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The effects of contextual interference on the acquisition, retention, and transfer of a music motor skill among university musicians

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THE EFFECTS OF CONTEXTUAL INTERFERENCE ON THE ACQUISITION, RETENTION, AND TRANSFER OF A MUSIC MOTOR SKILL AMONG UNIVERSITY MUSICIANS

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ABSTRACT

The contextual interference hypothesis holds that simple motor skill tasks are best learned when practiced under blocked, or repetitive conditions, but that retention and transfer are best accomplished when the skill has been practiced in varied conditions. The purpose of this study was to measure the effects of contextual interference practice conditions on the acquisition, retention, and transfer of a complex task—right hand lead percussion sticking technique among university musicians.

All participants (*N* = 120) demonstrated rhythmic competency for the task, and were necessarily unable to perform the sticking technique with accuracy at the start of treatment. Three treatment groups experienced an acquisition phase, in which they learning sticking patterns in blocked, varied, and control conditions. All participants took part in two retention and transfer tasks, with the objective of employing correct sticking patterns and rhythms. The first occurred five minutes after acquisition. The second followed latency periods of thirty minutes, one hour, six hours, or twenty-four hours. Performances were evaluated according to rhythm and pattern accuracy.

Evidence of a contextual interference effect resided in the acquisition phase, where varied participants experienced more error than blocked counterparts; however, in subsequent retention and transfer tasks, the rhythm and pattern accuracy for both groups was equivalent. Primary performance area had a significant effect on rhythm and pattern accuracy during the pretest, retention, and transfer tasks; vocalists scored significantly below instrumentalists. Effects of posttest retention and transfer latency timings were absent.

Overall, slight increases in rhythm accuracy and significant increases in pattern accuracy occurred from pretest to retention. These increases may indicate that the visual image of the music or kinesthetic feel of the task could have enhanced the music motor skill retention in this

study. Both rhythm and pattern accuracy scores declined during the transfer task, and could be attributed to the interference of pattern on rhythm within a complex task. Observation of control participants' acquisition phases and all participants' sight reading preparation revealed that most participants' approaches to self-structured practice were simplistic with regard to problem solving.

CHAPTER 1

INTRODUCTION

As teachers, we seek efficient teaching strategies that lend themselves successfully to student achievement. In the college environment, music education students are continuously confronted with the need to practice a variety of instrumental techniques. Their success in acquiring, retaining, and transferring this knowledge can be largely dependent on the practice strategies that have been taught by their teachers. Considering the substantial amount of time it takes to become expert, or even just proficient, on an instrument (Ericsson, Krampe, & Tesch-Roemer, 1993; Woody, 2001) it is of utmost importance that researchers examine how students best learn and practice. This challenge has been attempted in endless ways, but research in kinesiology and motor skills (Kerr & Booth, 1978; Shea, Kohl, & Indermill, 1989; Shea & Morgan, 1979; Wrisberg, 1991) is offering a new lens from which to view the structure of practice.

Researchers (Pacey, 1993; Saunders, 2004) have begun to transfer this knowledge from the fields of kinesiology and motor skills into the world of music education. This transfer has numerous possibilities and implications for the way motor skills are taught and learned in a music environment. This application of knowledge is still in its infancy, and with potential to change the course of music practice structure, there is a need for study in this line of research.

It can be argued, as Bartlett (1932) has contended, that our actions are never completely new, nor are they ever completely the same. After all, from the moment we are born, we begin to learn skills in communication, movement, and thought that are automatically linked to our brief past experiences. For instance, we learn to walk based on motions transferred from standing and crawling. These transfers never cease, but in the aging process, may become more refined and

specific, as we learn to run, dance, and play sports. Our past experiences provide the basis for classifying and storing knowledge. This knowledge is later recalled for necessary tasks or transfers to novel contexts. For example, exposure to music in the past can help us to identify a piece of music as jazz, or even as a jazz selection performed by Miles Davis, despite never having heard the selection previously. This also explains why we can sight read unfamiliar music, or drive controllably down a road we have never seen. We are using familiar concepts in unfamiliar contexts, and have acquired the means necessary to transfer knowledge to a new action. Bartlett (1932) introduced this transferable knowledge as a product of his schema theory. Schema, he contended, are scripts, meanings, or representations that outline knowledge and experience in our brain's memory, and are unique to each individual. We may form the schema for a dog based on our own breed of pet; however, we slowly accommodate other breeds, sizes, and colors of dogs into our schema. While these representations are modified and expanded over time to accommodate new ideas or transfers, they are also defined by limitations. Through experience, we come to realize that the qualifications for a canine are not limited to four legs and a tail, and that a cat is somehow a different animal altogether.

Schmidt (1975) transferred this idea to the motor skill domain, explaining that motor skills are also the result of the brain's reliance on a generalized motor plan (GMP), and the knowledge built from schemata. The GMP functions as a relatively unchanging framework, while the schemata are more specific constructs of the process that are unique within each individual's mind. For instance, musicians can successfully learn a generalized motor plan for performing scales; however, the various ways that the scales are remembered and recalled are schemata. A percussionist may envision the "lay" of the bars or the pattern that the mallets follow on the keyboard, while the flautist may anticipate the groupings and patterns of fingerings

on the instrument. For many domains of motor learning, the processes of acquiring schemata and retaining knowledge are of the utmost importance.

Researchers in the fields of kinesiology and motor learning (Kerr & Booth, 1978; Shea, Kohl, & Indermill, 1989; Shea & Morgan, 1979; Wrisberg, 1991) have proposed that the acquisition of schema is largely dependent upon the interfering variables that occur when a skill is acquired. This resulting contextual interference hypothesis states that the short-term speed of accomplishing a task is better for subjects who learn under blocked, repetitive conditions, or low contextual interference. Retention and transfer of the skill, however, are accomplished best by subjects who have been exposed to random sequences of practice, or high levels of contextual interference.

This hypothesis offers much promise for music practice because of the relationship between music and motor skills. All types of music performance require motor skills of different types and degrees. Within instrumental music, there is rarely a still moment; more often, there is frequent movement, often involving the limbs, hands, and fingers of musicians. These movements may be gross motor skills, such as those involved in the arm movements of timpanists. They may also be fine motor skills, such as the finger dexterity found in the technique of an oboe player. Many times, however, there is evidence of both types of movement. The string player for instance, must negotiate gross motor movements of bowing with the fine motor skills of fingering notes. All this taken into consideration, it seems that the way in which a motor schema can be acquired may directly affect the musician’s ability to retain and transfer skills. The combination of music and motor skills has had sparse investigation, however, until recently.

The implications of a lack of motor skill research in music performance can be casually observed in student frustration regarding practice efficiency. It can also be seen in a formal study

regarding the structure of music practice sessions. Kostka (2002) suggested discrepancies between the practice perceptions of students and teachers. Of 127 studio teachers, all indicated discussing good practice techniques with their students. Of the 134 undergraduate and graduate music majors surveyed, only 69 percent indicated that their teachers discussed such strategies with them. Fifty-five percent of students indicated having no definitive practice routine; yet, 94 percent of teachers believed that their students did. Additionally, when given choices to describe their feelings about practice (tedious but necessary, relaxing, challenging, fulfilling), 38 percent of students chose "challenging." Kostka's findings illustrate the need for study in effective practice techniques.

At the college level, music education students and teachers are usually pressed for time. This is especially so in instrumental methods classes where instruments and their techniques must be quickly learned. Percussion methods courses, in particular, must cover a vast amount of information and instruments. Vital to that course and instrumental ensemble teaching is proficient playing of the snare drum, but casual observation of directors and educators seems to suggest that there is no uniform approach to teaching right/left hand sticking for rhythms. It is possible that in their haste to teach the perceived importance of rudiments, educators are forgetting to teach an appropriate and logical approach to rhythms that are not rudimentally derived. This is akin to teaching clarinet with no alternate fingering options. In some isolated contexts this is fine, but when cross-fingering issues arise within an authentic piece of music it becomes problematic. Some educators and method books (Feldstein & O'Reilly, 1988; Feldstein & O'Reilly, 1977; O'Reilly & Williams, 1997; Rhodes, Bierschenk, Lautzenheiser, & Higgins, 1991) concentrate on rudimental sticking and simply adopt an alternate sticking style, regardless of the rhythm. While this can develop use of the weaker hand and more complex patterns of sticking, it is not always conducive to the expression, nuance, and timbre that are desired for a

piece of music. Although these are method books for developing the former aspects, there is little information for transfer of sticking to a new piece. Often, students are left to their own devices to formulate solutions.

A method of sticking seldom stated ostensibly in method books is the “right hand lead” style, which places the right hand on strong beats and the eighth notes falling in between beats. The purpose of this is threefold: 1) the right hand (dominant in percussion) is always on the strong beats, ends of phrases, etc. 2) in sets of sixteenth note derivations, there is always a running eighth note pulse in the right hand; and 3) the timbre is more consistent because (usually) more notes are being played with the right hand. Although more research is needed to attest to this stance, it is proposed that the right hand lead style is something that should be taught within the percussion methods course for use in future and present ensemble instruction.

Because right hand lead sticking is a skill that future music educators should possess, and because it can be acquired through visual and pattern imagery, it is a prime example of a motor skill that can be used to explore schema theory and motor learning within music. The general purpose of this paper, therefore, is to explore the effects of the contextual interference hypothesis on the acquisition, retention, and transfer of right hand lead sticking.

Motor learning hypotheses and related literature are outlined in the beginning of Chapter Two. The chapter continues with an overview of the contextual interference hypothesis that is central to this study. Research on laboratory experiments is discussed, followed by real-life applications of the hypothesis and rationale for its existence within motor skills. The chapter continues with a section devoted to music and motor skill interaction. This section traces the marriage of motor skills and music throughout time, beginning with origins in the beliefs of early educators who advocated the combination of music and movement. Beliefs of mental imagery in relation to learning music are also discussed. The section ends with the more modern research

that links musicians and their skills with structure and events in the brain. Once the relationship between music and motor skills is established, the possibility of combining the contextual interference hypothesis and music is discussed, with regard to seminal research. Aside from possible treatment effects of the contextual interference hypothesis, there are many other variables that may factor into music motor skill learning. These factors are also discussed in Chapter Two, with task complexity, age, gender, teaching methods, and practice techniques addressed. A laboratory learning hypothesis, the Kamin effect, and its ramifications on retention, are also presented. Finally, a section on the need for study reintroduces the right hand lead sticking and the possibility that differences in music performance specialty areas (woodwinds, brass, strings, voice) may affect the motor learning of this task.

CHAPTER 2

REVIEW OF LITERATURE

The Contextual Interference Hypothesis

Researchers in the fields of kinesiology and motor learning have proposed that the acquisition of schemata are largely dependent upon the interfering variables that occur when a skill is acquired. Shea and Morgan (1979) conducted seminal studies of contextual interference in motor learning. Using different spatial configurations, researchers had subjects knock down wooden barriers with tennis balls. Results indicated that the short-term speed of accomplishing the task was better for subjects who learned under blocked, repetitive conditions, or low contextual interference. Retention and transfer of the skill, however, were accomplished more successfully by subjects who had been exposed to a random sequence of practice, or high level of contextual interference.

Similar studies corroborate the findings of this research, which first labeled contextual interference. Kerr and Booth (1978) had previously examined the effects of blocked versus varied practice conditions. Sixty-four children were instructed on throwing tasks within a 12-week physical education program. Posttest evaluation, conducted in the last week of the program, revealed that varied participants performed the throwing task significantly better than blocked subjects.

Shea, Kohl, and Indermill (1989) also tested subjects in both blocked and varied environments. Subjects underwent an acquisition stage involving the production of force using their preferred hand. The task involved hitting a force transducer in an effort to raise a trace dot on an oscilloscope to various target lines. Acquisition performance was better for blocked participants than for varied participants. In retention tests occurring 24 hours later, all participants were tested in both blocked and varied conditions. The group that underwent varied

acquisition performed both varied and blocked tasks better than the group that underwent blocked acquisition. Researchers stated that "the benefits of blocked practice (low contextual interference) occur early in practice with response production becoming increasingly more rigid and inflexible. On the other hand, the benefits of random practice (high contextual interference) surface after initial practice" (p. 145).

Langley and Zelaznik (1984) suggested that phase practice (similar to varied practice) could produce better results in transfer than duration practice (similar to blocked practice). Subjects were asked to knock down three wooden barriers that were arranged in a reversed "Z" formation. While duration-trained subjects were asked to complete the whole task in an overall time period, phase-trained subjects completed the same task in three specified time intervals. The time intervals were different from each other, but added up to the total time of the other group. In a transfer segment, half of each treatment group participated in a duration transfer task, while half of each treatment group participated in a phasing transfer task. Phase-trained subjects and duration-trained subjects performed equally well on the duration transfer task; however, on the phasing transfer task, phase-trained subjects outperformed their duration-trained counterparts. Langley and Zelaznik suggested, as Schmidt (1985) had, that phase training is a subcomponent of duration training, and, thus, facilitated the flexibility necessary for higher order thinking within a novel transfer task. They also suggested a second hypothesis that phase-trained subjects experienced higher levels of contextual interference, as they were asked to learn three time periods within each trial.

Building upon the aforementioned study, Carnahan and Lee (1989) constructed a similar research design with a duration group, and "phase" groups of variable and constant timing segments. The variable group experienced three differently timed segments, while the constant group experienced three equally timed segments (similar to blocked timing practice). Results

indicated no differences between the two phase groups on transfer tasks, suggesting that the degree of contextual interference did not matter. Both phase groups did outperform the duration group, suggesting that the mere presence of segment training strengthened transfer performance. Although these motor skills deal with a time variable, the concept itself would seem to indicate that blocked and varied orderings of tasks may not matter as much as the fact that the mere presence of ordered or constructed time periods are present.

Until the early 1990s, research remained largely confined to laboratory studies or artificial tasks. Wrisberg (1991) placed contextual interference study in more realistic situations by testing badminton serves in a university physical education class. Thirty-two participants were assigned to four groups based on the amount of contextual variety involving long and short serves. Participants experienced a six week acquisition phase with 108 total serve trials. No data was taken during this practice time, however, due to time constraints. In the class meeting following acquisition, Wrisberg tested participants with 12 blocked trials of each serve. He found that retention accuracy was highest for subjects who were trained to alter their motor skills in the most varied of orderings. This group was significantly superior to two of the other three contextual interference conditions. Research findings did, in this case, hold up in the realistic scenario of classroom lessons and evaluation.

Most of these studies (Kerr & Booth, 1978; Shea, Kohl, & Indermill, 1989; Shea & Morgan, 1979; Wrisberg, 1991) hold that simple tasks are best learned under blocked conditions, but they are best retained and transferred when they have been acquired under varied conditions. This consistency of findings has come to be known as the contextual interference (CI) hypothesis. It seems that schemata formulated under varied conditions actually strengthen over time.

Researchers such as Schmidt (1975) have argued that a varied approach to skill acquisition forces the subject to create different strategies, alter motor skills, or use more active processing. Lee and Magill (1983) claimed that blocked practice facilitates subjects' use of knowledge of results (KR), which offers immediate subject feedback and guides subsequent repetitions. In a varied practice environment, KR cannot be used immediately to alter a repeated task. Because the tasks are constantly changing, they must be assessed and performed through cognitive problem-solving skills, and delayed use of KR.

This result is seen in research on aiming tasks (Anderson, Magill, & Sekiya, 2001). Using a pen-shaped stylus on a drawing board, participants were asked to use their nondominant hand to produce a smooth, continuous motion to a target location that was 80 millimeters from the starting location. Forty participants were randomly assigned to four groups based on KR presentation and the presence of a task-intrinsic feedback source of a spring. Group size (n = 10) was equal and each group contained equal numbers of males and females. Participants in two of the groups performed the 80 acquisition trials without the spring attachment and were provided KR either after each trial (Delay 0) or after a delay of two trials (Delay 2). The other half of the participants had use of the spring attachment and also received KR either after every trial (Delay 0 SPG) or after a delay of two trials (Delay 2 SPG). Groups receiving immediate KR (Delay 0, Delay 0 SPG) had significantly more accurate acquisition trials; however, the same groups performed significantly worse on retention tests of 40 trials after a 24 hour period. Groups with the task-intrinsic feedback of the spring attachment (Delay 0 SPG, Delay 2 SPG) also scored significantly worse in performance on the retention test. Interestingly, there was a significant interaction between delayed KR and no spring action. This group (Delay 2) performed significantly better than the other three groups. In this study, feedback that came immediately or within the task itself, produced quick and guided results, but did not yield long range success.

Research into knowledge of results has produced several theories to support the success of varied practice in contextual interference research. The elaboration hypothesis (Shea & Morgan, 1979: Shea & Zimny, 1983) states that a more random ordering of tasks provides comparisons of results, which uses “more distinctive and elaborate memory representations” with “variable information processing strategies” (p. 187). The reconstruction hypothesis (Lee & Magill, 1985, 1983) claims that the process necessitates a productive “forgetting” of the motor skill program, resulting in a subject reconstruction of the task at each repetition. Over time, this strengthens and concretizes the knowledge. This raises the question of whether the contextual interference hypothesis might hold up in music performance research.

Expert musicians certainly seem well equipped to make use of their own knowledge of results. Within practice sessions, metacognition is displayed, as musicians use visual and aural representations for comparison of the target task and the performance (Hallam, 2001). Expert musicians “continually adjust the processes of planning, gathering information, forming hypotheses, making choices, and reconsidering decisions” (Hallam, 1997, p. 181).

Interaction of Music Performance and Motor Skill

Music is so interwoven with physical movement and the resulting knowledge of results that comes in visual, audible, and even kinaesthetic form; thus, it provides a highly applicable area for motor skill research. There is reason to believe that in the development of knowledge and schemata, movement should precede or accompany the conceptual learning process. Within the field of music, movement has been related to performance and memory, as Suzanne Langer (1953) stated that music was itself “virtual movement.” Kemp (1981) has suggested that musical activity fosters a more “feelingful” form of intelligence. Based on Cattell’s (1973) brain research, Kemp suggested that artistic people are superior in intelligence as a result of this “holistic” knowing. Certainly, it can be argued that musical training involves the cognitive,

affective, and psychomotor domains (Bloom, Englehart, Furst, Hill, & Krathwohl, 1956; Krathwohl, Bloom, & Masia, 1956; Simpson, 1972).

Music researchers (Taylor, 1989; Thackray, 1972; Van Zee, 1976) have adopted the idea that movement can indeed aid in the development of musical skills. The perception of muscular sensation, known as kinaesthesis, has been shown to significantly improve recognition and recall in musical identification tasks (Taylor, 1989). The idea of kinaesthesis is not new to music, however, as educators and researchers have long married the two in teaching methodologies (Deutsch, 1982; Gordon, 1971; Jacques-Dalcroze, 1921; Mursell, 1951; Seashore, 1938).

Jacques-Dalcroze (1921) claimed that experiencing music through the body provides the imagery that is necessary for musical memory. His formulation of Eurythmics stressed the function of movement and rhythm with regard to aural training and improvisation, and met with his personal philosophy that the human body is the first instrument. Mursell, Seashore, Gordon, and Deutsch made similar claims that even aural training can be enhanced by the imagery produced through kinaesthetic or motor skill perception. Gordon (1971) states, "Because music is an aural art, one must first acquire aural perception and kinesthetic reaction in order to develop musical understanding in a conceptual sense" (p. 60). Kemp (1990) summarizes these basic ideas, by stating,

> through whole-body experience we can know music and think music. The rationale is that the neuromuscular sensations involved in the making of sounds, or responding gesturally to sounds, become fused with the actual memory traces or image of the sounds themselves. In this way recall of sounds and musical thinking processes are multidimensional, producing a powerful amalgam of sensory/perceptual knowledge (p. 224).

