Zimmerman, 1989).

The above research demonstrates ways in which music used independently can enhance physical therapy sessions. Therefore, music used in conjunction with feedback scheduling could result in even greater success in achieving desired outcomes of skill acquisition. Motor learning, as previously stated in this literature review, is a large part of physical therapy practice. Current
strategies for giving extrinsic feedback during treatment sessions, as well as the theories that provide the foundation for these teaching methods, were discussed. These methods have proven to be successful throughout the literature. This study hypothesizes that the addition of music to a practice session may enhance the skill acquisition process to an even greater extent than either music or motor learning techniques when used in isolation.

Music is considered a form of higher cognitive functioning due to the fact that it can access “inherent firing patterns and enhance the cortex’s ability to accomplish [spatial-temporal] pattern development” (Rauscher, 1995, p.45). Since motor activity involves “movements based on muscular activity in time and space” (Thaut, 1985, p.109), the carry-over of the spatial-temporal pattern development, that occurs through the use of music, can assist in the processing of the learning parameters necessary for skill development (Campbell, 1995; Schmidt, 1991; Singer, 1980). Therefore, the use of music in combination with motor learning strategies can facilitate skill acquisition and reacquisition in physical therapy.

Music in conjunction with motor learning strategies may be even more beneficial in pediatric physical therapy, since “with a child, you have to make therapy [it] playful and exciting to hold their attention” (Zillgit, 1997, p. 18). Learning and relearning of motor skills is a large part of pediatric physical therapy. For children, motor learning takes place through the exploration of their environment (Campbell, S., 1995). Music has been found to be influential in encouraging this exploration (Campbell, P., 1995). Not only does music increase a child’s willingness to move, but it also may help hold the child’s attention (Furman, 1978). Most children have substantially shorter attention spans than adults (Zillgit, 1997); and as Staum (1983) states, “young children with limited tolerance for repeated practice may be responsive only to those structures which are readily enjoyable” (Staum, 1983, p. 70). Therefore, the
addition of music to the learning environment may enable children to focus long enough to gather all the relevant information in the acquisition of a novel skill. Music’s ability to decrease the emotional and physical sensation of pain may also have a substantial effect on motor learning in the pediatric population (Zimmerman, 1989). Often children seen in physical therapy have conditions that make movements painful and difficult. These movement limitations decrease the exploration within their environment, thus leading to a decrease in motor learning potential (Thaut, 1985). Through the use of music, pain may be blocked by more pleasing sensory information (Thaut, 1988; Zimmerman, 1989) allowing the necessary movements to occur, thereby enhancing motor learning. Lastly, music can help coordinate the timing of muscular activity (Thaut, 1985). Therefore, if exercises routinely performed by the child during therapy sessions, were synchronized to music, the child might be able to learn the sequence of movements in accordance with the music. This provides the child with knowledge of what to expect next, giving them an increased sense of control in an environment which may be very frightening and overwhelming.

In pediatric physical therapy creativity is paramount. Open minded therapists, who are willing to integrate alternative and traditional teaching methods, advocate that “sometimes the road less traveled” (Zillgitt, 1997, p. 19) just might be what it takes to reach a patient and get the desired results. Music and dance, in combination with the traditional rehabilitation routine, may promote optimal learning experiences for the pediatric patient. More clearly stated by Warren (1984),

“The arts do not stand in isolation and are most definitely not, in themselves a cure for all ills. However, what the arts can do is in the individuals act of creation, engage the emotions, free the spirit and make individuals do something because they want to and not just because someone decides it is good
for them. The arts can motivate in a way possibly no other force can, because it is through the arts experience, through making a mark that no one else could make, that we express the individual spark of our own humanity” (Warren, 1984, p. 4).

Research by Staum (1988b) has influenced the methodology of this study. Staum (1988b) studied the effect of background music on the motor performance recall in preschool children, ages three to five. In her research, Staum (1988b) taught children a movement sequence, consisting of six discrete motor tasks, under three different conditions. The conditions included music synchronized with the movements, music asynchronous with the movements, and silence. In part one of Staum’s (1988b) study, the children’s ability to perform the task previously learned was assessed one and a half hours after the training session. In the second part of the study, however, different children received four training sessions over a four week period and were then assessed on their ability to perform the task. Unfortunately the results from both parts of the study did not yield significant results in proving the hypothesis of the study, that music affects the motor performance recall in preschool children. However, it was noted that in both experiments, the group which trained and was tested with the movements synchronized to music achieved higher results than any other group. Staum (1988b) listed several limitations to her study that may have led to the insignificant results. The researcher suggested that more significant results might occur if older children were used as subjects, as “factors of attention and practice could [can] be better controlled” (Staum, 1988b, p.27). Also Staum (1988b) taught the children the movement sequence in groups consisting of approximately fourteen to twenty children and stated smaller group teaching sessions may prove to be more effective.
The present study, due to the similar area of focus, considered the suggestions made by Staum (1988b) in constructing the methodology for research. The subjects for this study were children, between the ages of seven and eight, and each child was trained and assessed on the serial task on an individual basis. The serial task (see appendix A) and evaluation tool (see appendix B) used in the current study were similar to the task and method of evaluation used in the study by Staum (1988b). Only one evaluator was used in the data collection process, therefore promoting reliability of the results. For more detailed information regarding the methodology of the present study, see chapter three.

In conclusion, research is lacking in the area of motor learning and music in all populations. We realize that the use of children without motor impairments will be a limitation of the study, with regards to its applicability to physical therapy practice. However, it is proposed that the learning process of a child with a motor disability will “follow the same developmental sequence as do those of normal children” (Thaut, 1985, p. 112), suggesting that extrapolation of this research in future studies may help combat motor dysfunction in the disabled pediatric population.
CHAPTER THREE
METHODODLOGY

Experimental Design

The experiment was of the acquisition-retention design to assess motor learning in children. It involved twenty-one children, ages seven and eight, with no known physical, psychological, or emotional impairments. The requirements insured that the subjects had the physical ability to perform the serial task as well as the mental capacity to understand and follow directions necessary to learn and perform the skill. The subjects were randomly divided into two conditional groups. In both conditions, the children were instructed in a novel serial task, consisting of a series of discrete motor skills. For the serial task chosen, task criteria were set to determine if the subject had correctly performed the serial task in the specified order. In condition one, the experimental group involved twelve children who practiced the serial task synchronized to a musical selection of appropriate tempo to facilitate task performance. The verbal cues for the serial task followed the rhythm of the music. In condition two, the control group involved nine children who practiced the serial task with the identical verbal cues without musical intervention. During the ten minute acquisition session, each subject performed the serial task ten times. Both the control and the experimental group performed five trials of the task followed by a thirty second rest period during which extrinsic average feedback (see appendix J) was given regarding the performance of the task trials. This
same sequence was followed for the remaining five trials. Following the ten practice trials, each subject was asked to perform the serial task learned without verbal cues or videotape demonstration and their performance was evaluated. Finally, each of the subjects, in both groups, were given a retention test approximately twenty-four hours after the practice session to assess the motor learning which occurred. The twenty-four hour delay of the retention session has been used in assessing the learning of motor skills by numerous motor learning researchers (Gable, C., 1991; Vander Linden, D., 1993; Winstein, C., 1990; Winstein, C., 1991). This delay of the retention test allows the researcher to determine the amount of motor learning as opposed to motor performance that occurred. The retention test consisted of each subject being asked to perform the serial task, which the subject learned during the previous practice session, one time with only an initial verbal cue. The test was in no way an emotional or physical stress to the child. Each videotaped performance, of trials number eleven and twelve of the serial task, was evaluated by a researcher of the study after the conclusion of the final data collection session. Each subject’s score was recorded by subject number on separate data collection sheet.

Subjects

The subjects were twenty-one children, of both genders ranging in age from seven to eight years from a local parochial elementary school. Although the subjects were selected by convenience sampling, they were randomly assigned into two groups, condition one or condition two. Based on the fact that the study was designed to measure individual change, the subjects, regardless of group assignment, were not matched according to age, gender, demographics, or ability level. A letter was sent to the school requesting participation in the present research study. The letter described the rationale for the study and the procedures that would be followed
A facility consent form (see appendix D) was required upon the school's agreement to participate in the study.

The inclusion criteria required all subjects to have no history of physical, psychological, or emotional impairment. In addition, the subjects had no vision or hearing difficulties. The teacher of the prospective subjects, due to her close relationship with the children, was given a screening form for each child prior to the beginning of data collection (see appendix E). The screen provided accurate information about each child's ability in reference to performance of the serial task and determined which students were to be included in the study.

Upon completion of the teacher screen, a letter was sent to the parents of the prospective subjects describing the purpose and methods of the study (see appendix F). A signed consent form was required (see appendix G) after a parent granted permission for his/her child to participate in the study.

After all inclusion criteria had been met and a signed parental consent form had been acquired, the subjects were randomly divided into the conditional groups. Each subject's confidentiality was protected by assigning each participant a number for identification purposes. Numbers were placed in a hat and drawn one at a time, alternating between condition one and condition two assignments. The numbers were used on all data collection forms. A list associating each subject with his/her identification number was only available to the researchers of the study in order to schedule times for the acquisition and retention sessions. After scheduling for the study had been completed, and letters to the teachers had been sent informing them of times and dates of data collection, the list was destroyed and not used, for any reason, as a part of the study. Finally, during the days of participation in the study the subjects were asked to wear loose fitting clothing and tennis shoes.
Site and Facilities

In order to promote compliance, the research was conducted at a local parochial elementary school. The acquisition session and retention session were both conducted in the same location. At the school, a room large enough to perform the serial task, as well as to accommodate the necessary equipment was supplied to the researchers. The room was quiet and separate from other occupied areas in order to decrease distractions.

Instruments

Videotapes used to demonstrate the serial task were constructed prior to the beginning of data collection. The videotapes presented to the subjects of both the control and experimental groups contained identical verbal cues directing performance of the serial task. The only difference between the two tapes was the addition of music to the tape shown to the experimental group. The verbal cues in the experimental condition were presented in song format to direct the performance of the task. The music, Walt Disney's "Tiki Tiki Tiki Room," was chosen to appropriately fit the age of the subjects, and was of an appropriate tempo to facilitate the correct timing of the task.

A VCR and 25 inch television monitor were used to demonstrate the serial task in both conditions. A video camera was used to tape the subjects during acquisition and retention sessions increasing the accuracy of data collection by the researchers of the study. The children were identified on the videotape by their assigned number.