The possibility that movement may aid in forming musical schemata explains why "muscle memory" can aid in musical automaticity. It is conceivable that the physical sensation of movement combines with musical sound and music imagery to create a synergistic effect, and produce an increase in music motor skill. Similar thoughts pervade research that combines motor

skills and various forms of imagery (Halsband, Binkofski, and Camp, 1994; Heuser, 1998; Shaffer, 1982, 1984). Shaffer (1984, 1982) studied how motor programs and imagery interact with cognitive skills and memorization to produce automaticity over time. Uniquely, he has transferred his ideas from motor skills to music performance.

Shaffer (1982) discovered that in typing, sequences of key presses are controlled by what Davidson and Correia (2002) deem "timing profiles across performances of the same word sequences" (p. 238). Shaffer's (1982) conclusion was that the generalized motor program was inevitably a major influence on the typists' productions of words. Reminiscent of schema formation, Shaffer's theory holds that movements occurring in different fingers or limbs can overlap throughout time and successive motor movements; however, they are organized around fixed events or reference points. In typing skills, fingers are constantly beginning the movements toward new keys. This is often done quickly and efficiently through memorized and frequently used patterns of key presses. Other, lesser-known patterns or the beginnings of words or phrases may serve as reference points. Similarly, in music events, one can commit to memory those shorter music motor tasks, such as rhythmic patterns. The reference point may be the start of the rhythm or a stressed note in the pattern. Of this, Shaffer states,

> Subsequences of movements may become organized as a group if they occur frequently or have a short time scale. We can thus think of a compound movement-trajectory, which includes the movements for several motor events, launched from a common reference point and articulated on an internal schedule. In this case the motor program can specify the onset of the first event and leave the motor system to compute the internal schedule (p. 112).

His last sentence seems to allude to the thought that formation of schemata in motor skills can allow for automaticity or muscle memory that can take over in situations. This, as Heuser (1998) has stated, can allow the mind to focus on other things, such as harder tasks or reference points.

In another study, Shaffer (1984) concluded that pianists' small deviations from the pulse occurred as a result of these same motor features. He examined performances of a Chopin study

that pitted three notes in the right hand against four in the left hand. Shaffer determined that it was possible for performers to deviate from the beat in small groupings, while maintaining an overall framework of correct tempo throughout the larger whole of the piece. For these performers he concluded that the organization of familiar patterns within the brain often resulted in clusters of groupings within the larger task of a lengthier performance. Because the performer recalled and performed these smaller series of notes as a whole unit, they gave phrasal interpretation and nuance to the smaller note grouping. With the technical familiarity of these patterns, the performer could turn the motor skill of rhythmic consistency over to automaticity, and focus more on interpretation. As a result, adherence to the beat source within the groupings suffered slightly. Attention at the temporal reference points, however, allowed for overall correct timing within the entire excerpt. Shaffer summarizes this, stating,

> a timekeeper providing a superordinate time reference allows the hands timing independence, makes it computationally easier for procedures serving each hand to arrange the movement timing for their respective subdivisions of the beat, and allows one or the other hand to make planned excursions away from the beat, lagging or leading it (p. 584).

Mental imagery is so pervasive in music as it is seen in the patterns of notes (diatonic, arpeggiated, etc.), the clustering of chords, and the groupings of rhythms. Investigations by Shaffer indicated that subjects tend to group rhythms based on barring and spacing, and have an internal "sound schema" for rhythms to which they have long been exposed. Similar observations exist in other research that combines mental imagery and music (Halsband, Binkofski, and Camp, 1994; Heuser, 1998).

Heuser (1998) outlined the importance of motor skill acquisition to musicians, stating that technical drills are the key factor in acquiring quick and efficient physical responses in performance.

> The real importance of such deliberate practice...rests not in directly observable improvements in fluency and execution but in the contribution drill makes to the

> development and refinement of the mental representations of motor control strategies and action plans that are the foundation of performance skills (p. 144).

In using drill to develop technique, Hallam (1995) revealed two techniques that have emerged. One involves the repetition of material with a gradual increase in tempo to that of the target. The other technique involves repetition with some alteration to the material, such as articulation or rhythm. Hallam (1995) and Miklaszewski (1989) also found that expert musicians commonly alternated between fast and slow tempos. Drill, combined with alterations such as this, may allow the performer to turn his or her attention to other musical and artistic tasks (Heuser, 1998).

Halsband, Binkofski, and Camp (1994) agree that musical drill can create mental imagery and musical schemata that may be accessed during times of decision-making and problem solving. They found that the way notes were grouped, articulated, or accented had an impact on transfer to new music. In essence, the visual layout of music within musical drill might foster or inhibit the acquisition of schemata and motor skill reliance.

Despite evidence to the contrary, Adams (1987), in his review of literature, states that mental imagery in isolated motor skill learning has not been proven as successful. Because there is evidence that mental imagery can positively affect music skills, and because music performance is so tied to motor skills, this presents a syllogism that suggests imagery can have a positive effect on motor skills. Reading and interpreting music notation is another factor in the complex motor skill of music performance; however, it may also be a factor that would allow mental imagery to indirectly enhance motor learning.

Scientifically, Altenmuller and Gruhn (2002) describe music performance as a combination of motor skills that have been acquired, stored, and maintained, and an auditory feedback process used to monitor progress. In describing the brain of musicians, they call this combination a “highly developed auditory-motor integration capacity, which can be compared to

the oral-aural loop in speech production" (p. 69). It is thought that prolonged practice of musical motor skills may enlarge certain sections of the brain. Schlaug, Jancke, Huang, and Steinmetz (1995) have found brain differences that exist between musicians and nonmusicians. *In-vivo* imaging has shown that increases in corpus callosum (CC) size commonly appear until the middel of the third decade of life, with maximum increase during the first decade of life. Motor skill development is thought to improve gradually from ages 4 to 11 years, which corresponds with this maximum CC growth. In this study, 30 professional musicians and 30 matched control participants underwent *in-vivo* magnetic resonance morphometry. It was shown that professional pianists and violinists had a signficantly larger anterior portion of the corpus callosum than their nonmusician counterparts. There was also a significant difference in anterior callosum size between musicians who had begun musical training earlier and those who had begun training later. Since previous data have evidenced a correlation between larger callosum size and number of cross fibers in the CC, it is also hypothesized that there is greater interhemispheric communication within the brains of musicians. Schlaug, Jancke, Huang, and Steinmetz state,

> Thus, during the development of the CC and especially of its anterior part 'environmental' factors such as intense bimanual motor training of musicians could play an important role in the determination of callosal fiber composition and size. This, then would fit well within a concept of cerebral plasticity as an adpative structural-functional process following changes in stimulation intensity (p. 1054).

Additionally, by monitoring nerve cells involved in sensory stimulation, Elbert, Pantev, Wienbruch, Rockstroh, and Taub (1995) found that violinists possess enlarged sensory areas that correspond to the index through fifth fingers of the left hand. Using nine musicians (six violinists, two cellists, and one guitarist) and six nonmusicians, researchers applied stimulation to participants' fingers in the form of light pressure from a pneumatic stimulator. Magnetic source imaging showed that the center of cortical response for the left hand was significantly shifted in the brains of musicians as compared to those of the control group. Cortical

representation of the left hand digits was also significantly larger for string players than for their control counterparts. The right hand and left thumb, which remain more static during string playing offered no differences in topographical structure or cortical strength from that of nonmusicians. Findings also revealed that the strength of cortical representation had a significant negative correlation with participants' age at the onset of playing. In other words, the highest strength of cortical representation was exhibited by participants who began their training at the earliest ages.

The individual ways in which humans acquire skills may be a product of the brain's structural differences; however, researchers are also looking at the influence of other issues. Jancke, Schlaug, and Steinmetz (1997) investigated hand skill asymmetry in professional musicians. They examined 31 keyboard and string players who were decisively right handed. They were compared and matched with three control groups of nonmusicians, including groups of 31 right handers, 31 left handers, and 31 mixed handers. Data from tapping tests and hand dominance testing revealed that "consistent right handers" (musicians and nonmusicians) demonstrated significant superiority in right hand skills as compared to the other groups. In comparison to each other, right handed musicians performed significantly superior to their nonmusician counterparts. Most notable, however, is that the asymmetry between right and left hands was significantly lower in musicians. In other words, their right and left hand scores came closer to equality than any of the other groups. Also of interest was a regression analysis that revealed a relationship between hand skill asymmetry and age of commencement of musical training. Lower assymetry scores were associated with lower age of commencement, producing a moderate negative correlation. The researchers hypothesize that early hand skill training combines with the cortical organization of hand motor dominance, leading to a marked increase in the performance of the nondominant hand. Because the existence of left or mixed handedness

is only slightly higher in musicians than nonmusicians, the researchers claimed that "the higher prevalence of left or mixed hand preference reported in previous studies may be due to increased skill of the nondominant hand as a result of early and intensive training" (p. 430).

All of this research seems to suggest that the central nervous system adapts to the task demands when training is prolonged. Researchers refer to these adaptations as "brain plasticity." There is evidence that the brain structure and plasticity of musicians may differ from that of nonmusicians. More research is needed to determine whether findings of brain research can be generalized to the population of musicians. That the generalized motor plan and individual recall schemata may have such different effects on musicians is yet another reason to explore the effect of movement on musical motor skill learning. Music's relationship with movement and mental imagery is difficult to define or measure, but attempts to do so may shed light on methods of teaching and learning in music.

Contextual Interference in Music

Virtually all forms of human musical performance are generated by the practice, retention, and transfer of skills; however, study of the CI effect is quite new to the field of music, and relatively few studies even mention the method of practice as it pertains to blocked or varied musical behavior. The association of practice and contextual interference is indirectly covered in a study by Lehmann and Ericsson (1997). The authors stated that,

> Mere repetition and experience lead to more fluent performance, but by themselves do not lead to the mental representations that experts employ (e.g., the difference between rote memorization and more complex internal representations of a piece of music that allow experts to adapt to different performance problems) (p. 56).

Duke and Pierce (1991) studied the effects of tempo and context on performance and transfer. Twenty-seven musicians practiced nine one-measure target tasks in a blocked setting until three errorless trials were achieved. They later performed these trials with varying tempi and in differing melodic contexts. Though practice condition was not isolated, results indicated

that performers' tempo accuracy and pitch accuracy were decreased by performance tempos and melodic material in new performance contexts. This follows the research of Sidnell (1986), who believed that motor programming of a pattern changes when performance is required at a different tempo from that at which it was learned (Mackenzie, 1986). Duke and Pierce (1991) suggested that teachers and researchers develop experiences that can foster students' transfer and application of knowledge to new situations. The overriding possibility in motor research is that practicing in varied contexts can provide improvements in facilitation of new contexts.

A similar method was used in research by Moore, Brotons, Fyk, and Castillo (1997). They tested 600 six to nine year old children to investigate the effects of repeated trials and other variables on learning a new song. Children listened to and sang back three different melodic phrases. Although they were given three chances to improve each phrase, almost half of the participants sang most accurately on their first attempts. In fact, researchers reported that children often repeated mistakes as opposed to making improvements on subsequent trials. If the blocked fashion of practice limits error correction and accuracy of subsequent performances, an increased variety in musical skill acquisition (or high contextual interference) may ultimately produce better retention and transfer. In regard to this research, it must be noted that the participants were novice performers, who may or may not have possessed the ability to produce a true assessment of their own knowledge of results. This would have inhibited improvement in subsequent trial improvement, rendering a harsh interpretation of the effects of blocked practice on music performance.

Pacey (1993) has attempted to answer the question by taking the concepts of schema theory and contextual interference and applying them to music practice. Pacey tested the acquisition of loudness, tempo (bow speed), and pitch in a small group of string players. The initial performance, which followed a period of varied acquisition, did not differ from previous

performances. Over the course of several observations, however, children showed greater improvement in loudness and tempo in their performances. This research supports the contextual interference hypothesis, which holds that motor skill retention and transfer should increase over time.

Variables Affecting Contextual Interference

There are numerous variables that factor into the acquisition, retention, and transfer of performance skills. One is the issue of task difficulty. Research in motor learning refers to classifications of difficulty as simple or complex in nature. Wulf and Shea (2002) maintained that simple tasks often include “only one degree of freedom, requiring comparatively small amounts of practice to reach performance asymptotes, and placing relatively modest demands on attention, memory, and/or processing capacity” (p. 185). These have traditionally been the type of tasks used for investigative purposes, as they eliminate subjectivity and offer ease within measurement constructs. However, as Shea and Wulf point out,

> if the goal is to understand motor skill learning in general and to provide recommendations for the training of motor skills in applied settings (e.g., in sports, music, or industry), it seems that more ‘complex’ skills, at least initially, pose greater challenges to the cognitive capacity of the learner (p. 185).

The study of complex tasks, though needed, has been largely absent in motor research, and its nature often defies clear and succinct definition. Some researchers have defined task complexity based on reaction time (Henry & Rogers, 1964; Klapp, 1995), movement time (Fitts, 1954), response errors (Schmidt, Zelaznik, Hawkins, Frank, & Quinn, 1979), or degrees of freedom (Bernstein, 1967). That all of these variables can drastically change with task requirements and participant expertise leaves researchers to contend that there is no one specific definition that can transfer to novel tasks without revision. Wulf and Shea (2002), therefore, loosely define complexity as tasks that cannot be mastered in a single session, have several

degrees of freedom, and are “ecologically valid.” Simple tasks, on the other hand, are acquired in one session and are largely “artificial” in nature (p. 186).

Naylor and Briggs (1963) stated that the organization and complexity of a task could be the determining factor in whether whole or part practice would be preferable. In this case, complexity was defined as the number of parts or components in a skill, as well as the information-processing demands of the task. Serving a tennis ball, learning a dance routine, and getting into a wheelchair are all complex; however, complexity does not always mean difficulty. The organization of a skill refers to the relationship among the component parts of a skill. When the parts are interdependent the way one part is performed depends on the way previous parts are performed. Independent tasks do not have component parts that influence the outcome of other parts. A dance routine or handwriting may be examples of this (Magill, 2004).

If the skill is low in complexity and high in organization, practice of the whole skill is the better choice; however, if the task is high in complexity and low in organization, part practice is usually more efficient. There are three common part practicing techniques. Fractionization involves practicing isolated limbs first for a task that is bimanual in nature. Segmentation involves separating the task into parts and then practicing one in isolation. After it is completed, it is combined with the next segment. This technique is also called the progressive part method or chaining. Simplification involves reducing the difficulty of the whole skill. This can be accomplished by reducing the difficulty of the objects, or by reducing the attention demands of the skill without changing the action goal. For skills having a rhythmic component, an auditory accompaniment can be prepared, creating an extra component of the skill. This extra component, however, can provide the necessary trigger for movement refinement. Yet another simplification process is reducing the speed of the task (Magill, 2004).

The complexity of tasks, as they relate to the research design, is of primary importance. Overall, the CI hypothesis has been shown to exist among simple motor tasks, but not in complex motor tasks or music motor tasks. Does this suggest that music performance is so complex as to be counterintuitive to the high retention and transfer accuracy achieved under varied practice? The case can be made that music performance is indeed a complex task. All performance involves motor skills of some variety, and instrumentalists, such as woodwind, piano, string, and percussion players must often contend with bimanual coordination. Because music often involves the reading and interpretation of written notation, the process of performance encompasses an added "step" in the motor skill process, only making the performance more difficult. Like a foreign language, the notation must first be decoded before it can result in physical movement. By these standards and the suggestions of Wulf and Shea (2002), even "simple" isolated rhythms may be complex as they involve several degrees of freedom. In the context of longer durations or more isolated segments, the music is seldom mastered in one practice session. When the context of an ecologically valid task is added, music certainly remains complex. More study is needed to understand how contextual interference affects music motor skill performance, retention, and transfer under arguably, and ever-present, complex conditions.

There is also evidence that motor skills may differ based on age. Gilbert (1980) tested 808 children who were aged three through six by administering the Motoric Music Skills Test (MMST). The MMST is made up of 44 test items, and measures motor music skills in five subcategories, including motor pattern coordination, eye-hand coordination, speed of movement, range of movement, and compound factors. Scores in all five areas were grouped according to participants' age in half years (3.0 to 6.5), yielding 40 data sets. Analysis showed that, with one exception, mean scores in all motor skill areas increased with age. The only exception within

these data sets was a slight decrease in the mean score of eye-hand coordination from the age of 6.0 to 6.5.

It seems apparent that music motor skills increase with age; however, this does not always mean that successful *practice* of music motor skills increases with age. The tendency to develop problem solving or practice strategies seems not an effect of musical proficiency (or of age, for that matter), as Cantwell and Millard (1994) found that both levels of learners existed in young, but technically skilled musicians. Costa-Giomi (2003) attributed high and low achievement among elementary piano students to cognitive ability, as they demonstrated more complex problem solving skills. Higher achievers were more apt to make corrections themselves, and required fewer instances of an external source for their knowledge of results. Although music motor skills may improve with age, success in their practice may be a more direct result of cognitive ability.

In regard to gender, Gilbert (1980) found statistically significant differences between boys and girls participating in her study. Girls performed significantly better on tasks that involved motor pattern coordination, eye-hand coordination, and compound factors. Boys, on the other hand, performed better on musical motor skill tests involving speed and range, although these results were not significant. There were no significant interactions between age and gender. Few would argue that there are inherent differences in physical abilities between genders. In assessing motor skills, Henry and Rogers (1964) found that the speed of arm movement among college men was significantly faster than that of college women.

There is also evidence that preferred method of teaching is affected by a student's gender. Phillips and Aitchison (1997) studied the effects of psychomotor instruction on elementary general music students' singing performance. Although this study dealt with dependent measures of respiration and singing performance, it yielded an observation that the breath-management

skill treatment was more effective for boys than girls. The researchers hypothesize that boys may be more motivated by exercises that use muscle control and more ostensible physical ability. This could mean boys' preferences to learning through motor skill involvement influences their ability levels on certain music motor skills.

Aside from task complexity, age, and gender, research has often included other factors that contribute to retention. Structure within the practice atmosphere is also the topic of a study by Palmer (1976). In this research, two classes were given rhythmic reading instruction based on the Kodaly-derived methods of Mary Helen Richards' *Threshold to Music* (1971). Two other classes were presented with an instruction series based on an approach from Edwin Gordon's *The Psychology of Music Teaching* (1971), while another two classes served as a control group. As expected, the classes receiving specific rhythmic instruction performed significantly better than the control classes on several rhythmic tests. There was no practical significance between the Richards and Gordon approaches. It seems that specific structured instruction certainly improved rhythm reading for students. Because the investigator was present in the four classes with rhythmic instruction, it is thought that some of the effect may be due to the engaging presence of a teacher.

Melodic music reading was the subject of MacKnight's (1975) research involving two different teaching styles. In this study, the researcher introduced pitch to 90 fourth grade beginning instrumentalists. An experimental group was taught using a series of tonal patterns, which mixed a novel pitch with other familiar tones to form a phrase. The control group learned pitches by identifying letter names, fingerings, and sounds. Results, measured by the Watkins-Farnum Performance Scale (1954), revealed that the tonal pattern approach was significantly better than the note identification approach for music reading and performance. This seems to

indicate that learning is enhanced when novel information is not only conceptual, but is embedded within familiar contexts and exists in ecologically valid scenarios.

Aside from learning new skills within a structured practice and a familiar, realistic context, there are other techniques and procedures that may affect performance success. Coffman (1990) studied the effects of mental practice, physical practice, and knowledge of results on piano performance. He defined mental practice as “the covert or imaginary rehearsal of a skill without muscular movement or sound” (p. 187). Coffman designed a pretest-posttest study, in which the performance material was similar, but not identical. Two halves of a piano selection served in a rotating fashion for a participant’s pretest and posttest material. Four types of treatment were used, including physical, mental, alternating physical and mental, and a motivational control. Analysis of the eighty participants’ pitch errors, rhythm errors, and performance time revealed that using physical practice alone, or in combination with mental practice, was superior to mental practice alone. Alternating physical and mental practice was essentially equivalent to exclusive physical practice. Coffman also notes that the structured practice, as alluded to in studies above, may have stymied participants’ need to concentrate on isolated problems. He also notes that the use of a metronome may have had a similar effect, limiting participants’ chances to alter tempo. Mental practice has also been discovered as a technique used by adolescent pianists who practice in greater, rather than lesser quantity (McPherson & McCormick, 1999).

Ross (1985) examined the effectiveness of mental practice on the performance improvement of college trombonists. In a pretest-posttest design, Ross measured the pitch, rhythm, and articulation accuracy of a stimulus etude. Results indicated that participants in a combined mental and physical practice state performed more error-free measures than the other practice groups: physical practice, mental practice, mental practice with slide movement, and no

practice. The researcher stated that participants were able to reap rewards of aural and kinesthetic feedback throughout both the physical and mental practice segments. Ross also states that when mental practice is followed by physical practice, it gives the performer the chance to think through music concepts and develop strategies for the identification of patterns. It is also noted that even with just mental practice, the trombonists improved their performance accuracy. It seems that mental practice combined with physical practice can be even more effective than physical practice alone.

The issue of visual rhythmic grouping has already been discussed with regard to musicians' mental imagery. In the context of practice, however, Gruson (1988) has made several observations according to skill level and experience. Quantitative and qualitative analysis of practice time revealed that significant changes in practice occur as musicians' skill levels increase. As a pianist's skill level increased, they played bimanual parts separately, practiced longer, and verbalized more. As skill level increased, the musician reported using more rehearsal strategies and more cognitively complex strategies. Additionally, an increase in skill level corresponded to more frequent repetitions of isolated sections. These sections also contained more notes than those sections practiced by less experienced counterparts. This supports the research undertaken by Bean (1937), who found that professional musicians could recall around five notes of an excerpt. Non-professionals, he stated, could only recall three, while beginners could only remember one or two notes. Bean attributed this difference to the recognition of melodic patterns by professionals, as opposed to the analytical, note-by-note attempts at musical memory by non-professionals and beginners. This skill in pattern recognition has been linked to success in sight-reading (Wolf, 1976). Gruson (1988) stated,

> Musical practicing may be viewed as a sequence of transitions from controlled to automatic processing in which larger and larger chunks of musical information are built up from more basic subcomponents….With practice, the associations between printed

> notes and manual positions become automatized and attention may be focused upon more complex musical patterns… (p. 108).

That skill level may produce the ability to recognize more and lengthier patterns seems to suggest that these musicians may have greater success at sight reading or novel tasks.

In terms of longer rehearsal frames, Hallam (1995) and Miklaszewski (1989) found that professional musicians used a majority of their practice time for holistic (whole practice), as opposed to serial (part practice). This, it was reported, was done to accomplish a better audible representation of the sound, and to bring to light performance problems that only happened in the context of full performance. In their study of 22 pianists of varying skill levels, Williamon and Valentine (2000) found that time spent practicing for a specific performance was not related to the quality of that performance. Performance success, however, was attributed to the length of music excerpts incorporated into the rehearsal session. This focus on segment length is consistent with the research of Wolf (1976) and Gruson (1988).

It should be noted again that the quantity of practice does not always predict the quality of performance (Costa-Giomi, 2003). Sullivan and Cantwell (1999) found that effective practice strategy among university instrumental and vocal majors was more an issue of the musician's ability to adopt more substantive types of practice. Higher-level learning was characterized by more cognitively derived strategies, such as altering speed, linking, prioritizing, and developing automated technique. Lower level learners exhibited rote learning, trial and error, and avoidance of error. Cassidy and Byo (2005) found that similar higher-level practice strategies existed among a small sample of university music majors. These more experienced players repeated sections, altered tempo, and isolated difficult areas. The authors point out, however, that not all of these techniques were used advantageously.

Shea, Lai, Black, & Park (2000) have postulated that practicing in spaced-out sessions across days can benefit the learning of motor skills. Closely related to this idea, researchers

(Fenn, Nusbaum, and Margollash, 2003; Nader, 2003; Walker, Brakefield, Hobson, & Stickgold, 2003) have determined that sleep may facilitate “the recovery and subsequent retention of material learned opportunistically at any time throughout the day” (Fenn, Nusbaum, & Margollash, 2003, p. 614).

Walker, Brakefield, Hobson, and Stickgold (2003) studied the effect of wake and sleep stages on long-term memory task involving finger tapping. During the acquisition phase, participants increased the speed and accuracy of the five element tapping sequence. Following acquisition, brain changes relative to the task continued, although at a slower rate. Such changes occurred through the six-hour time period that is known as the memory consolidation stage. It is at this point that a newly acquired motor skill becomes resistant to interference, provided no interference has transpired up to that point. Change in participants’ brains also continued through a period of sleep, allowing the motor skill to be enhanced upon waking with no further training. It is possible that rest may help consolidate, or concretize skill acquisition. Such research could offer tremendous insight into useful and efficient practice techniques. If these results hold in musical research, performance quality, regardless of acquisition conditions, may increase in some degree for all musicians.

The Kamin Effect

Also related to sleep is a trend in retention of skills, known as the “Kamin effect.” With its origins in laboratory animal experiments, the Kamin effect was discovered by Leon J. Kamin (1957). His idea holds that there is a curve in the retention process, whereby retention decreases after the initial conditioning and increases after the retention decline levels. Kamin discovered this after carrying out an avoidance response task among 57 laboratory rats. These animals were trained to move from one side of a shuttlebox to the other to avoid an electric shock that ensued after a set amount of time. After 25 learning trials, Kamin tested retention by using what he

coined as “relearning trials.” In this stage the rats underwent the same conditions, but in randomly selected groups tested at different time intervals following the initial learning stage. Kamin tested one group of ten rats immediately following learning, then tested four more groups of ten after half hour, hour, six hour, and 24 hour time span had passed. Finally, one group of seven was tested 19 days following the learning stage. Kamin reported that,

> The degree of transfer from original learning to relearning was a significantly curvilinear function of retention interval. The amount of retention declined significantly from 0 to 1 hr., then rose significantly from 1 hr. to 19 days. There was no significant difference between 0 to 19 days. The data were interpreted in terms of two independent processes: a forgetting process which reaches an asymptote by 1 hr., and an “incubation “ process (Kamin, 1957, p. 460).

These forgetting and incubation stages are reminiscent and certainly related to the hypothesized methods that Lee and Magill (1983) have described for recall of motor skills. Their “reconstruction hypothesis” holds that forgetting a task can result in the brain’s need to reconstruct schemata.

Kamin replicated his study in 1963 hoping to clarify the state of the retention curve and duplicate findings. Kamin first found a similar effect to his seminal research findings, with one notable exception that a six hour retention group had a retention rate similar to that of a one hour group. The one hour and six hour groups were not significant from each other; however the two groups were significant from all other groups, producing the signature curvilinear Kamin effect.

In a separate experiment within the same study, Kamin (1963) studied the thirty trials within each groups’ assigned retention time. He noted a “warm-up” effect within these sets, which were arranged in three blocks of ten. The warm-up effect showed that, frequently, groups experienced a decrement in their initial number of shock avoidances before “recovering” and increasing in number throughout successive trials. This trend would repeat again after every intersession break, with the initial mean avoidance score declining well below that on which it finished in the previous trials. The trend was consistent for every group. Aligned with former

research findings, however, the one hour group performed at a lower level, thus, exhibiting less visible "warm-up" effect. In other words, at the one hour time interval there seems to exist a low ceiling of retention that impedes the improvement seen in other timing groups.

The Kamin effect holds that retention functions in a curvilinear shape over time. From the point of skill acquisition, the retention accuracy of that skill continuously decreases until the time interval of one hour elapses. After this one hour "low point," the retention accuracy of the skill begins to increase over time, with improvements occurring as late as 19 days. The Kamin effect was replicated and further investigated in studies by Denny (1958), Denny and Thomas (1960), and Denny and Ditchman (1962). In the study by Denny and Ditchman (1962), 60 rats underwent similar conditions to the Kamin studies. Relearning, however, took place at intervals of 0 hr., .5 hr., .75 hr., 1 hr., 1.25 hr., and 1.5 hr. for the purpose of finding the "low point" in the short term retention interval that seems to approximate one hour. Denny and Ditchman found that retention declined from 0 hr. to 1 hr. and rose again from one hr. to 1.5 hr. Statistically speaking, the "low point" was located between the .75 hr. and 1 hr. mark, but considered close enough to be in line with the mark of one hour as the maximum Kamin effect. The researchers explain the shape of the curve by attributing it to anxiety rather than an incubation period for reconstructing the avoidance habit. According to a hypothesis by Bindra and Cameron (1953), anxiety may increase following learned trials, and can produce a "freeze" in ability. For rats, this may mean a manifestation of anxiety to the point that shuttling through their box was impossible. According to the hypothesis, after an hour, this anxiety dissipates and retention increases. As Kamin (1963, p. 718) states, "These experiments in general reinforce the notion that 1 hr. is the 'locus of maximal effect' in producing the curvilinear retention function..." Does the Kamin effect hold true in music scenarios where conditioning and punishment are not present?

Tallarico (1973) applied the effect to music by constructing a two part test. In the first part of the test, the forty participants listened to a melody that was played a total of five times. Each playing of the melody was preceded by a specific question involving musical aspects such as meter, pitch, dynamics, length, and rhythm. During the second portion of the tests, participants listened to sixteen melodic excerpts and were asked to indicate whether or not the melody was the same one used in part one of the test. The second portion of the test was administered to five groups of subjects after one minute, thirty minutes, one hour, six hours, and twenty-four hours. A phenomenon similar to that of the Kamin effect was observed, with a general increase in incorrect responses up to the one hour group. Following this group, incorrect responses decreased with groups who were tested after more than one hour. Different from the Kamin (1957) study, however, was the fact that the thirty minute group and one hour group had similar numbers of errors.

Tallarico's (1973) study is referenced in Wilson's (1980) study on the effect of sleep and time on music memory. Of Tallarico's work, Wilson points out that it involved recognition memory of facts and concepts. He states that there is no present indication that the Kamin effect may apply to a musical task; however, Wilson notes that recall memory is a part of music performance, although it may be a more complex form. Wilson's study itself concerns music performance, and while it is concerned with the Kamin effect, the primary focus of the study was that of a sleep effect. For some cases, it was impossible for the researcher to isolate the Kamin effect from the confounding variable of sleep, and its possible role in memory and retention. Wilson also acknowledges that the small number of subjects used in the study makes for cautious generalizations. He did find, however, that there was evidence to support a Kamin effect within tasks learned under waking conditions. For these subjects, who learned immediately after waking (as opposed to right before sleep), there was an increase in retention from the 24 hour to 72 hour

interval. This late increase, Wilson claims, may be due to the fact that the highly complex recall task may necessitate a longer time interval for the Kamin effect to appear. Although Wilson's study takes the Kamin effect into consideration, it is not a time replication of the original, and it was done with limited numbers of participants. Tallarico's study, although a design replication of Kamin's, was done with a music recognition task. At the present time, there has been no music study that attempted to link the Kamin effect with music motor skill using a design replication of the original study.

Need for Study

Schema theory and contextual interference, as they relate to task difficulty, age, gender, teaching methods, practice efficiency, and the Kamin effect remain sparse subjects in music research; yet, their potential to enhance our practice methods and time efficiency is promising. Because the right hand lead sticking style is not arbitrary, but rather conducive to mental imagery and movement schemata, it is a prime example of a musical motor skill, which may be used to measure the effects of contextual interference.

The present research is motivated by several aspects. Foremost is the need for practice efficiency. Teachers and students are continually constrained by time, especially at the university level where instrumental techniques courses require proficiency within a matter of weeks, or even days. This is the case in percussion techniques, where a plethora of instruments, techniques, equipment, maintenance, and literature must be negotiated within a semester. Skills, such as rudiments and right hand lead sticking, can be relegated to mere concepts with little experiential learning. When this occurs, students seldom retain knowledge, and fail to perform the skill with accurate consistency. That "learning by doing" can enhance performance skill is an idea related to contextual interference; how we "learn by doing" is the question that drives this line of research. Evidence suggests that a varied approach to learning fosters more successful retention

and transfer of a simple motor skill. As Wulf and Shea (2002) point out, there is a need to investigate whether the CI hypothesis occurs in complex tasks. There is also reason to believe that the visual image and imagery of notated music, although rendering a music task even more complex, can facilitate in the acquisition of schemata requisite to skill stabilization. It is also possible that the Kamin effect can be a factor in retention of a motor skill, and that musicians with certain applied areas may be more adept at acquiring, retatining, or transferring these motor skills. More research is needed to answer these questions and tie the resulting information together. We may then find that the format of long-standing music practice traditions are in question, and that there is a possibility that new findings have the capacity to change the way we practice and the way teach others to practice.

Although there are many factors at play in the study of music and motor learning, the process of teaching two-handed sticking patterns brings to light yet another issue that may influence the acquisition, retention, and transfer of students who are learning this novel motor skill task. That is the issue of bimanual motor involvement within past experiences of the applied area. While most woodwind, string, and piano players are used to bimanual coordination on their instruments, vocalists are largely devoid of any finger, hand, or arm movements that are requisite to performance technique. Their overt movements remain primarily gestural, and may be considered gross and phrasal, compared to instrumentalists whose movements must consist of fine motor skills and note-by-note movements. On the continuum between bimanual instrumentalists and vocalists are brass players, whose movements are primarily dominated by the use of one hand. Although motor tasks, such as tuning motions, muting, and instrument stabilization are carried out with the secondary hand, these tasks remain ancillary in technique and movement to the dominant hand, and are ostensibly different from the tasks carried out in virtual equivalence by bimanual performers. Given these descriptions of motor movement by

various musicians, it is conceivable that past and existing music motor skill practice may influence the way new motor skill tasks are learned, or the degree to which they are successfully retained or transferred.

The purpose of this study, therefore, is to measure the effects of contextual interference practice conditions on the acquisition, retention, and transfer of a percussive motor skill task among university musicians. Other research questions include the following: Is the Kamin effect a factor in retaining knowledge? Are there any differences in the motor skills acquisition, retention, and transfer of this task with regard to applied area and the status of these areas as a bimanual, unimanual, or nonmanual concentration?

CHAPTER 3

MATERIALS AND METHODS

Participants

Participants were 120 music majors at Louisiana State University (LSU). Most participants were directly affiliated with the music education department of the school, with a large majority majoring in music education. As such, participants were a sample of convenience from defined populations. The remaining participants had either experienced music education instruction at the college level prior to changing their music concentration, or they were music performance majors with private teaching experience. Additionally, all had the required physical capabilities and musical understanding necessary for completing the study. Exemption from oversight by the LSU Institutional Review Board was granted (see Appendix A). All participants were given consent forms (see Appendix B), which were signed before taking part in the study.

Participants ranged from freshmen through doctoral students, and comprised 24 graduate students, 12 student teachers, 18 seniors, 30 juniors, 18 sophomores, and 18 freshmen. All principal instruments (applied areas) within the School of Music were represented with the exception of percussionists. Percussionists and those who had significant training in sticking patterns and percussive motor skills were not used due to the nature of the experimental task. The applied area counts were 25 woodwinds, 37 brass players, 46 vocalists, 6 pianists, and 6 string players. Half of the participants were male and half were female.

Materials

In order to teach participants a novel music motor task, materials were constructed and arranged for use in the study. Among these were ten rhythmic units as seen in Figure 1. Participants performed these rhythmic units to learn patterns that involved right and left handed (bimanual) sticking. As seen in the figure below, these patterns were written with with either an

"R" of "L" underneath each notes as a designation of the correct right (R) or left (L) sticking to be used.

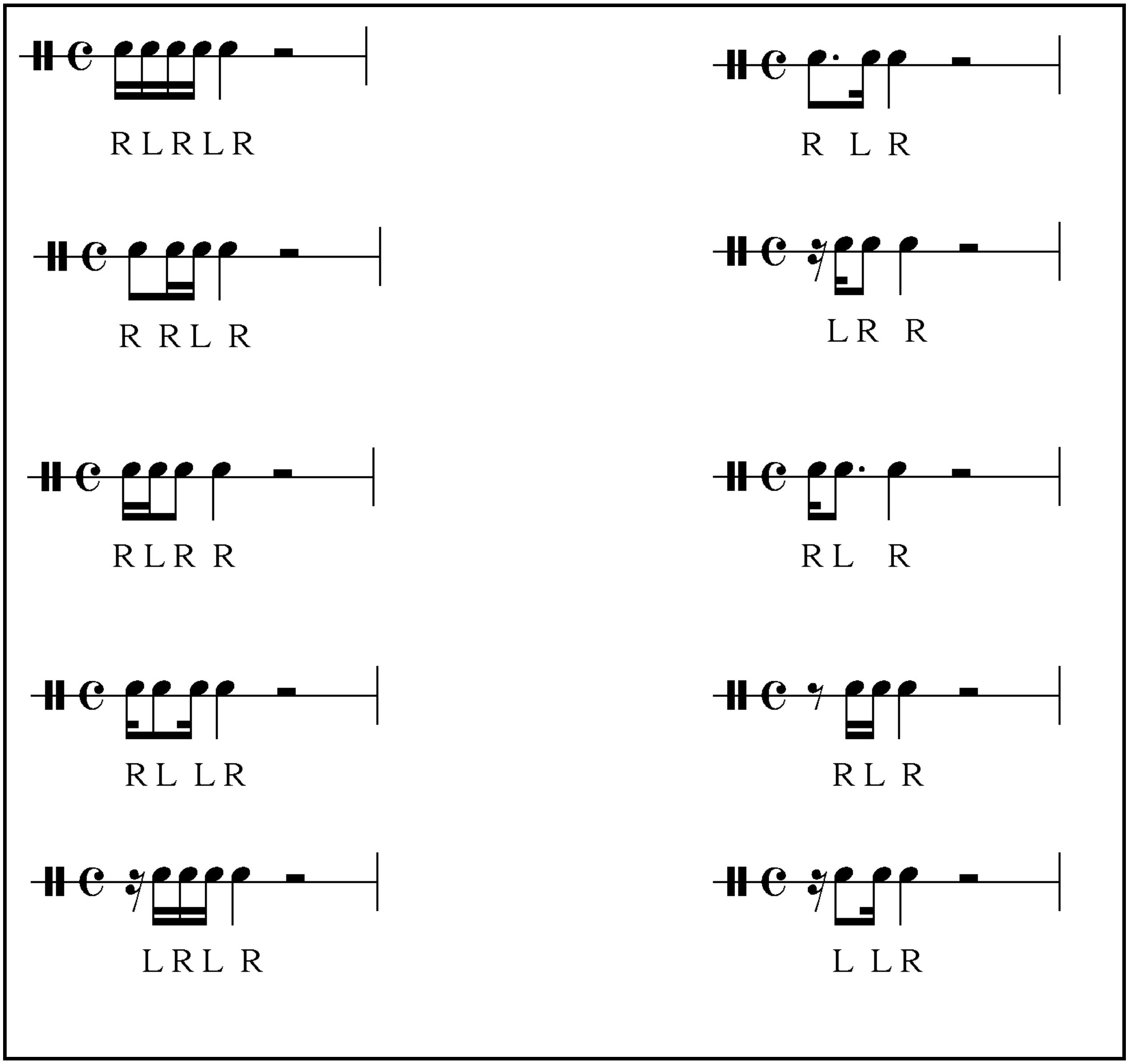

Figure 1. Basic Rhythmic Units

Excerpts and their corresponding sticking patterns were based on rhythmic derivations of one beat of four sixteenth notes in common time (the top, left unit above). Each rhythmic unit was visually displayed in the study as a one beat unit followed by a right-handed downbeat.

Overall, pilot tests revealed that the rhythmic trials were not so easy as to be immediately playable with accuracy at relatively faster tempo (72 beats per minute and higher); however, they were not so difficult as to be unplayable at a more moderate practice tempo of 68 beats per minute.