An evaluation checklist (see appendix B) based on the research conducted by Staum (1988b) was used in the study in order to objectify the individual performance of the serial task by the subjects on the eleventh and twelfth trials. Not only was the sequence in which the discrete motor skills were performed evaluated, but each discrete skill itself needed to be
performed at a general level of predetermined accuracy in order to document successful completion of the serial skill. The first two discrete skills were not scored and therefore, served only as cues to aid in the performance of the remaining four components of the serial task.

**Procedure**

The goal for each subject was to achieve the correct sequencing of the serial task (see appendix A) and to perform the individual discrete tasks making up the serial task to the level described in the evaluation checklist (see appendix B).

Prior to data collection in the present research study, a preliminary study was performed in order to assess research design construction. The preliminary study involved ten children, ages seven and eight randomly divided into two groups of five subjects. The inclusion criteria for the preliminary study were identical to that of the present study. The subjects were screened by their teacher to exclude those with a history of physical, psychological or emotional impairment. The procedure for the preliminary study involved each subject performing the serial task twenty times with a thirty second rest period after every fifth trial. During the rest period, extrinsic average feedback was given regarding task performance. Both conditional groups practiced the serial task twenty times with a demonstration videotape. The only difference between the groups was the addition of music to the identical verbal cues given in the experimental group. Approximately twenty-four hours after the acquisition session, each of the ten subjects participated in a retention session to assess the motor learning which occurred. Acquisition and retention performance of the serial task was evaluated by the evaluation checklist. Results of the preliminary study will be discussed in chapter four.

Upon review of the results of the preliminary study, minor adjustments were made to the methodological procedure of the study. First, the number of trials was adjusted. The subjects
during the preliminary study had twenty practice trials. It was decided that the subjects would be
given only ten practice trials in the current study. This was done in order to decrease the amount of exposure to the task, and thus enhance the possibility of observing the occurrence of motor learning. Secondly, during the preliminary study, the twentieth trial was recorded as the acquisition score. In other words, the acquisition score reflected the use of verbal cues along with task performance in both groups. In order to make the results of the retention session more capable of detecting actual motor learning, it was decided that at the conclusion of the ten practice trials the subjects, regardless of conditional group, would be asked to perform the serial task without music, verbal cues or videotaped demonstration. This eleventh trial was then recorded as the acquisition score. The retention session procedure was not changed as a result of the preliminary study.

In the current study, prior to the acquisition session, the subjects' teacher was sent a schedule of the dates and times that the subjects would be participating in the research study (see appendix H). The day before data collection, a researcher from the study talked to the participating subjects in order to explain the procedure and help decrease any anxiety among subjects. The acquisition session began with each subject receiving instructions about the procedure of the session (see appendix I). The subjects then watched a videotape that demonstrated the serial task under one of the two conditions. After observation of the task and opportunity for the subject to ask any questions, each subject began practicing along with the videotape for a total of ten trials with a thirty second rest period following a series of five trials. During the rest period, the subject was provided with extrinsic average feedback. The feedback was provided after a five second delay in order to allow for intrinsic error detection mechanisms to evaluate task performance. At the conclusion of the ten practice trials, the subjects of both
conditions were asked to perform the serial task one time without the use of verbal cues or the
demonstration videotape. This final trial during the acquisition session was then scored at a later
date using the evaluation checklist and recorded on a data collection sheet by subject number.
The subjects were given a reward for their participation in the session and given verbal
instructions regarding the retention session the following day. The subjects were personally
escorted to and from their classroom and the research area.

Each subject returned for the retention test approximately twenty-four hours following
the acquisition session. The subjects of both conditional groups were given identical verbal
instructions (see appendix K) regarding retention session expectations. No videotape in either
condition was shown, and extrinsic feedback was not provided during the retention test. During
the retention test, the children were simply asked to perform the serial task they learned one day
prior, and were in no way subjected to physical or emotional stress. The same evaluation tool,
specifying task criteria, used to assess task performance during the acquisition session was used
to assess motor learning during the retention test. The subjects were given a second reward for
their participation in the research study.

Data Collection

A total of thirty-one subjects participated in the research project. Ten subjects
participated in the preliminary study, and twenty-one subjects participated in the current study.
Of the thirty-one subjects, only one subject had to be disqualified secondary to missing the
second day of data collection due to illness. In the preliminary study, condition I included one
seven year old and four eight year olds. Condition II included three seven year olds and two eight
year olds. In the current study, condition I included six seven year olds and seven eight year
olds. Condition II included three seven year olds and five eight year olds.
Data collection techniques were specifically designed in order to provide a blinded study with intra-rater reliability. Each subject was videotaped by a single researcher during the acquisition and retention sessions. Following the conclusion of the retention session, the videotapes documenting subject performance were reviewed by a second researcher. The second researcher was not involved in the videotaping procedure and muted the volume during review of the tapes. Therefore, the researcher was not aware of any subject's conditional group. Each subject was identified on the videotape by number, protecting the subject's confidentiality. The videotapes were reviewed and the appropriate score recorded on a data collection sheet for the final trial of the acquisition session and the retention session trial. Intra-tester reliability was determined by reviewing a portion of the videotapes a second time. Intra-tester reliability was found to be 100% reliable. Each subject's performance could be viewed more than once, at an adjusted speed, if necessary. Please see appendix L for the data collection form of the preliminary study and appendix M for the current study.