Rhythmic units for this study were chosen by taking every possible permutation of eighth or sixteenth values within one beat, with the exception of the rhythm of two eighth notes followed by a downbeat. The chosen rhythms were also validated as being usual rhythms in duple meter, based on their classifications in Gordon's (2000) *Rhythm: Contrasting the Implications of Audiation and Notation.* Purposefully chosen by the researcher, and serendipitously qualified by Gordon (2000), these rhythmic derivations of four sixteenth notes all involved two or three notes per beat, with the notable exception of the four sixteenth note rhythm. This "busier" rhythm, however, was the "inspiration" rhythm for producing the right hand lead style of sticking. Because it involved no rests, it was predicted that this "busier" rhythm would be no more problematic than other units in the study.

The aforementioned unit of two eighth notes followed by a downbeat was purposely left out because of its subjective sticking interpretations even within the right hand lead style of sticking, which is what participants learned in the study. Depending on tempo and note values being played, percussionists may play the unit as "right, right, right," which falls in line with right hand lead reasoning; however, many percussionists also interpret the rhythm with a sticking of "right, left, right." This same sticking, in fact, is often used to introduce beginning percussionists to bimanual patterns before they have learned sixteenth note values. The sticking in this context can be thought of as the right lead style applied to a rhythmic augmentation of two sixteenth notes. As a result of this thinking, some percussionists continue to use a "right, left,

right" approach when straight eighth notes are seen in isolation or in certain contexts, such as cut time or fast passages.

Independent Variables

Three contextual interference practice conditions served as one independent variable in the study. The three groups were labeled as blocked, varied, and control treatments, and were so named because of the different practice conditions in the study. Participants in the blocked group performed each rhythmic unit (see Figure 1) eight total times before moving on to the next one. After experiencing all ten units, this resulted in 80 total trials. Control for effect of order among rhythmic units was accomplished by using a counterbalanced approach; all permutations of trial order were spread randomly and equally among the participant pool. The first four trials for each rhythmic unit were executed with hand patterns provided; however, the last four trials were completed without the aid of these written patterns.

Participants in the varied group also performed these same rhythmic units for a total of 80 trials; however, they played straight through ten random orders of the rhythmic units eight times. Participants never performed the same rhythmic unit more than once in each set; however, congruent with the blocked group, they performed each unit eight total times. The blocked group performed four sets of the rhythmic units with sticking patterns provided and four sets without sticking patterns provided. For the varied group, the presence and absence of sticking patterns was presented in a varied fashion to eliminate any blocked effect. The first two sets of ten, however, were presented with sticking patterns so that participants could experience a minimum adequate exposure to the sticking. Beginning with the third set of ten, the presence and absence of hand patterns were alternated. The third, fifth, and seventh sets appeared with no sticking patterns, while the fourth, sixth, and eight sets contained the patterns. Ending with sticking

patterns kept the last set of rhythmic units from becoming a part of a blocked effect since the next phase of the study began with a set of ten rhythmic units without sticking patterns.

The decision to vary sticking patterns was driven by an attempt to polarize the blocked and varied practice conditions. Without some variation in sticking pattern presentation, there was an element of blocked practice in the varied group. The decision to vary pattern presentation also helped to equalize participants' exposure to posttest conditions, in which no sticking patterns were provided. Because the blocked group practiced blocked rhythms with blocked presentations of patterns and no patterns, they were exposed to pattern absence by the fifth trial of 80. Varying the pattern presentation for the varied group meant that these participants encountered an absence of written patterns by the 21st trial, or start of the third set. If, like the blocked group, they had seen sticking patterns in their first four trials for each rhythmic unit, the varied group would not have encountered an absence of hand patterns until the 51st trial.

Although exposed to an absence of sticking patterns sooner, the blocked practice group never saw the same rhythmic unit again after having practiced it in its block of eight trials. The structure of back-to-back trials may support findings by Shea and Morgan (1979), who stated that this structure may increase blocked participants' accuracy in acquisition phases. The varied group had to wait slightly longer for the absence of patterns; however, due to the varied presentation of sticking patterns, this group had a chance to review each rhythmic unit's corresponding sticking as late as the eighth and final set of trials. It should also be noted that varied participants encountered each of the ten rhythms only once in each set. This allowed no chance for immediate correction; however, this practice condition may give insight into the knowledge of results hypotheses (Lee & Magill, 1983; Shea & Morgan, 1979; and Shea & Zimny, 1983), which attempted to explain varied contextual interference retention.

The control group in this experiment was allotted a set amount of time to acquire skills; this predetermined amount of time of 12 minutes approximated the total acquisition time required by the blocked and varied groups in a final pilot study. In this respect, the control group was similar to the duration-trained subjects from the Langley and Zelaznik (1984) and Carnahan and Lee (1989) studies. In the present study, control participants were left to their own devices, with no implied practice segments, timings, or orderings. The control group was presented with two hard copies of the rhythmic units. One page contained all ten of the rhythmic units with hand patterns provided, while the other page contained the ten rhythmic units without patterns.

The number of excerpts and trials in this study for blocked and varied practice groups were based on previous research (Anderson, Magill, & Sekiya, 2001; Duke & Pierce, 1991). The number of trials in both this and the model studies compared with other similar motor skill research. It should be noted that while Shea, Kohl, and Indermill (1989) found that the contextual interference effect increased with increased practice, Sekiya, Magill, and Anderson (1996) found that performance was not affected by the amount of practice. Pilot studies were conducted to test for appropriate trial count in this research. Trial count was gauged in an effort to avoid using too few trials, which produces fragile knowledge, and to avoid overlearning, which is the continuation of practice beyond the amount needed to achieve a certain performance criterion. While Driskell, Willis, and Copper (1992) reviewed fifteen research studies related to overlearning, and concluded that it had a positive influence on retention, overlearning was not desirable in this study. Avoidance of excess practice beyond that which was deemed necessary served to ensure that any effects on retention and transfer were a function of contextual interference and not overlearning.

The second independent variable involved the timing of posttest retention and transfer tasks. In order to investigate the effects of time away from practice on skill memory, participants

were equally divided into four groups labeled according to their respective posttest latency times of thirty minutes, one hour, six hours, or twenty-four hours. Time frames were chosen based on previous Kamin effect research (Denny, 1958; Denny and Ditchman, 1962; Denny and Thomas,1960; Kamin, 1963, 1957; Tallarico, 1973). The 120 participants were equally divided among the 12 treatment groups formed by these two independent variables (blocked, varied, and control practice conditions by thirty minutes, one hour, six hours, and twenty-four hours latency).

Because the performance specialty area was considered a factor that may have affected participants' abilities to learn a new motor skill task, applied area served as the third independent variable. These applied areas were condensed into bimanual, unimanual, and nonmanual categories. Bimanual musicians consisted of woodwind, string, and piano players who are accustomed to bimanual coordination on their instruments (n=37). Unimanual musicians were brass players whose movements are primarily dominated by the use of one hand (n=37). Nonmanual musicians were vocalists, who do not have to use any finger, hand, or arm movements that are requisite to performance technique (n=46).

Other variables, such as gender and education level were controlled for in the subgroup assignments, but were not analyzed. In the case of gender, previous studies (Gilbert, 1980; Henry & Rogers, 1964; Phillips & Aitchison, 1997) made no mention of differences in rhythmic ability between males and females. Other music differences attributable to gender, such as preference of motor skill emphasis in instruction (Phillips & Aitchison, 1997), are related to the use of motor skills in this study; however, the preference of instruction has no bearing on participants' viable treatment options. Other gender differences outlined in studies (Gilbert, 1980; Henry & Rogers, 1964) referred to strength and child development. The present study is not concerned with motor skill strength or child development. Rather, it is concerned solely with the rhythm and pattern

accuracy of a motor skill task among university musicians. It was therefore decided to forego any investigations into gender differences. Control for gender, however, was accomplished within the study as each subgroup contained equal amounts of males and females.

Education level was controlled within the design of subgroups as equivalent numbers of freshmen, sophomores, juniors, seniors, student teachers, and graduate students were placed in every subgroup. Education level was not investigated as an independent variable, however, since all practice and performance tasks were made up of rhythms considered basic and simple at the college level. Pilot testing seemed to indicate that there would be no differences in the rhythmic ability required to complete the study.

Considering the three independent variables, as well as control for threats to internal validity, the participant design yielded twelve subgroups, as seen in Table 1. These subgroups were organized and identified by name of treatment group and Kamin effect timing, with each subgroup of ten counterbalanced with regard to applied area, gender, and education level.

Procedure

Centered around the ten rhythmic units, this study consisted of four phases: a pretest, an acquisition phase, a retention and transfer task, and a posttest, which included a second retention and transfer task. Throughout all phases of the study, participants played on drum pads with provided mallets. To begin the study, participants were introduced to the drum pads with the opportunity to experiment with mallet grip and playing technique. All participants then completed a pretest to verify that there were no preexisting differences in rhythmic capabilities. Participants were asked to perform each of the ten rhythmic units at a tempo of 68 beats per minute using any sticking pattern they preferred. In an effort to control for possible effect of order, the list of rhythmic units was decided by drawing numbers in a random sampling without

replacement. The researcher giving verbal prompts of "one, two, three, four" before the start of each unit.

Table 1: Participant Subgroups

Kamin Effect Time	30 Minute			1 Hour			6 Hours			24 Hours			Totals
Treatment Group	Blocked	Varied	Control	Blocked	Varied	Control	Blocked	Varied	Control	Blocked	Varied	Control	
Nonmanual	4	3	4	4	4	4	4	4	4	4	3	4	46
Unimanual	3	3	3	3	3	3	3	3	3	3	4	3	37
Bimanual	3	4	3	3	3	3	3	3	3	3	3	3	37
Applied Area Totals	10	10	10	10	10	10	10	10	10	10	10	10	120
Male	5	5	5	5	5	5	5	5	5	5	5	5	60
Female	5	5	5	5	5	5	5	5	5	5	5	5	60
Gender Totals	10	10	10	10	10	10	10	10	10	10	10	10	120
Freshmen	1	2	1	2	1	2	2	1	1	1	2	2	18
Sophomores	2	1	2	1	2	1	1	2	2	2	1	1	18
Juniors	3	2	3	2	3	2	2	3	3	3	2	2	30
Seniors	1	2	1	2	1	2	2	1	1	1	2	2	18
Student Teachers	1	1	1	1	1	1	1	1	1	1	1	1	12
Graduate Students	2	2	2	2	2	2	2	2	2	2	2	2	24
Education Totals	10	10	10	10	10	10	10	10	10	10	10	10	120

The pretest process was designed to isolate participants' rhythmic capabilities and ensure that rhythm reading ability was not an unintended variable of the study. It also revealed that rhythmic and pattern accuracy was equivalent among groups from the beginning of the study. The pretest also ensured that no participants had extensive experience and/or a high accuracy rate of the right hand lead style of sticking. While some participants had been exposed to the right hand lead style of sticking, they were not able to apply it with consistency in a sight-reading or performance atmosphere. If a participant did not perform one of the rhythms accurately, he or she was coached on the rhythm using only rhythmic syllables. No sticking patterns were

discussed. If, after a reasonable amount of time, it was determined that a participant was not capable of consistent and accurate rhythmic production, s/he was dismissed from the study. This was the case for one participant, who was replaced with another musician of an identical profile.

The ideal participant for this study would have rhythmic command over all ten units, but would be naïve to or inexperienced with the performance of right-hand lead sticking. It was anticipated that participants would play some pretest rhythms with appropriate sticking patterns due to the nature of rhythms that could correspond with an alternating bimanual pattern; for instance, some participants with no right hand lead experience approached all rhythms in an alternating “right-left” fashion, which was the correct pattern for half of the ten rhythmic units in this study. If stressed notes were taken into account within an alternating sticking, participants sometimes played other rhythms correctly as well. For instance, participants sometimes played a pattern of an eighth note followed by two sixteenths correctly by employing a right-left alternating pattern. Although naïve to right-hand lead sticking, their interpretation of the dominant hand could make a correct pattern. Therefore, it was decided that participants would play no more than seven patterns correctly to continue with the study. As an added measure of control, each situation in which the participant played more than five patterns correctly was investigated to make sure that the patterns were not learned or committed to memory through prior practice. These investigations resulted in four participant dismissals from the study. In two cases, participants were graduate students and full-time teachers, who worked very closely with their high school percussion sections and drumlines. A third participant was a vocalist, who had extensive experience in high school percussion. The fourth was a brass player, who had studied right hand lead sticking to learn the correct patterns of a complex rhythmic part within an instrumental music score he was conducting. These participants were replaced with other musicians of identical profiles.

Following the pretest, all participants began the acquisition stage of the study in his or her assigned treatment group. Participants were first introduced to or reminded of the concept of right hand lead sticking. Although many participants were aware or had learned of this sticking in a conceptual way, most could not perform the process with a high degree of consistency. This lent credence to the MacKnight (1975) study, which stated that in learning melodic notation, a pattern, as opposed to an identification approach, was best. In the present study, the concept of right hand lead sticking was introduced or reviewed at the beginning of the acquisition phase. It was followed by presentation of the objective, which was for the participant to memorize the right hand lead sticking patterns that corresponded to the ten rhythmic units. All of these instructions were followed with active practice of sticking patterns embedded within familiar rhythms, which provided a framework for the formation of schemata.

For blocked and varied treatment conditions, the rhythmic units were practiced within a researcher-constructed practice schedule. Practice of the rhythmic units was done with verbal prompts from the researcher (as had been done for all participants in the pretest). During the acquisition stage, these numerical count-offs were the same as the pretest; however, they followed a strict timing that began two beats following the completion of the rhythmic unit's quarter note (see Figure 2). This process ensured that both blocked and varied treatment groups received equal amounts of time in performance and visual study of the rhythms and patterns.

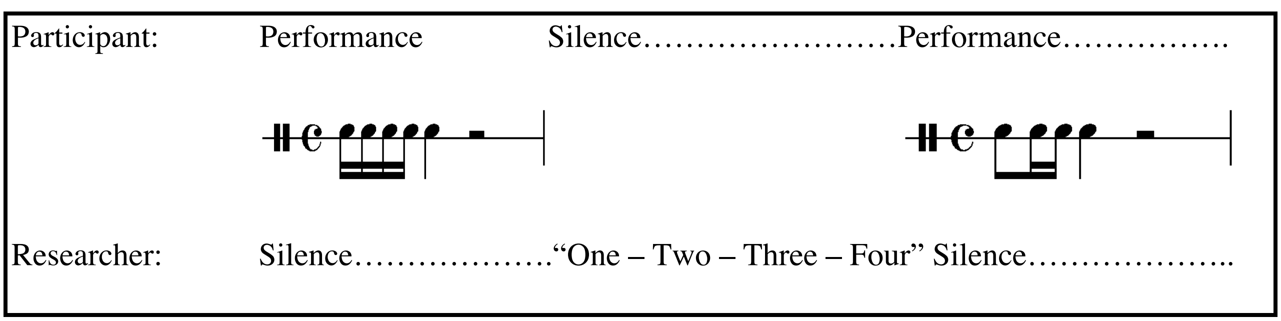

Figure 2. Example of Verbal Prompts and Performance

Throughout the acquisition phase (described in the previous section), blocked and varied participants played with the metronome sounding 68 beats per minute. The researcher gave prompts for the start of each trial in an attempt to give adequate rest periods for eye and hand adjustments and to avoid both mindless repetition and overanalysis of the trial. Tempo for the study was decided following pilot studies, and was carefully chosen to be slow enough to forego additional task complexity, yet fast enough to necessitate some degree of automaticity over time and trials.

Unlike the blocked and varied groups, the control group used the total time of acquisition in any manner they chose. This included the use of sticking patterns and the use of the electronic drum machine. Participants were also provided a stopwatch for knowledge of practice time. The control group was issued a traditional metronome during the acquisition phase. They were advised of the target tempo of 68 beats per minute during acquisition, and were informed that subsequent retention and transfer tasks would be performed at this same tempo. Control participants were allowed to use the metronome at any tempo during acquisition, and had the options of using the metronome continuously, intermittently or not at all.

The researcher was present with these participants during their practice time for the purpose of equalizing conditions and controlling necessary media. Control subjects were also given the opportunity to cease practice before their 12-minute time limit if they so desired. This decision was made in an effort to simulate real practice conditions, in which musicians may opt to terminate the session when they believe they have mastered the objective.

Five minutes after the completion of acquisition, all participants completed a short-term retention and transfer task. The retention task consisted of performing each of the ten rhythmic units once. For the purposes of comparison, all participants completed the same pretest order of the ten units. As with the pretest, no sticking patterns were supplied in the music during retention

tasks. All participants were asked to adhere to the same computer metronome setting of 68 beats per minute, with strict verbal cues given by the researcher.

The transfer task (see Figure 3) was constructed to be of increased difficulty, with an implied, continuous pulse (no stops other than observed rests) and longer series of back-to-back rhythmic units. The task was meant to be an ecologically valid step that simulated the transfer often expected of students. For instance, there is always a point at which students must apply an isolated concept, such as scales, rhythms, etc. to a new context of an etude, solo excerpt, or piece of music. It was also meant to be a simulation of music that students might encounter in percussion parts of music literature. The transfer was constructed to feature each of the ten rhythmic units approximately two times, with the exception of the four sixteenth note rhythm. This rhythm occurred more often, and appeared at the start of phrases and measures so that the participant could gain solid rhythmic footing and establish a probable mistake-free right hand lead beginning.

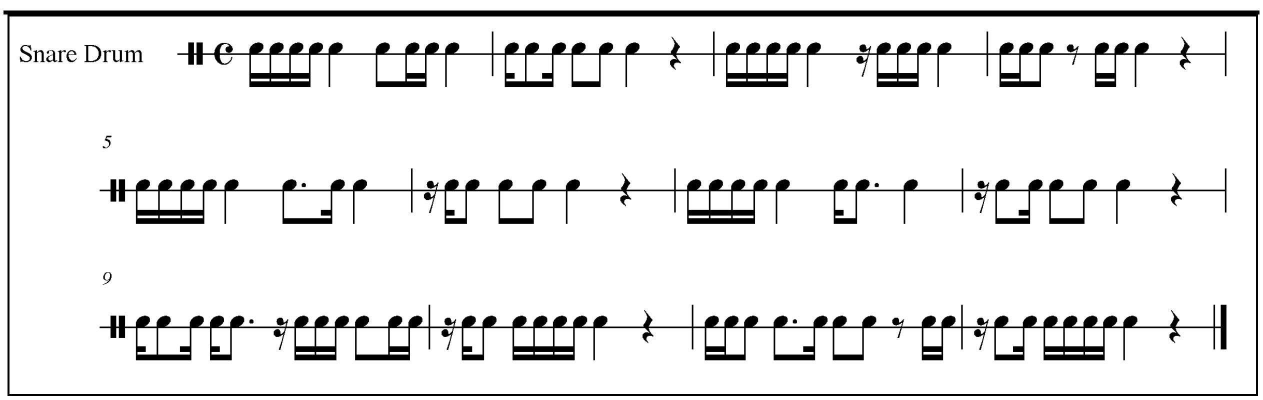

Figure 3. Transfer Task

The transfer task included the two eighth note permutation that was intentionally left out of the rhythmic unit acquisition phase. It was included because of its relative rhythmic ease within the more complex nature of the transfer task. Its placement as a “winding down” to the

phrases offered participants a short mental and visual break to the transfer without breaking the excerpt into series of awkward rests.

The transfer task was approached much like common sightreading tasks. Participants were given 45 seconds to look over the music (an average of 5 seconds per measure). During this time, participants could perform simulated practice (air sticking, quiet body movements), but that no audible sounds or contact with the drum pads could be made. Following the 45-second study period, the researcher gave a verbal count off for the participant to begin the transfer task performance. Together, the pretest, acquisition, retention, and transfer phases took approximately 25 minutes for each participant. This also included timing for all instructions, transitions, and participant acclimation, as well as the five-minute latency period prior to the retention and transfer.

Following the initial retention and transfer task, participants completed a posttest, which served as a second retention and transfer task. This was conducted following participants' assigned latency timings of thirty minutes, one hour, six hours, or 24 hours. The timings of these last retention and transfer tasks were developed to produce insight into the role of the Kamin effect on music motor skill accuracy.

The posttest retention test was a randomly selected order of the ten rhythmic units so that order sensitivity from the pretest and first retention task did not become a factor. The posttest transfer task for participants (see Figure 4) was a rearranged version of the first transfer task. All participants followed the same procedures in the posttest retention and transfer tasks as those used in the first retention and transfer tasks. The posttest phase of the study took approximately five minutes for each participant. Not considering their posttest latency periods, overall, each participant spent around 30 minutes of time involved in the study.

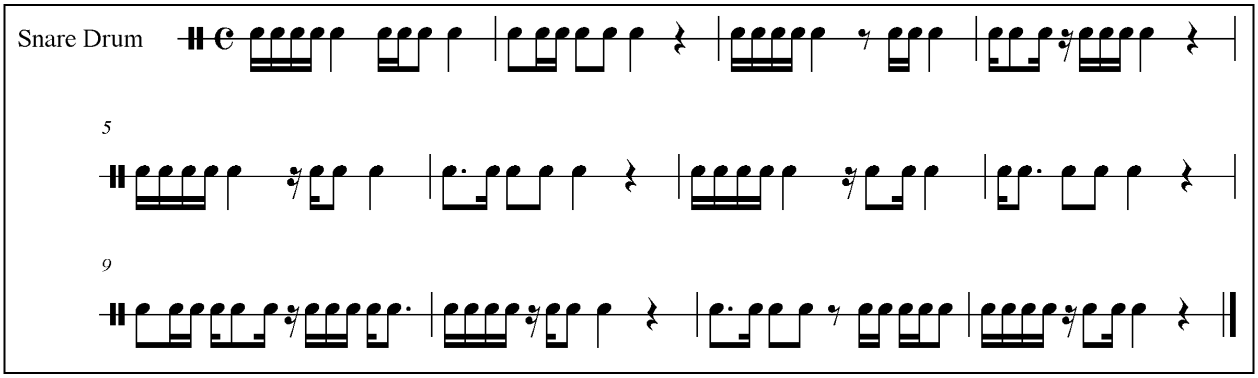

Figure 4. Posttest Transfer Task

Equipment

All rhythms, their corresponding patterns, as well as instructions for all facets of the study, were viewed by participants on a 900 MHz Macintosh iBook (version 2.3) computer placed at eye level. All groups, including the control group, read identical descriptions of right hand lead sticking and the objective of learning the sticking patterns that corresponded to the rhythmic units. Control participants practiced from hard copies of the rhythms, and were not exposed to the PowerPoint presentation for their acquisition trials; however, they did read initial instructions from several slides. Despite necessary differences in the instructions regarding practice conditions, the terminology and phrasing used among the three groups were kept consistent. Examples of the presentations with slides of instructions and music are seen in Appendix C, D, and E. Appendix C contains the entire presentation for control participants, while Appendix D and E contain a representative segment of the structure of respective blocked and varied practice conditions.

Participants performed using mallets on two electronic MIDI drum pads. One pad corresponded to the participants' left mallet, while the other was used for the right mallet. Each hit on the left drum pad was recorded in notational software as a "D" below bass clef, whereas

each hit on the right drum pad was recorded as an “F” below the bass clef. The resulting notation file provided visual proof of sticking pattern accuracy. Although the pads produced different sounds and notes, they were not plugged into a speaker; thus, they did not produce audible electronic sound to the participants. Audible feedback was obtained by the actual sound made when the mallets struck the pad. This was a familiar sound often made by drum practice pads.

The electronic drum machine used was a part of the iED01 Ion Electronic Drum Kit, which can be seen in Appendix F. Sold in electronic stores as a beginner level electronic drum set, it comes with five pads and two pedals that may be programmed to produce any combination of 230 percussion sounds. For this research, the two pads used were programmed to respond at the softest, and most sensitive, velocity setting. Pilot tests showed this allowed for the recording of soft playing, which many participants seemed to favor. Data from the drum machine was transferred to computer through the use of a Midisport 2 x 2 interface. This was connected to the drum machine with a Music Instrument Digital Interface (MIDI) cable, and connected to a dedicated 900 MHz Macintosh iBook (version 2.3) with a Universal Serial Bus (USB) cable. MIDI data was received, recorded, and notated by sequencing software with recording and editing capabilities. Additionally, the software also contained a metronome that could be heard by participants in all facets of the research, and can be heard in all playback modes to aid researchers. A traditional metronome was also be used by control participants in the acquisition phase of the study so that it could be easily manipulated.

The Ion electronic drum pads were chosen following work with several other options in small pilot studies. The researcher first experimented with the recording software using a Roland PC 200 MIDI keyboard controller. Participants were asked to strike two keys that served as rights and lefts within the hand patterns. A higher key equaled a right hand, while a lower key equaled a left hand. While the controller affirmed the validity of the software, use of the

keyboard raised concerns for ecological validity. Although the keys were of standard piano size, they were small for the comfort of some individuals' hand taps. This relegated all participants to using one finger on the keys for accurate measurement of rhythms. Consideration was given to removing keys from the keyboard controller, leaving only two keys to depress (one for each hand). While this would have eliminated the unintentional contact with other keys, it did not alleviate other problems. The nature of the keyboard is such that upon initial contact with keys, participants would have to further depress the key and allow it to lift back up to its rest position. Often, participants ended up "playing backwards," leaving keys accidentally depressed, and lifting up only to play the rhythm. This distorted the notation recorded on computer. All of this extra movement inherent to keyboard playing also created audible sounds that were fractions of seconds later than the rhythm produced; therefore, there was no precise keyboard contact sound that participants could use as knowledge of results. Although these aspects are normal for traditional keyboard playing, they interfered too much with knowledge of results and ecological validity in this study. The use of electronic drum pads eliminated all of these concerns, and approximated a task normally encountered in a music setting.

Use of finger or hand taps was originally entertained based on motor skill and sleep research that measured hand pattern accuracy, velocity, or reaction time (Klapp, 1995; Shea, Kohl, & Indermill, 1990; Walker, et. al., 2003; Wright & Shea, 1991). Finger or hand patterns had also been used in most of the previous research combining music and motor skills (Duke & Pierce, 1991; Halsband, Binkofski, & Camp, 1994; Pacey, 1993; Shaffer, 1984). In most cases, this was due to the fact that participants were practicing motor skills in which finger and sticking patterns were an integral part of playing an instrument. Finger and hand taps were also considered for this study in an effort to avoid participants' unfamiliarity with stick grip, and because of the potential for mallet technique to become an obstacle to performance accuracy;

however, after selecting the electronic drum machine for the study, it was decided that participants' use of mallets would make the task more ecologically valid, despite their lack of familiarity with technique.

Studies in the motor skill area have also required participants to complete a task involving a somewhat novel motor skill motion. Sekiya, Magill, and Anderson (1996) had subjects track visual stimuli on a computer screen using a traditional mouse. Studies by Fitts (1954) and Schmidt, Zelaznik, Hawkins, Frank, and Quinn (1979) had participants strike metal plates with a stylus. Much like the mallet motion in the present study, these tasks primarily involved use of the wrist and lower arm to control another instrument.

Pilot studies for the current research revealed that motor skills are adequately transferred to the novel task of sticking by participants who are already immersed in what can be generally defined as "musical" gestures and movement within their own music performances. As such, participants were shown an appropriate mallet grip at the beginning of the study. This was done within the initial instructions, and participants were allowed to experiment with the mallets and drum pads until they were comfortable with the technique. As such, physical discomfort or mallet technique should not have been a factor in their performance.

Heavy xylophone mallets were chosen for this study because of the weighted core end, which produced increased leverage and velocity for the player. This was necessary for securing response on the Ion drum pads, which did not respond as well to lighter drum sticks, despite the softest velocity setting. To counter this problem, pilot testing was done with higher quality Roland virtual drums and pads. In these tests, the sensitivity of the Ion drum pads exceeded that of the more expensive and higher end "v-drums." It should be noted that while most electronic drum kits and higher level models are billed as responsive to even hands, in this case, they had

difficulty in picking up hand and finger taps and softer playing of any type. In the current research, heavy xylophone mallets alleviated this problem.

Dependent Variables

Participants' rhythmic accuracy and sticking pattern accuracy scores were recorded for all phases of the study. These raw data were converted to percentages, and constituted the dependent variables. These percentage scores included rhythmic and sticking pattern accuracy on a pretest, an acquisition phase, initial retention and transfer tasks, and posttest retention and transfer tasks. Pretest accuracy scores, as well as both retention task scores, were the percentages obtained when the number of correct trials was divided by the total number of ten trials. Acquisition accuracy scores for blocked and varied treatment groups were the percentages obtained when the number of correct trials was divided by the total number of 80 acquisition trials. Since control participants spent their acquisition time in free, self-organized practice, their data were analyzed separately. Their use of practice time was analyzed descriptively by observing videotapes of their acquisition phases. Since both transfer tests contained 24 of the rhythmic units, accuracy scores for all participants were the number of correct units divided by the 24 total correct units. It should be noted that although the permutation of two eighth notes was used during the transfer task, it was not on the list of ten rhythmic units, and it was not considered for rhythm or pattern accuracy.

Each pretest, acquisition, and retention trial was scored objectively as either correct or incorrect based on the proper hand patterns and rhythmic interpretations within the required metronome marking of 68 beats per minute. Rhythm and sticking pattern accuracy were scored using the musical notation generated from the Cubasis (1996) music recording and editing software. When necessary, the rhythmic values displaced in the notation file were quantized to the nearest sixteenth note value. Comparisons of these objective measures to casual observation

analyses revealed that rhythmic inaccuracy was often masked by the player's nuance, phrasing, and interpretive stress of the unit. For the purpose of grading each unit objectively, a "one" was scored for a correct trial, and a "zero" for an incorrect trial. If the rhythmic pattern was correct, the rhythmic accuracy was scored as correct, regardless of pattern used. Likewise, if the sticking pattern was correct, the pattern accuracy was scored correct, regardless of rhythm.

Scoring by unit was selected since the goal for the task was to see and perform the combination of notes as a rhythmic unit. This method of scoring was influenced by the method used in the Watkins-Farnum Performance Scale (1942) and by ideas set forth by Watkins (1942). In this test, a measure was the unit of scoring; thus, an entire measure was counted wrong regardless of whether the student made one mistake or multiple mistakes within the measure. The same scoring procedure applied in this study, with the unit of scoring being the rhythmic unit's rhythmic pattern or sticking pattern.

Even though all performance tasks were assessed by the rhythmic unit, visual imagery changed for the transfer task as rhythmic units occurred in succession and thus appeared closer together. It was presumed that the units had been acquired and recalled using schema organized in a one beat hand pattern. Because the transfer task involved so many back-to-back rhythms, it was performed by many participants with numerous stops and starts, and more rhythmic and pattern mistakes throughout. As such, the analysis of the notation for this task was much more subjective, and necessitated several other guidelines employed for grading the transfer task.

A rhythmic error was assigned to a unit if it followed an incorrect number of rests or if it fell in the wrong place in context with the preceding rhythm. In these cases, pattern accuracy was not affected by rhythmic placement. When a rhythmic placement error was imposed on a unit, succeeding rhythms were based on the performer's newly established beat. For instance, if a phrase was to start on beat one, but the participant began it on beat four, only the rhythmic

accuracy of the first unit was penalized. The ensuing units were graded as correct as long as they fell in correct timing relative to the penalized unit. In many cases, participants added a downbeat to the rhythmic units, as had been called for in previous pretest, acquisition, and retention trials. In the transfer tasks, this downbeat was often left out in lieu of another immediate unit. In this case, the first unit was counted as rhythmically correct, while the second unit usually required rhythmic penalty. This occurred when the second unit was to consist of a rest on the downbeat, but was played as a note on the downbeat. Again, pattern accuracy was not affected by these rhythmic grading procedures.

Additionally, there were subjective decisions that could not be qualified as objective by mere use of the software. Some participants became disoriented within the task and left out large chunks of material, or repeated them over and over. When material was repeated or there were "start overs," the units were graded up until the point where activity first ceased. Any subsequent attempts to perform the same material were overlooked by the researcher. In other words, there was no consideration given to second attempts. Grading of units resumed when participants picked up with the "new" material never before played. In these cases, the first unit was rhythmically penalized to be consistent with the aforementioned rules. Appendix G contains representative examples of participants' performance notation, as well as examples of what constituted correct or incorrect rhythm and accuracy.

All participants' sessions were videotaped for possible further analysis and use as a backup data source. An audio recording was also transferred straight from drum machine to a stereo cassette tape; thus, the programmed sounds of the drum machine could be heard, indicating aural proof of pattern and pad usage. These tapes were consulted only as a backup data source since the audio sound contained no recorded beat source reference or metronome

sound. For most participants' performances, the software notation provided objective evidence of accuracy, and was used as the primary data collection source.

There were four participants, however, for which the computer failed to work in some way. For three of these four cases, the computer metronome failed to give audible sound to the participant. These performances were still generated as music notation in the computer software; however, the playing did not correspond directly to the internal metronome beat because control participants used an external, traditional metronome. Therefore, most, if not all, rhythms were displaced in the software's visual notation. For grading purposes, the videotape was used to assess rhythmic accuracy with the traditional metronome; the software notation was used to assess sticking pattern accuracy and lend support to the rhythmic accuracy assessment. In the fourth case, the computer failed to intake any sound from the drum machine on one participant's pretest. In this case, the videotape was used as the primary data source for the pretest information.

Although most data were very objective, the human interpretation of it created instances of subjectivity. For this reason, interobserver reliability was completed for 15 percent of the files. One file from each of the twelve subgroups was randomly chosen for reliability purposes. The case involving the computer failure was then added to ensure that the more subjective videotape analysis was reliable. Finally, another five files from the remaining 107 participants were chosen. Reliability was conducted by a doctoral music education student, who was advised of all grading procedures and rules. After these raw scores were recorded, rhythm and pattern reliability quotients were calculated for the more objective portions of the study, which consisted of pretest, acquisition (blocked and varied), and retention tasks. These parts of the study consisted of purely isolated rhythmic units. Rhythm and pattern reliability numbers were also generated for the more subjective transfer tasks, which consisted of back-to-back rhythms. Calculated using the formula

agreements divided by agreements plus disagreements (Van Houten & Hall, 2001), reliability resulted in the following quotients: pretest, acquisition and retention rhythm r=.99, pretest, acquisition, and retention pattern r=.98, transfer rhythm r=.97, and transfer pattern r=.96. An overall reliability of r=.98 was achieved.

Since control subjects were able to practice as they desired in the acquisition phase, their playing produced data that were not comparable to those of the blocked or varied practice sessions. Because the researcher did not structure control practice sessions, and because "accuracy" was unable to be determined, they were analyzed using the data obtained by videotape. Of interest in the control groups was the use of time with regard to physical and mental practice that was explored in Ross' (1985) study. Although impossible to qualify what seems to be mental practice, it is possible to quantify time spent in active, simulated, and passive states of practice.

The control group acquisition phases were analyzed using Scribe 4.1 software (1994). Using this software, the observation session can be directly linked with a media display that is either external (such as a television) or internal (such as a CD-ROM file). Scribe depicts the frequency, sequence, and duration of each recorded behavior according to codes selected by the user. The software was set up to accommodate six mutually exclusive categories that defined the state of practice for participants at any given time. Categories included active practice, simulated practice, and passive practice; each of these was considered with the condition of the metronome on or off. If the metronome was audible in any way, practice was categorized as "metronome on." If the metronome was off or was muted, the practice was categorized as "metronome off."

Active practice was defined as the participants striking the drum pads with mallets, as they would in other facets of the research task. Simulated practice was defined as using body, arm, hand, or stick movement to approximate the task. Most often, participants used the sticks or

hands to tap on their legs. Passive practice was defined as any time spent while not engaged in the other two categories. During most of this time, participants seemed to engage in mental practice, while at other less frequent times, they seemed to take a break, aloof to the task at hand. Regardless of the ostensible focus of attention, it was impossible to say whether or not the participant was engaged in mental practice. For instance, visual attentiveness to the music did not mean the participant was concentrating on the music or task. Likewise, visual inattentiveness to the music did not mean the participant was not mentally engaged in the task. Therefore, all practice not qualified as active or simulated was considered as passive.

Categories of practice were recorded upon the participants' changes of behavior. The one exception to this rule was during active or simulated practice. Observation of participants' active practicing revealed that many practiced the rhythmic units much like they were asked to play the retention task (with six beats in between). Other participants continuously moved from pattern to pattern, which required time for eye readjustment. Still others would not start the rhythmic unit unless they were mentally on "beat one" with the metronome. In most cases, participants were simply concentrating on a mental count-off or visual readjustment, and did not have time to engage in the mental problem solving practice that requires longer amounts of time. For these reasons, it was decided that active or simulated practice would continue as long as participants allowed no more than six beats to elapse between movements. If six beats did elapse, the category was automatically recorded as passive practice upon the seventh beat. The beat used for reference was either the metronome or the mental tempo being used by the participant when the metronome was off.

Whether or not participants were playing the rhythmic units was not taken into consideration, as some participants played rhythms and patterns of their choice to simply acclimate themselves to the motor skill of hitting the pads. When this was done, concentration

seemed to be more on stroke, distance, and velocity, as opposed to rhythm and pattern of specific units. This process was not considered as off task, and rather, was a vital part of performing the rhythms and patterns with success.

Because of the subjective nature of observation, interobserver reliability was obtained for 15 percent of the control participants' acquisition phases. Six videotaped acquisition phases were picked at random, with two of the segments lasting less than the 12 minutes allowed for participants. There was a total reliability observation time of 57 minutes and 24 seconds. A music education graduate student, who was advised of all observation techniques and software procedures, conducted reliability. The formula for duration reliability (Van Houten & Hall, 2001) was adapted to reflect observation of one category across the six participants (mean difference of the two observers' category timings divided by the number of cases. Reliability of practice categories resulted as follows: Active Metronome On (MD = 2.5 seconds, with a range of 0 to 12 seconds); Active Metronome Off (MD = 2.67 seconds with a ranges of 0 to 16 seconds); Simulated Metronome On (MD = 1.83 seconds with a range of 0 to 5 seconds); Simulated Metronome Off (MD = 4.5 seconds with a range of 0 to 27 seconds); Passive Metronome On (MD = 4.17 seconds with a range of 0 to 16 seconds); and Passive Metronome Off (MD = 8.33 seconds with a range of 0 to 28 seconds). Overall reliability (MD = 2.88 seconds with a range of 0 to 28 seconds) was achieved among all categories. The total reliability observation time for these files was 57 minutes and 24 seconds, which equated to 3444 seconds. With a total of 144 seconds of observer difference, only four percent of this time was inconsistent.

Although data from the control group's acquisition phase was quantitative, there were also important observations to be made casually. Considering that the blocked and varied treatment groups practiced with a constant audible tempo, the control group was the only

treatment environment allowing for change within the beat source. Participants were able to turn off the metronome or change tempo settings at will. The way in which this practice tool was used may substantiate or refute suggestions made by Coffman (1990) concerning the limitations imposed by use of a constant beat source. Observation of control subjects' practice techniques may also give insight into their recognition of patterns with regard to skill level, as suggested by Gruson (1988). Since participants learned ten rhythms and patterns, half of which included more than three notes per beat, the approach taken by musicians of different skill levels was especially of interest.