Data Analysis

The subjects were divided into two independent sample groups: the experimental group that practiced the serial task with the addition of music and the control group that practiced the serial task without musical intervention. The scores for the subject population of this research study did not follow a normal distribution, resulting in the need for non-parametric statistical analysis. In both the preliminary and current study, the Mann-Whitney U Test was used to analyze the data, with the p-value set at 0.05. Please see appendix N for the statistical analysis for the preliminary study and appendix O for the current study.

First, the difference between acquisition and retention session scores for each subject was calculated. This value was used for the subject's score in both conditional groups. The Mann-
Whitney U Test combines both groups and ranks all scores, smallest to largest. If there are a small number of rankings that are tied, there is a correction factor that can be applied. However, this correction has been proven to only change the results minimally. This analysis is designed to test the null hypothesis that all groups would be equally distributed among the ranks. The Mann-Whitney U Test, therefore, had the ability to test our hypothesis that those in the music group would demonstrate greater improvements in motor learning of the serial task than those of the control group. Statistical analysis was performed by the Statistical Package for the Social Sciences (SPSS) computer program.
CHAPTER FOUR
RESULTS

Preliminary Study (N=10)

A ceiling effect in the performance of the serial task was observed, as the majority of the subjects achieved close to the absolute score on the evaluation tool. Ninety percent of the subjects showed no decline in task performance from acquisition to retention session, regardless of conditional assignment. As a result of this, there were numerous tied rankings demonstrated by the statistical analysis. Literature on the use of the Mann-Whitney U Test suggests that if the number of tied ranks is excessive then the results of this test could be questionable. Using the Mann-Whitney U Test, there was insufficient evidence to show that the scores for the music group exceeded the scores for the control group, documented in appendix N. The p-value was 0.6905 and was not corrected for tied ranking.

Current Study (N=20)

Based on the results of the preliminary study, minor adjustments were made in the methodology and data collection was repeated. Unfortunately the results did not prove to be statistically significant, even with the procedural changes having been made. A ceiling effect was again demonstrated, as ninety-five percent of the subjects did not have any difficulty remembering the serial task practiced the previous day. The subjects in the music group did not demonstrate greater improvement in the motor learning of the serial task when compared to the control group. The Mann-Whitney U Test was used for statistical analysis, documented in appendix O. The p-value was 0.4727 and was not
corrected for tied rankings, therefore the increased amount of tied ranks, once again makes the results obtained through this statistical analysis questionable.
The discussion section will first cover the limitations of the study. The strengths of the study will then be discussed along with areas in which we feel there is a need for further research.

**Limitations**

The results of the study did not prove to be statistically significant. The main reason for the lack of significant results was the ceiling effect demonstrated by the subjects’ performance on the serial task chosen. The ceiling effect is explained by Richard Schmidt as a problem that occurs often in motor learning research. It is the result of the majority of the individuals coming close to the “absolute score” which exists with most tasks and can not be exceeded (Schmidt, 1988). The closer one comes to the absolute score, “the changes in the performance levels of the people doing the task become increasingly insensitive to the changes in habit that may be occurring in the people as they practice” (Schmidt, 1988, p.352).

There are several reasons why the results demonstrated a ceiling effect. First, the serial task chosen may have been too simple for the age of the children included in our research study. Consequently, the majority of the children were able to learn the task within the specified time period allowing for no comparable differences to be noted among the subjects. The number of discrete motor skills included in the serial task chosen was suggested for the age group by past research. (Staum, 1988b) However, further analysis of the serial task, made it apparent that the sequence of the discrete tasks
forming the serial task may not have been a truly novel sequence. The task required the subjects to touch their knees, touch their toes, jump up, and clap their hands. There is a very popular song, "head, shoulders, knees and toes, knees and toes," that many of the children in the age group studied could have been familiar with. Subsequently, the similar sequence of the discrete skills in the serial task may have not produced the novel skill we were hoping to test, allowing for the majority of the subjects to score near the "absolute score" as described by Schmidt (1988).

Lastly, the ceiling effect may have occurred as a result of our evaluation tool not being specific enough to detect the subtle differences in the subjects' performances during the acquisition and retention sessions. The evaluation tool was designed to focus on the correct sequence of the serial task, not necessarily the individual performance of each discrete task. Consequently, the subtle differences that may have been present in the quality of performance of the individual discrete skills were not detectable by our evaluation tool.

In addition to the ceiling effect, which was demonstrated with our results, the demographics of our subject population were also a limitation. All subjects were from the same parochial school, in the same small town, and were acquired via convenience sampling. As a result, it may be assumed that there was little variety in culture, familial structure and financial standing of the children involved in the research study. More significant results may have been seen if a broader representation of the general population had been acquired. One final characteristic of the subjects that was not closely controlled was the amount of previous experience that each subject may have had in athletics or dance training. The children with previous experience in this area may have had an advantage over the children with no previous experience due to the nature of the serial task. Finally, our study included only able-bodied
subjects, instead of children with disabilities. If children with disabilities had been used as subjects, the results of our study may have been more directly applicable to the field of physical therapy.