CHAPTER 4

RESULTS

The purpose of this study was to investigate the effects of contextual interference on the acquisition, retention, and transfer of a music motor skill, and to investigate whether the Kamin effect was a factor on retention or transfer. All participants ($N = 120$) completed a pretest task that consisted of playing ten rhythmic units with mallets on drum pads, followed by an acquisition phase, where they learned sticking patterns that corresponded to the ten rhythms. There were three treatment groups within this acquisition phase, producing 40 participants in each group. Blocked participants repeated each of the ten rhythms eight times in a row, while varied participants performed eight random orderings of the ten rhythms. Control participants had 12 minutes to practice as they wished, and were able to use the drum pads and metronome as desired. Five minutes after the acquisition phase ended, all participants took part in a retention and transfer task, with the objective of employing the correct sticking patterns and rhythms. The retention task consisted of playing the ten isolated rhythms, while the transfer consisted of 24 rhythmic units arranged in a realistic excerpt with back-to-back units, rests, and phrases. Participants were also grouped according to four Kamin effect latency times: thirty minutes, one hour, six hours, and twenty-four hours. Following this time interval, participants completed a posttest, which included another set of retention and transfer tasks. Each treatment group had ten participants assigned to each Kamin effect timing, making twelve groups of ten. Each subgroup was counterbalanced according to gender, grade level, and applied area (nonmanual, unimanual, and bimanual)

Scoring for all tasks was accomplished by referencing the computer generated music notation. Rhythmic units were graded according to rhythmic accuracy and pattern accuracy. Rhythmic units were correct if the rhythm was played correctly; pattern accuracy was correct if

the sticking pattern was correct, regardless of rhythm. As units were counted correct or incorrect, they were assigned a respective number of one or zero for rhythm or pattern. For each task, these numbers were added and divided by the number of points possible to arrive at a percentage score. These data were analyzed using the Statistica 4.1 (1994) software. An *a priori* alpha level of .05 was selected for multivariate analyses within the study; however, in the case of univariate analyses, since their were two dependent measures, it was decided to use a more stringent alpha level of .025.

In order to determine whether there were any preexisting differences among the 12 subgroups in the study, rhythmic and pattern accuracy scores from the pretest were analyzed according to treatment group and Kamin effect timing (the basis for formation of subgroups). No significant differences ($p > .05$) were found (see Table 2). This indicated that groups were essentially equivalent from the beginning of the study in terms of their abilities to perform the given tasks.

Table 2: MANOVA Summary Table: Effects of Subgrouping (Treatment and Kamin Effect) on Pretest Rhythm and Pattern Accuracy Scores

Effect	Wilk's Lambda	*F*	df 1 (variable)	df2 (error term)	*p*-level
Treatment	.94	1.79	4	214	.13
Kamin Effect	.97	.53	6	214	.79
Treatment * Kamin Effect	.85	1.53	12	214	.11

In order to look at the immediate effect of treatment and applied area on rhythmic and pattern accuracy, a MANOVA with repeated measures was calculated using pretest, retention,

and transfer scores. As seen in Table 3, differences between rhythm and pattern accuracy were observed for the main effects of treatment [Wilks' Λ = .90, $F(4, 220) = 2.99$, $p = .02$], applied area [Wilks' Λ = .73, $F (4, 220) = 9.16$, $p < .0001$)], and task [Wilks' Λ = .12, $F (4, 108) = 200.14$, $p < .0001$). There were no significant interaction effects ($p >.05$).

Table 3: MANOVA Summary Table: Effects of Treatment, Applied Area, and Task on Rhythm and Pattern Accuracy Scores

Effect	Wilk's Lambda	*F*	df 1 (variable)	df2 (error term)	*p*-level
Treatment	.90	2.99	4	220	.02
Applied Area	.73	9.16	4	220	<.0001
Tasks	.12	200.14	4	108	<.0001
Treatment * Applied Area	.92	1.18	8	220	.31
Treatment * Tasks	.91	1.27	8	216	.26
Applied Area * Tasks	.94	.90	8	216	.52
Treatment * Applied Area * Tasks	.80	1.57	16	330	.07

Univariate ANOVAs (see Table 4) completed on separate rhythmic and pattern accuracy scores across treatment revealed no significant effect of treatment group on rhythmic accuracy [$F (2, 211) = 2.48$, $p > .025$] or pattern accuracy [$F (2, 211) = .005$, $p > .025$]. Mean percentage scores of rhythmic and pattern accuracy by treatment group can be seen in Table 5. All treatment groups achieved greater rhythmic accuracy scores than pattern accuracy scores. Control participants, although much less accurate than their counterparts on rhythm, were virtually equivalent in pattern accuracy mean scores.

Table 4: Univariate ANOVA Summary Table: Effect of Treatment on Rhythm Accuracy and Pattern Accuracy Scores during Pretest, Retention, and Transfer

Variable	Mean Square Effect	Mean Square Error	F (2,111)	p-level
Rhythm	1734.44	699.66	2.48	.09
Pattern	2.99	625.12	.004	.10

Table 5: Means Table: Treatment Groups Across Rhythm and Pattern Accuracy Scores during Pretest, Retention, and Transfer

Treatment	Rhythmic Accuracy Mean	Pattern Accuracy Mean
Blocked Treatment	84.13	59.93
Varied Treatment	83.96	59.73
Control Treatment	77.41	60.04

The univariate ANOVAs (see Table 6) for the main effect of applied area indicated significant differences in both rhythmic accuracy [F (2, 111) = 18.49, $p < .0001$] and pattern accuracy [F (2, 111) = 15.49, $p < .0001$]. Mean accuracy scores according to applied area status can be seen below in Table 7, and are graphically displayed in Figure 5.

Table 6: Univariate ANOVA Summary Table: Effect of Applied Area on Rhythm Accuracy and Pattern Accuracy Scores during Pretest, Retention, and Transfer

Variable	Mean Square Effect	Mean Square Error	F (2,111)	p-level
Rhythm	12937.93	699.66	18.49	<.0001
Pattern	9682.41	625.12	15.49	<.0001

Table 7: Means Table: Applied Area Across Rhythm and Pattern Accuracy Scores during Pretest, Retention, and Transfer

Applied Area	Rhythmic Accuracy Mean	Pattern Accuracy Mean
Nonmanual	70.19	49.91
Unimanual	87.73	65.96
Bimanual	87.57	63.83

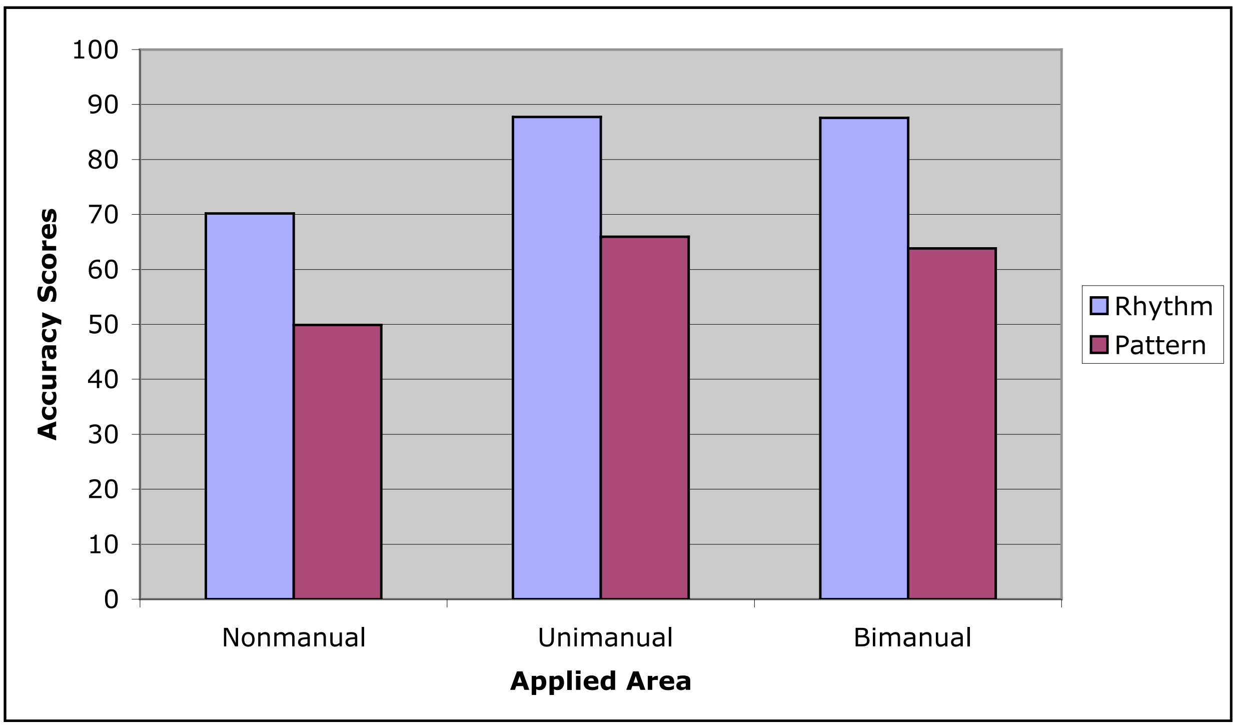

Figure 5. Rhythm and Pattern Accuracy Means by Applied Area during Pretest, Retention, and Transfer

Because there were significant differences in both rhythm and pattern accuracy according to applied area, post hoc analyses were conducted. Results of a Newman-Keuls post hoc test for

the effect of applied area on rhythm revealed significant differences. As seen in Table 8, these occurred between unimanual and nonmanual groups ($p < .001$), and between the bimanual and nonmanual groups ($p < .001$). There was no significant difference ($p > .05$) between the unimanual and bimanual groups on rhythmic accuracy throughout pretest, retention, and transfer tasks. As seen in Table 7 and Figure 5, rhythmic accuracy scores of unimanual and bimanual participants were equivalent, with nonmanual scores almost 18 percentage points lower.

Results of the Newman-Keuls post hoc test (see Table 9) for the effect of applied area on pattern also revealed significant differences. Again, these occurred between the bimanual and nonmanual groups ($p < .001$), and the unimanual and nonmanual groups ($p < .001$). There was no significant difference ($p > .05$) between the unimanual and bimanual groups on pattern accuracy. As seen in Table 7 and Figure 5, the mean pattern accuracy score of the unimanual group was only two percentage points higher than the bimanual group, while the nonmanual mean pattern accuracy score was nearly 16 and 14 percentage points lower than the unimanual and bimanual groups respectively.

Table 8: Post-hoc Analysis for Main Effect of Applied Area on Rhythm

Applied Area	Nonmanual	Unimanual	Bimanual
Rhythmic Mean	70.19	87.73	87.57
Nonmanual		.0001	.0001
Unimanual	.0001		.96
Bimanual	.0001	.96	

Table 9: Post-hoc Analysis for Main Effect of Applied Area on Pattern

Applied Area	Nonmanual	Unimanual	Bimanual
Pattern Mean	49.91	65.96	63.83
Nonmanual		.0001	.0001
Unimanual	.0001		.51
Bimanual	.0001	.51	

The univariate ANOVAs for the main effect of task (see Table 10) indicated significant differences in rhythmic accuracy [F (2, 111) = 52.37, p < .0001] and pattern accuracy [F (2, 111) = 450.17, p < .0001]. Mean scores of rhythm and pattern accuracy according to task are seen in Table 11 and Figure 6 below. As expected, the pretest pattern scores appeared quite different from the retention and transfer task accuracy scores on pattern. In general, there was an increase in accuracy on both dependent measures from pretest to retention task, and a decrease between retention and transfer tasks. In all cases, rhythmic accuracy was higher than pattern accuracy.

Table 10: Univariate ANOVA Summary Table: Effect of Task on Rhythm Accuracy and Pattern Accuracy during Pretest, Retention, and Transfer

Variable	Mean Square Effect	Mean Square Error	F (2,111)	p-level
Rhythm	6759.70	129.08	52.37	<.0001
Pattern	111931.00	248.64	450.17	<.0001

Table 11: Means Table: Task Across Rhythm and Pattern Accuracy Scores during Pretest, Retention, and Transfer

	Rhythmic Accuracy Mean	Pattern Accuracy Mean
Pretest	84.19974	25.73082
Retention Task	87.91998	85.36375
Transfer Task	73.37136	68.61221

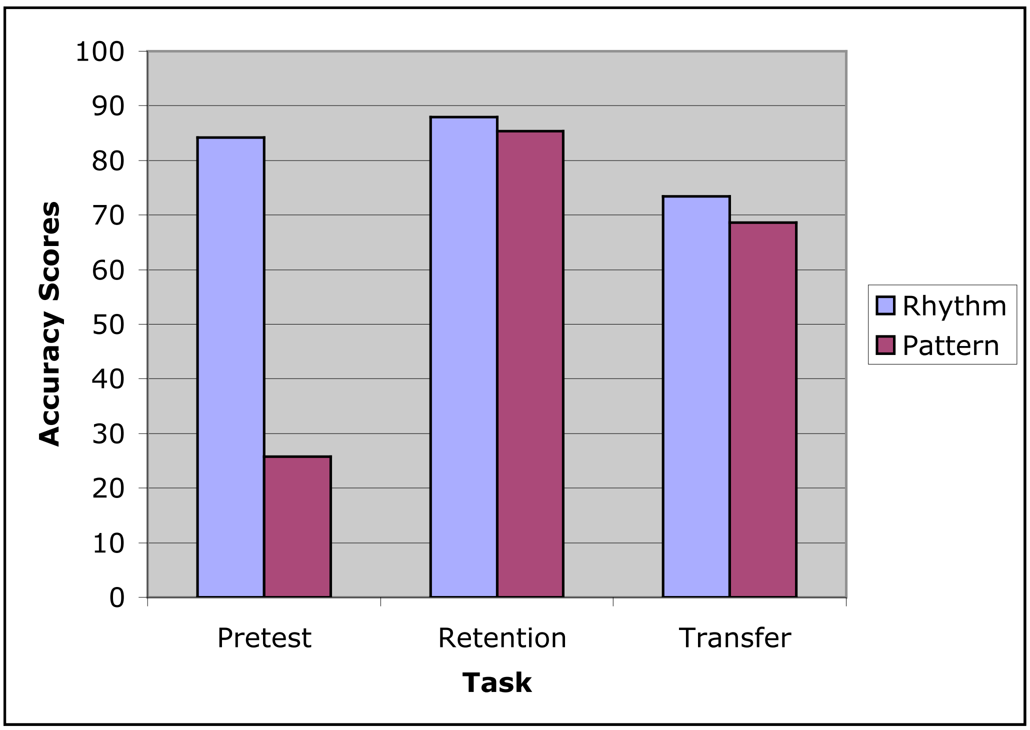

Figure 6. Rhythm and Pattern Accuracy Means by Task during Pretest, Retention, and Transfer

Because there were significant differences in both rhythm and pattern accuracy according to task, post hoc analyses were conducted. Results of a Newman-Keuls post hoc (see Table 12) revealed significant differences for the effect of task on rhythm. These occurred between the

pretest and retention tasks (p = .01), and between the pretest and transfer tasks (p < .0001). There was also a significant difference (p < .0001) between the retention and transfer tasks on rhythmic accuracy. As seen in Table 11 and Figure 6, while there was only a four-percentage point gain from pretest to retention, there was a 15-percentage point decrease in rhythmic accuracy from the retention task to the transfer task.

Results of a Newman-Keuls post hoc test (see Table 13) for the effect of task on pattern revealed significant differences among the means. These occurred between the pretest and retention tasks (p < .0001), and between the pretest and transfer tasks (p < .0001). There was also a significant difference (p < .0001) between the retention and transfer tasks on pattern. As might be expected (refer to Table 11 and Figure 6), there was a large gain of nearly 60 percentage points from the pretest to the retention test. Similar to the rhythmic accuracy scores, there was a decrease between the pattern accuracy of the retention task and transfer task; this time, the difference was nearly 17 percentage points.

Table 12: Post-hoc Analysis for Main Effect of Task on Rhythm

Applied Area	Pretest	Retention	Transfer
Rhythmic Mean	84.20	87.92	73.37
Pretest		.01	<.0001
Retention	.01		<.0001
Transfer	<.0001	<.0001	

Table 13: Post-hoc Analysis for Main Effect of Task on Pattern

Applied Area	Pretest	Retention	Transfer
Rhythmic Mean	25.73	85.36	68.61
Pretest		<.0001	<.0001
Retention	<.0001		<.0001
Transfer	<.0001	<.0001	

In this study, contextual interference was manipulated in two treatment groups. Due to the imposed structure of the research design, accuracy scores for the blocked and varied groups were accessible in a straightforward manner. The control group, however, practiced under conditions not structured by the researcher, rendering accuracy scores impossible to obtain. Therefore, accuracy scores of the blocked and varied groups during the acquisition phase were analyzed statistically, while the acquisition phase of the control group participants were analyzed descriptively.

To investigate the blocked and varied groups' data, a MANOVA was conducted with acquisition rhythm and pattern accuracy scores as the dependent variables. Results, seen in Table 14, revealed a significant difference (Wilk's $\lambda = .86$, $F(2, 73) = 6.09$, $p = .01$) between the two rhythm and pattern accuracy scores due to the main effect of treatment group. There was no significant difference due to the main effect of applied area, nor a significant interaction between the main effects ($p > .025$).

Table 14: MANOVA Summary Table: Effects of Treatment and Applied Area on Rhythm and Pattern Accuracy Scores during Acquisition

Effect	Wilk's Lambda	*F*	df 1 (variable)	df2 (error term)	*p*-level
Treatment	.86	6.09	2	73	<.01
Applied Area	.92	1.52	4	146	.20
Treatment * Applied Area	.89	2.25	4	146	.07

The subsequent univariate ANOVAs (see Table 15) show that both rhythm and pattern accuracy were significantly affected by treatment grouping ($p < .025$ and $p < .001$, respectively). The rhythm and pattern accuracy means of the two treatment groups can be seen in Table 16. The rhythmic and pattern accuracy of the blocked group was superior to that of the varied group by approximately six percentage points in both cases. It is notable that for both the blocked and varied groups, pattern accuracy was greater than rhythmic accuracy.

Table 15: Univariate ANOVA Summary Table: Effect of Treatment on Rhythm Accuracy and Pattern Accuracy during Acquisition

Variable	Mean Square Effect	Mean Square Error	*F* (1, 74)	*p*-level
Rhythm	908.42	170.28	5.33	.024
Pattern	706.13	64.58	10.93	.001

Table 16: Means Table: Treatment Across Rhythm and Pattern Accuracy Scores during Acquisition

Treatment	Rhythmic Accuracy Mean	Pattern Accuracy Mean
Blocked	94.59	96.56
Varied	87.81	90.59

Videotapes of the control group's acquisition phase were analyzed descriptively to investigate participants' use of time. Participants' practice behavior was categorized as active, simulated, or passive. These three conditions were considered in regard to the metronome being on or off, creating six mutually exclusive categories. The statistical software was used to provide percent of time spent in each of the categories. Results of the data analysis (as seen in Table 17) revealed that approximately 70 percent of participants' time was spent in active practice..

Table 17: Percentages of Practice Categories Spent by Control Participants in Acquisition

Practice Type	Percentage of Time
Active Practice Metronome On	44.59
Active Practice Metronome Off	25.28
Simulated Practice Metronome On	6.55
Simulated Practice Metronome Off	7.30
Passive Practice Metronome On	6.78
Passive Practice Metronome Off	9.05

Participants spent nearly 45 percent of their time in active practice with the metronome on, while around 25 percent of the time was spent in active practice with the metronome off. No other category exceeded ten percent of participants' overall time. It is notable, however, that of the four simulated and passive categories, the highest percentage of time was spent in passive practice with the metronome off.

In order to investigate the Kamin effect, rhythm and pattern accuracy scores from the retention and transfer tasks (session 1) and the posttest retention and transfer tasks (session 2) were analyzed according to treatment group and Kamin effect grouping. Although not normally acceptable, a separate MANOVA was used for this analysis. The rationale for this was that the difference in retention and transfer tasks and posttest retention and transfer tasks seemed a matter of memory and Kamin effect rather than a matter of skill development or talent level. Using this data within the MANOVA on pretest, acquisition, retention, and transfer would have also resulted in unacceptably small cell sizes due to the addition of the posttest session. Data comparing retention and transfer and posttest retention and transfer could have been displayed graphically; however, the amount of data present within the descriptive statistics would have made interpretation difficult and cumbersome. Therefore, given these less than desirable options, it was decided to use a separate MANOVA for ease of interpretation. Since generalization of the results is suspect given these options, the data is presented here simply as a point of departure for discussion and cautious conjecture.

As seen in Table 18, significant differences occurred between rhythm and pattern accuracy scores within the main effects of treatment (Wilk's $\Lambda = .91$, F (4, 214) = 2.45, $p < .05$), and task (Wilk's $\Lambda = .33$, F (2, 107) = 108.21, $p < .0001$). There were no significant differences due to the Kamin effect or session, nor any significant interactions ($p > .05$).

Table 18: MANOVA Summary Table: Effects of Treatment, Kamin Effect Timing, Session, and Task on Rhythm and Pattern Accuracy Scores during Retention and Transfer and Posttest Retention and Transfer

Effect	Wilk's Lambda	*F*	df (variable)	df2 (error term)	*p*-level
Treatment	.91	2.45	4	214	<.05
Kamin	.94	1.11	6	214	.36
Session (First/Second)	.97	1.39	2	107	.25
Task (Retention/Transfer)	.33	108.21	2	107	<.0001
Treatment * Kamin	.89	1.05	12	214	.41
Treatment * Session	.97	.80	4	214	.52
Kamin * Session	.90	1.85	6	214	.09
Treatment * Task	.96	1.15	4	214	.33
Kamin * Task	.95	.87	6	214	.51
Session * Task	.98	.84	2	107	.43
Treatment * Kamin * Session	.88	1.13	12	214	.34
Treatment * Kamin * Task	.88	1.18	12	214	.30
Treatment * Session * Task	.96	1.01	4	214	.41
Kamin * Session * Task	.90	1.97	6	214	.07
Treatment * Kamin * Session * Task	.93	.68	12	214	.77

Univariate ANOVAs (see Table 19) were completed to investigate the main effect of treatment on rhythm and pattern accuracy scores. Results revealed no significant effects ($p > .025$) for either dependent measure. The means for treatment can be seen in Table 20 and Figure 7. The rhythm and pattern accuracy mean scores for the varied group are slightly higher than

those of the other treatment groups. It is notable that the blocked and varied groups' rhythm accuracy mean is higher than their pattern accuracy mean, while the control groups' pattern accuracy mean is higher than their rhythm accuracy mean.

Table 19: Univariate ANOVA Summary Table: Effect of Treatment on Rhythm Accuracy and Pattern Accuracy during Retention and Transfer and Posttest Retention and Transfer

Dependent Variable	Mean Square Effect	Mean Square Error	*F* (2,108)	*p*-level
Rhythm Accuracy	2516.69	1265.41	1.99	.14
Pattern Accuracy	81.56	1262.51	.06	.94

Table 20: Means Table: Treatment Across Rhythm and Pattern Accuracy Scores during Retention and Transfer and Posttest Retention and Transfer

Treatment	Rhythmic Accuracy Mean	Pattern Accuracy Mean
Blocked	81.49	76.32
Varied	82.49	77.65
Control	75.18	76.54

Univariate ANOVAs were also used to investigate the main effect of task on retention and transfer accuracy scores. Results (see Table 21) indicated a significant difference between retention task and the transfer task on rhythmic accuracy ($p < .0001$) and pattern accuracy ($p < .0001$). Rhythm and pattern accuracy means organized by task are seen in Table 22. The retention accuracy mean for rhythm was almost 15 percentage points higher than that of the transfer task. The retention accuracy mean for pattern was approximately 16 points higher than that of the transfer task.

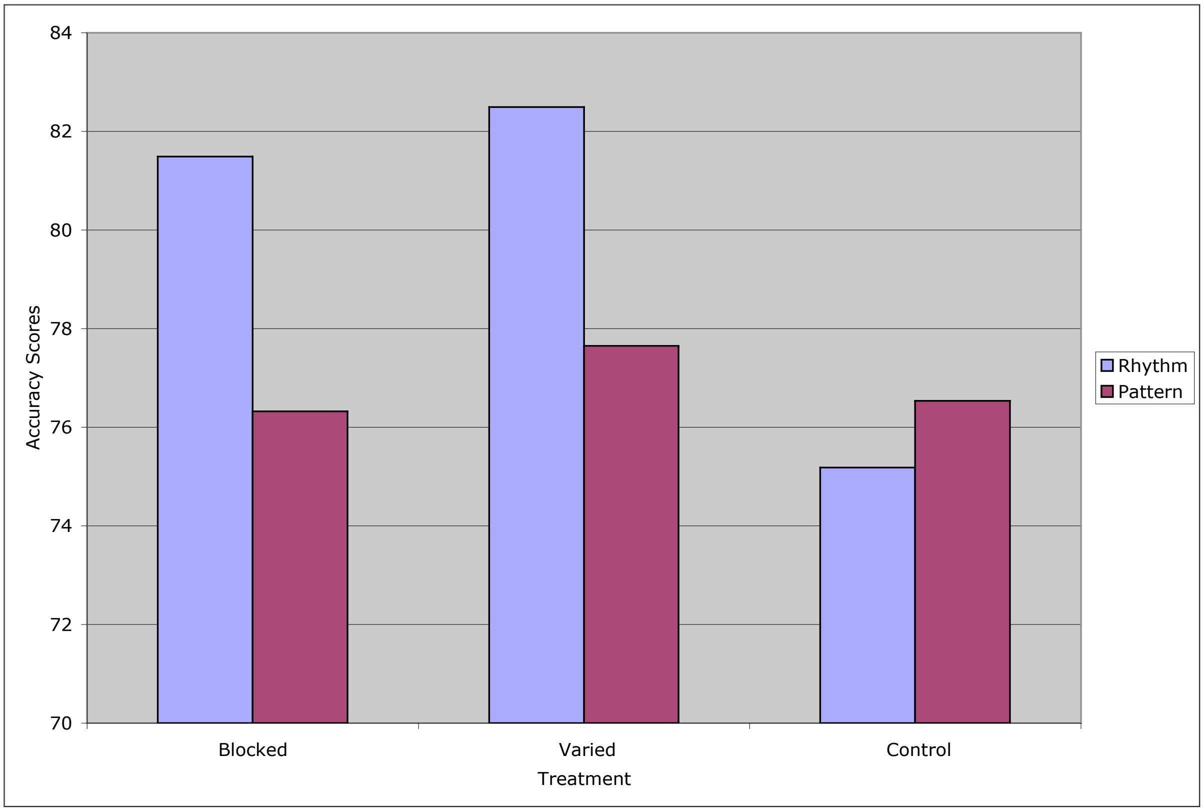

Figure 7. Rhythm and Pattern Accuracy Means by Treatment during Retention and Transfer and Posttest Retention and Transfer

Table 21: Univariate ANOVA Summary Table: Effect of Task on Rhythm Accuracy and Pattern Accuracy during Retention and Transfer and Posttest Retention and Transfer

Dependent Variable	Mean Square Effect	Mean Square Error	*F* (1,108)	*p*-level
Rhythm Accuracy	26613.89	193.15	137.79	<.0001
Pattern Accuracy	30056.95	154.68	194.32	<.0001

Table 22: Means Table: Task Across Rhythm and Pattern Accuracy Scores during Retention and Transfer and Posttest Retention and Transfer

Dependent Variable	Rhythmic Accuracy Mean	Pattern Accuracy Mean
Retention Accuracy	87.17	84.75
Transfer Accuracy	72.27	68.92

A rhythm and pattern accuracy means table by treatment, applied area, and task (pretest, retention, transfer, and posttest retention and transfer) can be seen in Appendix H. This table also contains the standard deviations for each of the accuracy scores. The high values of these numbers attest to the amount of participant variability within the tasks. Values for the pretest indicated that overall, the task was relatively easy for participants in regard to rhythm; however, in regard to the pattern, the task was much more challenging. This, of course, changed following acquisition of the skill. The standard deviations of the retention tasks revealed that this was a relatively easy task in both rhythm and pattern. In most cases, participants' scores were within one standard deviation away from the perfect score, and were, thus, negatively skewed. Judging from the more modest rhythm and pattern accuracy scores, as well as the standard deviations, the transfer tasks proved to be more of a challenge than the retention task.

CHAPTER 5

DISCUSSION

The purpose of this study was to measure the effects of contextual interference practice conditions on the acquisition, retention, and transfer of a percussive motor skill task among university musicians. Other research questions included the following: Is the Kamin effect a factor in retaining knowledge? Are there any differences in the motor skills acquisition, retention, and transfer of this task with regard to applied area and the status of these areas as a bimanual, unimanual, or nonmanual concentration?

All participants (*N* = 120) completed a pretest task that consisted of playing ten rhythmic units with mallets on drum pads. Participants then went through an acquisition phase, where they learned sticking patterns that corresponded to the ten rhythms. Three treatment groups existed within this acquisition phase, producing 40 participants in each blocked, varied, or control group. Five minutes after completing the acquisition phase, all participants took part in a retention and transfer task, with the objective of employing the correct sticking patterns and rhythms. The retention task consisted of playing the ten isolated rhythms, while the transfer consisted of a realistic excerpt with back-to-back units, rests, and phrases. Participants were also grouped according to four Kamin effect latency times: thirty minutes, one hour, six hours, and twenty-four hours. Following their respective time intervals, participants completed a posttest, which included another set of retention and transfer tasks. Scoring for all tasks was accomplished by referencing the computerized music notation, and each phase of the study was graded according to rhythmic accuracy and pattern accuracy.

The contextual interference hypothesis, along with the use of blocked, varied, and control treatment groups, was selected for this study based on previous research in the music and motor skill domain (Kerr & Booth, 1978; Pacey, 1993; Shea, Kohl, & Indermill, 1989; Shea & Morgan,

1979; Wrisberg, 1991). All of these studies point to the idea that a simple task is better acquired under blocked, or repetitive conditions, but over time, retention and transfer of the skill is better accomplished when the skill was learned under varied conditions. This CI hypothesis had not previously been applied with any consistent results in music, nor had it been found to exist with any consistency for a complex motor skill task.

In the present study, treatment (blocked practice, varied practice, and free practice) did not significantly factor into isolated rhythm or pattern accuracy. As discussed in previous chapters, all music tasks could certainly be complex by motor skill research standards (Bernstein, 1967; Schmidt, Zelaznik, Hawkins, Frank, & Quinn, 1979; Wulf and Shea, 2002). In the present study, participants had to negotiate music notation, bimanual motor coordination, and ten rhythmic units, which were sometimes placed in novel contexts. Rhythm was not considered a confounding variable because its relative simplicity at the college level was demonstrated in participants' pretest performance; however, the rhythmic presence as a vital part of the study most likely contributed to the complexity of the task. It could be that the music motor task in this study was too complex as to be counterintuitive to CI hypothesis effects. This cannot be stated with any assurance, though, as more research is needed on both simple and complex tasks in music. It is also possible that the task was of relative complexity to the individual, based upon their on their own experiences. For instance, it could be argued that the task was more complex for vocalists or other musicians who had not experienced much bimanual coordination.

Although treatment effects were largely nonsignificant in this study, there were several interesting finds. While the control group was equivalent to the blocked and varied groups in terms of pattern accuracy throughout the pretest, retention and transfer, they were approximately six percentage points below the blocked and varied groups in terms of rhythm. Although these musicians could all be considered quite proficient, it seems that their rhythmic mistakes may

have gone uncorrected in the absence of structured practice or required metronome usage. This is reminiscent of the research by Carnahan and Lee (1989), whose study in phase and duration training suggested that a more structured practice produced superior performance results.

Another viable explanation is that inferior performances were the result, not of practice condition, but of a lack of internal knowledge of results. This brings to mind the study by Moore, Brotons, Fyk, and Castillo (1997), in which younger musicians in a blocked practice setting tended to repeat mistakes, as opposed to correcting them. Because the performance accuracy of control participants did not match that of the blocked or varied, it could be argued that, in the present study, lack of imposed structure or metronome use inhibited knowledge of results-even throughout a rather musically advanced pool of musicians.

Participants' applied areas were also investigated because of the differences in requisite motor skill movement within their performance areas. Although no studies directly stated that music motor skill experience could influence learning of a novel task, Jancke, Schlaug, and Steinmetz (1997) found that bimanual musicians were superior to nonmusicians on motor skill tasks involving the nondominant hand. Inspired by Jancke, Schlaug, and Steinmetz and Schmidt (1975), the thought pervading this research was that more motor skill task development would result in construction of more recall schemata. These schemata could then be accessed by the brain when faced with a novel, but related task. Because the present study used a bimanual coordination task, it was thought that musicians who spent a majority of time engaged in bimanual practice might perform differently from those who consistently practice in unimanual or nonmanual contexts.

Investigation of pretest, retention, and transfer tasks revealed that applied area was a significant factor in participants' rhythm accuracy and pattern accuracy scores. Differences occurred between the nonmanual and unimanual groups and between the nonmanual and

bimanual groups in both rhythmic and pattern accuracy. It seems that in this study vocal musicians did not become as skilled at the task as the instrumentalists. Although their pattern scores improved following treatment, vocalists' overall potential for pattern memorization seemed more limited than that of the instrumental counterparts. Perhaps these limitations were due to the vocalists' lack of overt motor skills necessary for vocal technique. It could be that lack of a predilection for overt motor skills was a determinant for pursuing vocal music over instrumental music. It would seem logical that a lack of experience in body and motor coordination would mean less formation of schemata in novel tasks. If that was the case, then vocalists might experience more difficulty, and require more effort with novel tasks; however, it would also seem that bimanual musicians should outperform unimanual musicians. This was not the case, however, as unimanual musicians obtained higher rhythmic and pattern accuracy means than the bimanual musicians. Scores between the two groups were so close that the small differences could be attributable to almost anything, even an extreme score. Differences between blocked and varied participants on rhythm and pattern accuracy were almost nonexistent. This raises the question of why the bimanual and unimanual groups performed so similarly.

Perhaps the brass musicians from the unimanual group had been involved in activities that fostered motor skill schemata and motor skill experience. A majority of the brass players were in marching band throughout high school and college. With this, they experienced the coordination of stepping in tempo while playing a variety of rhythms. Although data was not taken on the following idea, it could also be conjectured that male musicians have participated in formal or informal athletics where overt motor skills are used. Since the majority of brass players were male, and the majority of woodwinds, pianists, and string players were female, it could be hypothesized that prior differences between males and females influenced the accuracy of

performing a novel music motor skill. This possibility may have enabled the unimanual group to have equivalent accuracy scores with that of the bimanual group.

With its origins in laboratory experiments, the Kamin effect was another variable worthy of inclusion in the present study. Past research of this effect (Denny, 1958; Denny and Ditchman, 1962; Denny and Thomas, 1960; Kamin, 1963, 1957) revealed that retention of a learned task functioned in a curvilinear manner over time. Even within music, researchers (Tallarico, 1973; Wilson, 1990) reported results that approximated the Kamin effect's decrease to a low point of retention (at one hour) followed by an increase in retention lasting days later. Because research of the Kamin effect had been sparse in motor skills, music, and especially music motor skill performance, it was decided that a portion of the present study be devoted to this variable. Because the research design involved retention and transfer testing for the CI hypothesis, the Kamin effect variable was easily added through another set of retention and transfer tasks performed at various latency timings.

Investigation of the Kamin effect involved rhythm and pattern accuracy scores from the retention and transfer tasks (session 1) and the posttest retention and transfer tasks (session 2). There were no significant differences found in rhythm or pattern accuracy due to the Kamin effect. Despite this result, there were interesting trends in rhythm and pattern accuracy scores. While no sign of a one hour low point existed, a curvilinear function of retention was present, bending in the opposite way of the expected Kamin effect. Although not significant and small in nature, the rhythmic and pattern accuracy improved with each Kamin effect timing, reaching the apex at the six hour mark and falling only slightly at the 24 hour time period. This finding could be related to the ideas postulated by Walker, Brakefield, Hobson, and Stickgold (2003), who state that the six-hour mark is known as a memory consolidation stage. At this point, newly acquired skills are usually less resistant to interference. The authors also stated that sleep could

enhance skills with no further practice. In the present study, this may account for the 24-hour latency group's lack of serious decline in rhythm or pattern accuracy.

Perhaps the more complex music task in this study offers a different effect of retention timing altogether. Unlike previous studies (Denny, 1958; Denny and Ditchman, 1962; Denny and Thomas, 1960; Kamin, 1963, 1957), which dealt with avoidance training in animals and recall of factual knowledge in humans, the present study involved cognitive music reading transferred to human motor skill performance. Although Tallarico's (1973) study concentrated on performance, his design was not a replication of the Kamin timings; thus, making comparisons was a cautionary prospect. It is possible that the curvilinear function of retention is entirely dissimilar for motor skill tasks, and that high and low retention points are reached at different times and in a different shape. More research is needed to determine the music motor tasks for which the Kamin effect is applicable.

Type of task became a factor in several parts of the study. Differences in rhythm accuracy resulted between the pretest and retention tasks, and between the pretest and transfer tasks. There was also a significant difference in rhythm accuracy between retention and transfer tasks. Similar results existed for the pattern accuracy, with significant differences occurring between the pretest and retention tasks, the pretest and transfer tasks, and the retention and transfer tasks. As expected, the pattern accuracy increased substantially (almost 60 percentage points) from the pretest to the retention task. Unexpected, perhaps, was the slight increase in rhythmic capacity from the pretest to the retention task. This seems to suggest that the acquisition of sticking patterns helped to visually or kinaesthetically organize the rhythms, and allow participants to generate an increase in rhythmic accuracy. Motor skill and music researchers have aluded to the possibility that music memory and performance could be enhanced through visual imagery or movement automaticity (Halsband, Binkofski, and Camp, 1994; Heuser, 1998; Kemp, 1990;

Shaffer, 1982, 1984). The collective idea from all of these studies was that an interfering variable can sometimes improve another skill, especially when it serves as a organizing reference.

Although rhythm and pattern accuracy rose from the pretest to the retention task, it decreased from the retention to the transfer task. This was expected, however, due to increased complexity within the transfer task. With so many back-to-back rhythms and patterns to negotiate, participants' newly acquired skill of sticking pattern may have interfered with the otherwise stable skill of rhythm.

Although the CI hypothesis did not come to fruition in this study, treatment was a significant factor in the rhythm and pattern accuracy of participants' acquisition. It seems that the varied group experienced substantially more error than the blocked group. This is consistent with acquisition processes in motor skill research (Kerr & Booth, 1978; Shea, Kohl, & Indermill, 1989; Shea & Morgan, 1979; Wrisberg, 1991). In the simple tasks of motor skill research, more error within varied practice conditions was the basis for what some researchers (Lee & Magill, 1985, 1983; Shea & Morgan, 1979: Shea & Zimny, 1983) deemed a forgetting or restructuring phase that contributed to the CI hypothesis. They argued that more error resulted in a more metacognitive approach to the skill, later resulting in an increase in task accuracy. Ultimately, the increase in accuracy would overtake the gains made by participants in blocked practice conditions. In other words, over time, varied participants developed better retention and transfer accuracy. While this outcome was not the case in the present study, the opposite effect (a decrease in retention and transfer accuracy) was not the case either. It seems, therefore, that although varied participants made more mistakes throughout acquisition, they performed equivalently to the blocked and control groups in all other phases.