**Strengths**

The strengths of the study will now be discussed. Special attention was taken in appropriately controlling the variables of the study. Consequently, the methodology was carefully structured so that the only differing variable between the two conditional groups was the addition of music to the acquisition sessions in the experimental group. In order to achieve this, the researchers had to adhere to a very descriptive methodological procedure. First, the acquisition and retention sessions were facilitated by the same researcher for every subject, thus decreasing variability of data collection procedures. During the acquisition and retention session, all verbal instructions were identical and prewritten (appendices I and K). Furthermore, during the acquisition session, the verbal cues for task direction on the videotape and the person demonstrating the task on the videotape were identical for each group. Lastly, the extrinsic feedback given during the practice session was strictly limited to pre-written information, documented in appendix J, and was given to each subject after a series of five trials of the task. Each subject received feedback one time during the acquisition session. The feedback for both conditional groups was given after a seven second delay to allow for intrinsic error detection.

The researchers of this study were able to further strengthen the methodology of the study through the use of the several data collection techniques. As stated above, the acquisition and retention sessions were facilitated by one member of the research study. Evaluation of task performance was then assessed by the other member of the research study, thus enhancing intra-tester reliability. The performance of the serial task was evaluated through videotape analysis.
The subjects were identified on the videotape by their assigned number. Analysis by videotape allowed the evaluator to reassess each subject's performance as many times as necessary to achieve the correct score. In addition, by muting the volume on the television, the evaluator remained blinded to the subject's group designation.

The uncomplicated, well-defined construction of this research design and the clear manipulation of only one variable further strengthens the study by allowing for easy replication. In addition, the small amount of equipment required for data collection would also make this study easily replicable. The equipment required, a videocamera, videocassettes, television, and VCR, is easily accessible in most situations. Another positive aspect to the study was the relatively small total time commitment per subject. The total time required for each subject averaged 10 minutes over a two day period.

One final strength of this study was the ability of the authors to formulate a working hypothesis directly based on an extensive literature review of the topics involved. Literature linking the use of music and motor learning principles to enhance the learning of motor skills is lacking; however, current research strongly supports the effects of each concept in isolation. Music has been shown to exhibit a profound effect on the mind and body. Furthermore, music has been shown to greatly decrease the variability in the timing and duration of muscular activity. Therefore, music has the ability to directly effect two components of motor learning: motor activity and spatial-temporal reasoning. Thus, the authors of this study hypothesized that combining two successful, related concepts for motor skill acquisition would yield significant clinical results.

Due to the lack of research in the area of music's ability to enhance motor learning, more information is needed to support its use in physical therapy and other areas. The weaknesses of
our study have generated several future research ideas. Although our particular serial task produced results demonstrating a ceiling effect in children ages seven and eight, a study utilizing the identical methodological procedures as the current study could be performed on younger children. In addition, experimenting with the difficulty, novelty, and chaining of component movements of the serial task among various age groups could be done utilizing the identical methodology used in the current study. Finally, more research needs to be done on music’s ability to affect motor learning in disabled persons, (i.e. those patients with learning disabilities, attention deficit disorders, and various physical and emotional impairments) to truly assess the success of music’s use in attaining functional gains in physical therapy practice.
Bibliography


Appendix A
Appendix A
Description of the Serial Task

1. March forward four steps
2. March backward four steps
3. Touch knees with both hands once
4. Touch feet with both hands once
5. Jump up once on both feet
6. Clap hands once
Appendix B
Appendix B
Evaluation Checklist for Serial Task

Subject Number: __________  Date: __________  Time: ________

Serial Task Evaluation

<table>
<thead>
<tr>
<th>Points</th>
<th>Criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
<td>In order: knees, feet, jump, clap</td>
</tr>
</tbody>
</table>
| 8      | One movement out of order  
or Complete reversal of order |
| 7      | Two movements out of order  
or One movement left out; others in order |
| 4      | Three movements out of order  
or One movement left out; others out of order |
| 2      | Two movements left out |
| 1      | Three movements left out |
| 0      | All four movements left out |

Scores:

| Practice Session (Trial 11) | Retention Session (Trial 12) |

Evaluation completed by: __________________________  _________
(Signature)  (Date)
Appendix C
Appendix C
Request for Participation in the Study:
A Letter to Facilities

Name of School
Attention: Principal or Superintendent
Address
City, State, Zip Code

Date

Dear (Name of Director of Facility),

As members of Grand Valley State University’s graduate program of physical therapy, we are currently conducting research for our master’s thesis. Our topic of study is “Music and the Effect it has on the Motor Learning of a Serial Task in Children, Ages Seven and Eight.

In pediatric physical therapy, the creativity of the therapist is crucial to the success of the treatment sessions. Research has shown the overwhelming response that children have to music. Music is a way to motivate and attach fun to situations that are potentially threatening to a child. A large amount of research has also been done regarding the physiological and psychological effects that music has on the body. With respect to physical therapy and the learning of motor skills, music has been shown to directly affect muscle activity, which leads to skillful movement production. In spite of this research, there is little documentation about music’s use in the practice of physical therapy. The goals of this research are to prove that music has the ability to enhance motor learning in normal children, and to promote future research using the combination of music and motor learning principles in physical therapy.

We are writing to local schools to stimulate an interest in our research study and ask for your cooperation in helping us find eligible participants. For our research we are including children of both genders, ranging from seven to eight years of age, with no history of physical, psychological, or emotional impairments. The study will require a total time commitment of twenty minutes over a two day period for each participant. The experiment will consist of having each child perform a sequence of discrete motor skills under one of two randomly assigned conditions, with or without music, during a practice session (Day One). On Day Two there will be an assessment of the sequence learned on day one. The children will receive a thirty second rest period after every fifth performance of the motor task. All information obtained from this study will be treated as privileged and confidential. In addition, the children involved in the study will in no way be subjected to physical or emotional stress during any part of the experimental procedure.
Thank you so much for taking the time to consider this request. Any help you could offer would be greatly appreciated. Please feel free to contact us with any questions, concerns, or comments at (313) 641-3571 or our research committee chairman, Barbara Baker, at (616) 895-3356.

Sincerely,

Tara K. Nielsen, S.P.T.

Karen L. Kurncz, S.P.T.

Barbara Baker, P.T.
Appendix D
Appendix D
Facility Consent Form
Consent form for the participation in the research study:
Music and The Effect it has on Motor Learning of a
Serial Task in Children Ages Seven and Eight

1. ______________(Name of Facility) state that we grant permission to Tara K. Nielsen and Karen L. Kurncz, physical therapy students from Grand Valley State University under the indirect supervision of committee chairman Barbara Baker, to use our facility as a site for the above research study.

2. **Purpose:** We understand that the purpose of this study is to investigate how music may affect the learning of a new task in children between the ages of seven and eight. We understand that the knowledge gained from this experiment will help physical therapists develop more efficient treatment sessions for the children under their care.

3. **Experimental Procedure:** We understand that the experiment will require our students’ participation for approximately twenty minutes over two consecutive days. We understand that during that time the student will be one of approximately thirty children video taped learning the new motor task. The student will perform the motor task eleven times the first day and one time the second day.

4. **Staff Consent:** We understand that any staff directly involved with the research project will have it personally explained to them by the researchers. Any questions the staff may have will be answered at this time and anytime there after. Our staff understands that they may refuse of withdraw from the study at anytime and that this refusal or withdraw will not affect the staff members standing at ______________(Name of Facility) now or at any time in the future.

5. **Space and Student Commitment:** We understand that the researchers will require the use of a quiet unoccupied room in order to perform the study. We also understand that the students will miss approximately twenty minutes of class time if chosen to participate.

6. **Right of Privacy:** The information that is obtained from this study will be treated as privileged and confidential. If the results are published, our students or facility will not be identified in anyway. The information obtained, however, may be used for statistical, scientific or medical purposes with our students’ and facility’s right of privacy retained.

7. **Research Results:** We understand that a summary of the results will be made available to us upon our request. We also understand that the video tapes of the students will be available to us upon our request.

8. **Consent:** We acknowledge that we have been given the opportunity to ask questions about the study and that these questions have been answered to our satisfaction. We understand that we may contact Tara K. Nielsen or Karen L. Kurncz at (313) 641-3571, Barbara Baker, research committee chairman, at (616) 895-3356, or Paul Huizenga, Human Subject Review Board
Chairman at Grand Valley State University, at 616-895-2472 if we have further questions. We acknowledge that we at ____________(Name of Facility) have read and understand the above information and agree to participate in the study "Music and the Effect it has on the Motor Learning of a Serial Task in Children, Ages Seven and Eight."

Please Print Facility Name

Date

Principal

Date

Superintendent

Date

Witness

Date

Witness

Date
Appendix E
Appendix E
Teacher Screen for Inclusion in the Study Entitled:
"Music and the Effect it has on the Motor Learning of a Serial Task in Children, Ages Seven and Eight"

Child's Name _________________________ Age ________
(Please Circle)

Can the child appropriately attend to classroom tasks? YES NO

To your knowledge, has the child been diagnosed with Attention Deficit Disorder (ADD) or Attention Deficit Hyperactive Disorder (ADHD)? YES NO

Is the child, to your knowledge, diagnosed with any of the following health impairments:

Physical (please check)

Vision Difficulties ______
Hearing Difficulties ______
Musculoskeletal Impairment ______
Coordination/Balance Deficit ______

Other _____________________ ______

Psychological Impairment YES NO

Emotional Impairment YES NO

Do you recommend this child as a participant in the research study entitled, "Music and the Effect it has on the Motor Learning of a Serial Task in Children, Ages Seven and Eight?" YES NO

________________________________________________________________________
(Teacher Signature) (Date)
Appendix F
Appendix F
Informational Letter:
To Parents of Possible Participants

Parent/Caregiver Name
Address
City, State, Zip Code

Date__________

Dear Parent,

As members of Grand Valley State University’s graduate program of physical therapy, we are currently conducting research for our master’s thesis. Our topic of study is “Music and the Effect it has on Motor Learning of a Serial Task in Children, Ages Seven and Eight.”

In pediatric physical therapy, the creativity of the therapist is crucial to the success of the treatment sessions. Research has shown the overwhelming response that children have to music. Music is a way to motivate and attach fun to situations that are potentially threatening to a child. A large amount of research has also been done regarding the physiological and psychological effects that music has on the body. With respect to physical therapy and the learning of motor skills, it has been shown that music can directly affect muscle activity, which leads to skillful movement production. In spite of this research, there is little documentation about music’s use in the practice of physical therapy. The goals of this research are to prove that music has the ability to enhance motor learning in normal children, and to promote future research using the combination of music and motor learning principles in physical therapy.

Your child’s name has been forwarded to us from (Name of Facility) as a potential participant in our research study entitled, “Music and the Effect it has on the Motor Learning of a Serial Task in Children, Ages Seven and Eight.” For our research we are including approximately thirty children of both genders, ranging from seven to eight years of age, with no history of physical, physiological, or emotional impairments. The study will require a total time commitment of twenty minutes over a two day period for each participant. The experiment will consist of having each child perform a sequence of discrete motor skills under one of two randomly assigned conditions, with or without music, during a practice session (Day One). On Day Two there will be an assessment of the sequence learned on day one. The children will receive a thirty second rest period after every fifth performance of the motor task. All information obtained from this study will be treated as privileged and confidential. In addition, the children will not be subjected to any physical or emotional stress during either of the research sessions.
Thank you so much for expressing an interest in our research study. Please feel free to contact us with any questions, concerns, or comments at (313) 895-3356. We look forward to meeting you and your child in the future.

Sincerely,

Tara K. Nielsen, S.P.T.

Karen L. Kurncz, S.P.T.

Barbara Baker, P.T.
Appendix G
Appendix G
Parental Consent Form
Consent Form for the Participation in the Research Study:
Music and the Effect it has on the Motor Learning of a
Serial Task in Children Ages Seven and Eight

1. I__________________, parent of __________________state that I agree to allow my child to participate, as one of the thirty subjects, in a research project being conducted by Tara K. Nielsen and Karen L. Kurncz of Grand Valley State University’s Physical Therapy Program under the indirect supervision of research committee chairman Barbara Baker.

2. **Purpose:** I understand that the purpose of this study is to investigate how music may affect the learning of a new task in children between the ages of seven and eight. I understand that the knowledge gained from this experiment will help physical therapists develop more efficient treatment sessions for the children under their care.

3. **Experimental Procedure:** I understand that the experiment will require my child’s participation for approximately twenty minutes over two consecutive days. I understand that approximately thirty other students will also be involved in this research study. I understand that during that time my child will be video taped learning the new motor task and will perform the motor task eleven times the first day and one time the second day.

4. **Child’s Consent:** I acknowledge that I have explained this experiment to my child and he/she has agreed to participate. I understand that the researchers will further explain the procedure to my child on the days of research and that my child’s questions will be answered at any time. In addition I understand that my child has the right to refuse to participate in the study at anytime.

5. **Risk to Child:** I understand that my child will be performing a simple motor task multiple times. I understand that the during the experiment it can be terminated at any time upon my child’s request. While no physical risks are anticipated, possible risks include fatigue and muscle soreness from the repeated performance of the motor task. I understand that I may refuse or withdraw my child at any time in the study and that this refusal or withdraw will not affect my child’s care at (Name of Facility) now or at any time in the future.

6. **Right of Privacy:** The information that is obtained from this study will be treated as privileged and confidential. If the results are published, my child will not be identified in any way. The information obtained, however, may be used for statistical, scientific, or medical purposes with my child’s right of privacy retained.

6. **Research Results:** I understand that a summary of the results will be made available to me upon my request. I also understand that the video tapes of my child will be available to me upon my request.
7. **Consent:** I acknowledge that my child and I have been given the opportunity to ask questions about the study and that these questions have been answered to our satisfaction. I understand that I may contact Tara K. Nielsen or Karen L. Kurncz at (313) 641-3571, Barbara Baker, committee chairman, at (616) 895-3356, or Paul Huizenga, Human Subject Review Board Chairman at Grand Valley State University, at (616) 895-2472 if I have further questions. I acknowledge that I have read and understand the above information and agree to allow my child _________________ to participate in the study “Music and the Effect it has on the Motor Learning of a Serial Task in Children, Ages Seven and Eight.”

Please Print Child’s Name ___________________________ Date ____________

Parent of participant ___________________________ Date ____________

Witness ___________________________ Date ____________

Witness ___________________________ Date ____________
Appendix H
Appendix H
Letter to Teacher:
Regarding Schedule for Practice and Retention Sessions

Date: __________

Dear (Teacher):

Thank you for allowing your students to participate in our research study. Below is a tentative schedule for our research study which will begin on January 7, 1998. We will come to your room to escort each of the participants to the designated research area and back to the classroom. If you have any questions or problems with this above procedure please contact us at (517) 224-6084.

**Tentative Schedule for Data Collection**

<table>
<thead>
<tr>
<th>Date</th>
<th>Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wednesday, January 7, 1998</td>
<td>8:00 a.m. - 12:00 p.m.</td>
</tr>
<tr>
<td>Thursday, January 8, 1998</td>
<td>8:00 a.m. - 10:00 a.m.</td>
</tr>
<tr>
<td>Wednesday, January 14, 1998</td>
<td>8:00 a.m. - 12:00 p.m.</td>
</tr>
<tr>
<td>Thursday, January 15, 1998</td>
<td>8:00 a.m. - 10:00 a.m.</td>
</tr>
</tbody>
</table>

Thank you for your cooperation,

Tara K. Nielsen, S.P.T.

Karen L. Kurncz, S.P.T.

Barbara Baker, P.T.
Research Committee Chairman
Appendix I
Appendix I
Acquisition Session Instructions

The following are instructions that will be given to each subject upon entering our experimental room:

"We are going to have you watch a videotape demonstrating six different movements. These six movements are in a specific order and it will be important for you to pay attention to this order. After you've watched a demonstration by the videotape, we will have you practice the movements ten times along with the videotape with a short rest period after the fifth time you perform the movements. During each rest period we may offer some suggestions on how you could perform the movements more like the demonstration videotape. At the end of today's session and then tomorrow when you come back, we will ask you to show us the movements you learned without the use of the videotape. Do you have any questions?"
Appendix J
Appendix J
Guidelines of Average Feedback Provided During Trials

1. Feedback will be given after the fifth trial of the serial task during a thirty second rest period. Therefore, there will be one opportunity in which feedback will be given during the ten practice trials.

2. Feedback given may consist of the following:
   a. Any verbal cues, given as commands for task performance, on the videotape can be used as reminders of the correct sequence and movements.

   b. The following motivational phrases are also permissible:
      1. Good Job. You are doing fine.
      2. Keep up the good work, we are almost finished.
      3. You are doing great, keep it up.
      4. Get ready, it is almost time to start again.
Appendix K
Appendix K
Retention Session Instructions

The following are instructions that will be given to each subject upon entering the experimental room for the retention test:

"Welcome back! We are going to start today with having you show us the six movements in the proper order that you learned yesterday. The only difference will be that today we won't be using the demonstration videotape and you will only have to perform the movement one time. Do you have any questions?"
Appendix L
Appendix L
Data Collection

Preliminary Study
N=10

<table>
<thead>
<tr>
<th>Subject Number</th>
<th>Condition</th>
<th>20th Trial</th>
<th>Retention</th>
</tr>
</thead>
<tbody>
<tr>
<td>15</td>
<td>II</td>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td>11</td>
<td>II</td>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td>13</td>
<td>II</td>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td>09</td>
<td>II</td>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td>08</td>
<td>II</td>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td>04</td>
<td>I</td>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td>05</td>
<td>I</td>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td>06</td>
<td>I</td>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td>02</td>
<td>I</td>
<td>10</td>
<td>2</td>
</tr>
<tr>
<td>10</td>
<td>I</td>
<td>10</td>
<td>10</td>
</tr>
</tbody>
</table>
Appendix M
### Appendix M

**Data Collection**

**Current Study**

**N=20**

<table>
<thead>
<tr>
<th>Subject Number</th>
<th>Condition</th>
<th>Acquisition</th>
<th>Retention</th>
</tr>
</thead>
<tbody>
<tr>
<td>01</td>
<td>II</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>16</td>
<td>II</td>
<td>10</td>
<td>1</td>
</tr>
<tr>
<td>20</td>
<td>II</td>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td>21</td>
<td>II</td>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td>25</td>
<td>II</td>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td>27</td>
<td>II</td>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td>29</td>
<td>II</td>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td>30</td>
<td>II</td>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td>03</td>
<td>I</td>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td>07</td>
<td>I</td>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td>12</td>
<td>I</td>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td>14</td>
<td>I</td>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td>17</td>
<td>I</td>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td>18</td>
<td>I</td>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td>19</td>
<td>I</td>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td>22</td>
<td>I</td>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td>23</td>
<td>I</td>
<td>10</td>
<td>Absent</td>
</tr>
<tr>
<td>24</td>
<td>I</td>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td>26</td>
<td>I</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>28</td>
<td>I</td>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td>31</td>
<td>I</td>
<td>2</td>
<td>10</td>
</tr>
</tbody>
</table>
Appendix N
**Appendix N**  
**Data Analysis**  
**Preliminary Study**

**Mann – Whitney U – Wilcoxon Rank Sum W Test**

<table>
<thead>
<tr>
<th>Mean Rank</th>
<th>Sum of Ranks</th>
<th>Condition I</th>
<th>Condition II</th>
</tr>
</thead>
<tbody>
<tr>
<td>6.00</td>
<td>30.00</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>5.00</td>
<td>25.00</td>
<td></td>
<td></td>
</tr>
<tr>
<td>U</td>
<td>W</td>
<td>One-tailed P</td>
<td>Z</td>
</tr>
<tr>
<td>10</td>
<td>25</td>
<td>.6905</td>
<td>-1.0000</td>
</tr>
</tbody>
</table>

*This exact p-value is not corrected for ties.*
Appendix O  
Data Analysis  

Current study  

Mann-Whitney U – Wilcoxon Rank Sum W Test  

<table>
<thead>
<tr>
<th>Mean Rank</th>
<th>Sum of Ranks</th>
<th>Condition I</th>
<th>Condition II</th>
</tr>
</thead>
<tbody>
<tr>
<td>9.71</td>
<td>116.5</td>
<td>12</td>
<td>8</td>
</tr>
<tr>
<td>11.69</td>
<td>93.50</td>
<td></td>
<td></td>
</tr>
<tr>
<td>U</td>
<td>W</td>
<td>One-tailed P</td>
<td>2</td>
</tr>
<tr>
<td>38.5</td>
<td>116.5</td>
<td>.4727</td>
<td>-1.4068</td>
</tr>
</tbody>
</table>

*This exact p-value is not corrected for ties.*