Contextual interference issues were casually noted in the reactions of participants, although this remained simply documented and unquantifiable data. Occasionally, blocked and

control participants made facial expressions, body movements, or small comments that indicated a momentary feeling of surprise upon seeing the transfer task. Although varied participants sometimes exhibited the same behavior, it seemed that their imposed structure of practice (varied sequences of back-to-back rhythms) prepared them better for the visual display of the transfer task. The sequences of different rhythms within varied practice could also be thought of as a kinesthetic preparation for the transfer tasks' back-to-back orderings.

With more research, these findings and observations could certainly change the way in which practice is viewed. As teachers and performers, we are often afraid that making mistakes will result in the "practicing of mistakes," and that overcoming error will be difficult to accomplish. That varied participants performed equally well suggests that engagement in some error is not detrimental to performance. Recall that expert musicians often engage in lengthier segments of music to put the performance in a more realistic context, and highlight problematic areas within a full performance context (Hallam, 1995; Miklaszewski, 1989; Williamon and Valentine, 2000). This doubtlessly produces error, but the error is housed within a greater, more significant, and more memorable performance context.

The interference of other musical phrases or segments may, in fact, be akin to varied practice, providing comparisons, frames of reference, or reminders for error avoidance. Simply put, the addition of more material may provide a better framework for the formation of schemata. In simpler contexts, there may be no material, comparisons, or references for the brain to "hold on to." That is not to say that varied practice is superior, or that blocked practice produces no error, and subsequently, no restructuring or formation of schemata. While blocked participants in this study did experience error, they commonly experienced it in a limited fashion within the first couple of repetitive trials. These participants were able to immediately use their knowledge of results to correct subsequent repetitions; however, they were not able to immediately use this

knowledge to compare multiple rhythmic units in a back-to-back fashion (as varied participants did). This is why varied participants may have ultimately felt more familiar with the transfer task. Obviously, as the equivalent results suggest, however, there are pros and cons to both forms of practice.

Also notable in the acquisition process was the fact that pattern accuracy was greater than rhythm accuracy for both the blocked and varied groups. This is especially surprising considering that sticking patterns were not consistently provided, and considering that all musicians demonstrated rhythmic competence prior to the acquisition. That the accuracy of the novel skill exceeded that of the preexisting skill may merely be a reflection of the participants' concentration or focus of attention. This contrasts with the pretest, retention, and transfer tasks, where rhythm accuracy scores were higher than the pattern accuracy scores.

In terms of the control group's acquisition phases, descriptive statistics revealed that participants spent 70 percent of their time engaged in active practice. Forty-five percent of this time was in active practice with the metronome on, while around 25 percent of the time was with the metronome off. No other category exceeded ten percent of participants' overall time. It is notable that of the four simulated and passive categories, the highest percentage of time was spent in passive practice with the metronome off. This may indicate that musicians favor practicing under ecologically valid conditions, and for this study, employed some degree of passive time in their sessions. From this data, however, it is impossible to determine whether this passive state included mental practice.

Although musicians overwhelmingly opted for active practice, this was not necessarily an indication of a highly self-structured practice session. Often, active practice is misconstrued as productive or organized, while passive or less ecologically valid practice is deemed nonproductive. In most cases, control participants usually began practice with an experimental

state, where they gathered their thoughts, experimented with the possibility of the metronome, or tested their technique or equipment. They then settled into a stable category of practice within the first minute. Participants tended to stay with this category for a while or even for the duration of the practice session.

In regard to control participants self-imposed practice sessions, observation of videotapes revealed that they most often made repetitions of the list of ten rhythms. Blocked repetition of units was only done when there was an error of rhythm or pattern. In this respect, control participants engaged in a form of varied practiced as long as their attempts were error-free. Upon encountering error, however, participants usually switched to a blocked format until the unit was corrected and subsequently repeated in the error-free format.

In all but two cases, the control participants used the target tempo for practice throughout their session. Even in situations where the metronome was off, participants opted to approximate the target tempo as closely as possible. In the two excepted cases, participants chose to alter the tempos, sometimes slowing it for isolated problem areas. When the tempo was increased, the decision seemed driven by the participants' realization of their own increased skill level. The faster tempo, following a period of target acquisition, allowed participants to perform more trials in practice. It also allowed sticking patterns to be performed faster in practice, so that the subsequent tempo of retention and transfer tasks seemed much slower. One additional participant selected the subdivision of four sixteenth notes on the metronome, but did not alter the tempo.

Both active and simulated practice of participants seemed simplistic in structure. Because participants did not often change their style of practice or alter tempos it could be argued that they did not have a plan formulated for this practice. This was not unexpected, though, as taken in isolation, the units were rather simple. Participants were naïve as to what the transfer task

would encompass. Again, the only frequently occurring and ostensible problem solving technique was the blocked repetition of units upon encountering error.

Time constraints on the part of the researcher and participants limited the data collection of some practice and nonperformance factors. Retrospectively speaking, insight into practice strategy existed not only in the aforementioned acquisition process, but also in the moments before the two transfer tasks. Since the transfer tasks were preceded by a 45 second study period, participants could engage in simulated or passive practice. Analysis of these portions of the study may have shed light on how students prepare for sight-reading, especially in a novel situation. Even casual observation of the transfer preparation period revealed interesting trends.

Although many participants engaged in passive study of the music, not one participant began simulated practice by isolating a section or going to the more complex parts of the tasks, which were the last four measures (see Figures 3 and 4). Although participants commented on the difficulty of these measures, and although a brief glance seems to visually highlight this section as more complex, participants took no actions to begin practice here. All participants began their simulated practice at the beginning of the task, and many were left without enough time to practice last four measures.

It seemed that the only structure participants used in this sight-reading practice was that which employed by control participants in the acquisition phase. Participants simply went through the music from top to bottom, stopping at error points, and going back to the start of the unit, measure, or phrase. This commonality among groups highlights what may be deemed a lack of practice structure or internal knowledge of results in a novel task. Some participants played well with the metronome in isolated contexts of the units; however, in the context of back-to-back units, they seemed to have no idea as to where the metronome beat occurred within their playing. Although the metronome was clearly audible, these musicians did not seem bothered by

the two tempos that were out of sync. Still others were able to keep a solid awareness of not only tempo, but also downbeat, even in the midst of error that displaced the beat or rhythm quite severely. These students, unlike others, never stopped, but came back in at the exact point. These observations could be associated with research showing the important role of cognitive ability in addition to musical skill in young musicians' abilities to solve problems in practice (Costa-Giomi, 2003; Sullivan and Cantwell, 1999). Although all participants were skilled musicians, they doubtlessly had different cognitive abilities and practice strategies based on their knowledge of results.

Conversations with participants in pretest screenings revealed that, although they had been previously exposed to right hand lead sticking, they had not always understood that the patterns were derived from the reference rhythm of four sixteenth notes and that the pattern of right, left, right, left always fell on the same part of the beat. This delayed realization of the concept raised concern over a new topic of how right hand lead sticking style is being taught or explained to nonpercussionists. The lack of conceptual understanding and performance ability raised the question of why students who have taken percussion techniques are not more comfortable with the concept or more adept at the skill. Perhaps more "learning by doing" is needed within techniques and music education classes. With such a gain demonstrated between this study's pretest and retention task, it seems that exposure to a short, but fast-paced and highly-organized practice session may increase the understanding and consistent application of right hand lead sticking.

Although it is hard to say that conceptual understanding might increase with exposure, there was evidence in the study that hinted at this possibility. After the short conceptual explanation of the sticking and the participants' physical application of it, some participants began "ghosting notes." Ghosting, which involves the motion, but not the striking of the surface,

in a rest is often a sign that a player understands that the pulse of sixteenths and the pattern of right, left, right, left, etc. continues throughout any given pattern.

Overall, the design of the study proved to be successful for investigation into the effects that treatment, Kamin timings, task, and applied area had on rhythm and pattern accuracy. Although all equipment functioned well a majority of the time, there are areas for improvement in future research. With more time allotted for method development, it might be possible to develop software that would objectively score and automatically record the accuracy of participant performance. Although use of the drum pads and notation software produced objective notation, the human element of grading and scoring these files produced subjectivity. The whole process, therefore required reliability testing, and consumed a substantial amount of time. Development of software specific to the study would certainly expedite the process of data collection in future endeavors.

Additional data collection on participants' experiences and opinions would have served well for insight into much of the quantitative data in this study. With more time, nonperformance factors could have been analyzed through tools such as questionnaires, structured interviews, or qualitative observation. Casual observation in this study suggested that the complexity of the task could be highly relative to the participant. Questionnaires and interviews about the research study could have helped to shed light on the motor skill acquisition process, as well as the thought processes and organization of participant practice. More information regarding participants' percussion backgrounds and their prior exposure to right hand lead sticking patterns were retrospectively of interest. Their opinions may also help answer how vital techniques can be more efficiently acquired under the pressure of time. Finally, further analysis of videotaped practice segments may give insight into the overt behaviors of musicians during times of sight reading preparation and novel tasks.

In summary, there were several important findings that emerged within the present study:

- Evidence of the contextual interference hypothesis resided only in the acquisition phase, where varied participants experienced more error than their blocked counterparts. Although varied participants' retention and transfer scores did not significantly surpass those of the blocked group, they did remain equivalent. In this case, more error in practice did not mean that subsequent motor skill performance suffered.
- Treatment was a significant factor in the rhythmic and pattern accuracy during pretest, retention, and transfer, as control participants scored significantly below blocked and varied participants.
- Although results remain interpreted with caution, the Kamin effect proved to be absent within the present study. An interesting trend of a six-hour high point in accuracy did emerge, although the increases and decreases in rhythm and pattern accuracy were quite small.
- Applied area proved to be a major factor in several phases of the study. It was a main effect of rhythmic and pattern accuracy during the pretest, retention, and transfer tasks, with nonmanual musicians scoring significantly below that of unimanual or bimanual musicians.
- Overall, pattern accuracy significantly improved among all participants from pretest to retention task, before decreasing significantly in the more complex transfer task. Unexpectedly, rhythm followed the same path, increasing significantly in the retention task, and decreasing significantly in the transfer task. It seems that visual imagery or kinaesthetic feel may have enhanced the music motor skill memory in this study.
- During the acquisition phases, control participants used nearly 70 percent of their time engaged in active practice, yet most participants' self-structured practice seemed

simplistic with regard to problem solving. The same observations were made in regard to the transfer task preparation for all participants.

- Many participants, who were previously exposed to percussion techniques, exhibited little procedural knowledge of right hand lead sticking.

All of these results bring to light areas of exploration for future study. Research on schema theory and the contextual interference hypothesis have begun in music. Before we can generalize about possibilities and outcomes, however, we must first begin the arduous task of operationally defining task difficulty within our field. One could certainly argue that even the "simplest" musical tasks are difficult. With endless combinations of pitch, rhythm, tempo, expression, technical facility, and music reading, seemingly "easy" tasks often belie their own complexity. If we find that music performance can be broken down into simple tasks, then certainly research is warranted to see if the CI hypothesis exists in a *simple* music motor skill task.

As Duke and Pierce (1991) have suggested, we need to find a method of teaching that affords students the chance to be more flexible and adaptive in complex tasks. Although many educators utilize a blocked approach to teaching musical skills, others (Duke & Pierce, 1991, Pacey, 1993) believe that facilitating varied approaches will allow musicians to be more resilient in later endeavors. For instance, most educators teach scales in a blocked format, introducing one at a time, and practicing it until muscle memory and automaticity take over. In a varied approach, one may choose to introduce all major scales at the beginning of the year, hoping that students will take on a more metacognitive approach to learning all of them at once. Similarly, it is possible that rehearsing varied repertoire throughout the day, week, month, or semester can facilitate better sight-reading or concentration on adhering to musical details.

As researchers and teachers, however, we must know what types of tasks, if any, benefit from the contextual interference hypothesis and which ones are too complex. If the hypothesis were to indeed exist in simpler tasks in music, researchers could then better define what constitutes task complexity within the music domain. Future study on the contextual interference hypothesis in music may include simpler tasks in the form of less rhythmic units or other target tasks. By the same token, further research on complex music tasks could be pursued since there is no definitive proof of the CI hypothesis' existence in complex music tasks or motor tasks. As discussed previously, however, we must not leave the idea that task complexity is relative to the individual, and that an internal cognitive ability of the musician may account more for success and accuracy than an external factor of task complexity.

Future research into the Kamin effect is also warranted, and is needed to determine if the effect is an integral part of motor skill tasks or student performance accuracy. More replication of Kamin timings could be used in future studies. In light of the six-hour high point in retention, other studies may concentrate on smaller frames of time for retention testing. For instance, the area of one to six hours was unexplored in the present study by virtue of the Kamin timing replication. Future research may, of course, focus on the conceptual knowledge of music, as opposed to that of motor skills or music performance.

Further study is also needed in the applied area of musicians. It was clear in this study that vocalists were rhythmically inferior to instrumentalists, suggesting that their lack of training in overt motor skills inhibited their acquisition of the music motor skill. Investigation into applied area and its role in motor development might require more data relative to past experiences. In future endeavors, researchers might employ questionnaires that investigate prior exposure to motor skill and bodily coordination, including athletics, marching band, dance, etc.

Although gender was not an independent variable in this study, it was controlled in subgroups. In light of the equivalent accuracy of unimanual and bimanual musicians, it cannot be ignored that a majority of unimanual participants were male (by three to one), and a majority of bimanual participants were female (by approximately two to one). Future research could attempt to isolate gender as a factor in motor skill acquisition, retention, and transfer.

Right hand lead sticking was used in this study because of its overt use of bimanual motor skills, and because of its status as a vital technique to the teaching and performance of percussion. Since the present study only focused on one university, generalizations cannot be made about the emphasis, quantity, or quality with which this skill is taught. It seems, however, that in this study, participants with percussion techniques experience were largely unable to apply the right hand lead sticking concepts to actual performance patterns. Even former band directors and graduate students from other undergraduate backgrounds faired no better, suggesting that the skill of right hand lead sticking may be underemphasized in courses for instrumental music teachers. More research is simply needed to investigate this situation. Along the same lines, research may be undertaken to see how computerized assisted learning formats for motor skill practice may enhance learning.

Observations also showed that self-imposed practice structure during acquisition and transfer task preparation was questionably absent or devoid of cognitive problem solving. More research is needed as to why participants did not employ more techniques, such as tempo manipulation or isolation of difficult parts. Future study might also concentrate on the sight-reading strategies that skilled musicians use when presented with a novel task.

These observations are shared within the intent of relaying future data gathering techniques that may enhance the understanding of participants' prior knowledge, experience, and thoughts regarding practice and performance. In-depth investigation into the perceptions of

participants may involve questionnaires, interviews, and more qualitative observation or mixed methods research. Questionnaires could gauge participants' perceived effects of blocked versus varied practice, as well as the impact on retention and transfer. Data could be gathered on the status of right hand lead sticking and participants' past exposure to similar motor skills. The use of a variety of data collection techniques may give more insight into the practice structure or sightreading processes of musicians.

Further research is needed to establish a base for all of these issues. As always, the study of practice structure among musicians can continue to increase the speed and efficiency of musicians who are always training in a novel skill. Insight into the practice of music motor skills is especially desirable at the university level, where practice efficiency is key to expediting the acquisition of instrumental proficiency. More importantly, however, is the need for this proficiency to transpire into long-term knowledge and skill. Student musicians must successfully retain basic techniques, such as right hand lead sticking. As future music educators they will, in turn, teach and transfer this knowledge to their students. In this new context, as well, longevity of knowledge and skill must prevail. Any future research in the realm of music motor skills may influence what and how we teach, what and how we practice, and subsequently, what and how we teach others to practice.

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APPENDIX A

INSTITUTIONAL REVIEW BOARD (IRB) EXEMPTION FROM OVERSIGHT

LSU

Institutional Review Board
203 B-1 David Boyd Hall
Louisiana State University and A&M College
Baton Rouge LA 70803

(225) 578-8692

FAX: 578-6792
irb @lsu.edu

INSTITUTIONAL REVIEW BOARD

ACTION ON PROTOCOL APPROVAL REQUEST

TO: James Byo
School of Music

FROM: Robert C. Mathews
Chair, Institutional Review Board for Research with Human Subjects

DATE: February 09, 2006

RE: **IRB#** 2613

TITLE: "The Effects of Contextual Interference on the Acquisition, Retention, and Performance of a Music Motor Skill Among University Musicians"

New Protocol/Modification/Continuation : N

Review type: Full _____ Expedited __X__ **Review date:** 02/10/2006

Risk Factor: Minimal __✓__ Uncertain ______ Greater Than Minimal _____

Approved ✓ 2/10/06 **Disapproved** __________

Approval Date: 2/10/06 **Approval Expiration Date:** 02/10/2007

Re-review frequency: (annual unless otherwise stated) ______

Number of subjects approved: 120

By: Robert C. Mathews, Chairman Robert C Mathews

PRINCIPAL INVESTIGATOR: PLEASE READ THE FOLLOWING -- Continuing approval is CONDITIONAL on:

1. Adherence to the approved protocol, familiarity with, and adherence to the ethical standards of the Belmont Report, and LSU's Assurance of Compliance with DHHS regulations for the protection of human subjects*
2. Prior approval of a change in protocol, including revision of the consent documents or an increase in the number of subjects over that approved.
3. Obtaining renewed approval (or submittal of a termination report), prior to the approval expiration date, upon request by the IRB office (irrespective of when the project actually begins); notification of project termination.
4. Retention of documentation of informed consent and study records for at least 3 years after the study ends.
5. Continuing attention to the physical and psychological well-being and informed consent of the individual participants including notification of new information that might affect consent.
6. A prompt report to the IRB of any adverse event affecting a participant potentially arising from the study.
7. Notification of the IRB of a serious compliance failure.
8. SPECIAL NOTE:

**All investigators and support staff have access to copies of the Belmont Report, LSU's Assurance with DHHS, DHHS (45 CFR 46) and FDA regulations governing use of human subjects, and other relevant documents in print in this office or on our World Wide Web site at http://www.fas.lsu.edu/osp/irb*

APPENDIX B

PARTICIPANT CONSENT FORM

1. **Study Title:** The Effects of Contextual Interference on the Acquisition, Retention, and Transfer of a Music Motor Skill Among University Musicians

2. **Performance Site:** Louisiana State University

3. **Contacts:** The following investigators are available for questions about this study:
   Paige Rose (225) 802-7179
   Dr. James Byo (225) 578-2593

4. **Purpose of the Study:** The purpose of this research project is to determine whether there are differences in the accuracy of a music motor skill among three different groups, each undergoing a different practice condition.

5. **Subjects**

   A. **Inclusion:** Musicians at the aforementioned school who demonstrate college-level music rhythmic performance proficiency

   B. **Exclusion:** Participants with an applied performance of area of percussion will be excluded from the study.

   C. **Maximum Number of Subjects:** 120 subjects

6. **Study Procedures:** The study will be conducted in two phases. The first phase will last approximately 45 minutes. In this first phase, subjects will undergo a short pretest on their major instrument that assesses rhythmic accuracy. Participants will then spend approximately 20 minutes completing an acquisition phase that involves the performance and association of rhythms and sticking patterns. Participants will then complete a retention and transfer task to assess performance accuracy and the ability to apply the learned patterns in a new context. The second phase will be conducted either 30 minutes, one hour, six hours, or 24 hours later, depending on the participant's assignment. This second phase will last approximately 10 minutes, with participants completing retention and transfer tasks similar to the first phase.

7. **Benefits:** Participants will undergo repetitions of rhythmic reading and hand patterns. This may improve their music reading ability and hand coordination. In addition, they may be given course credit for their participation. Any participant who wishes not to participate in the study may earn course credit in another way by contacting the instructor.

8. **Risks:** There are no known risks to participants in this study. All recordings of performances and records of accuracy will be kept confidential.

9. **Measures taken to reduce risk:** All research will be conducted with trained personnel. All records, information, performance files, coding, etc. will be stored where only researchers have access. There will be no reference to names or identifying qualities of participants within the written content of the study.

10. **Right to Refuse:** Participation in this research study is voluntary, and participants may choose not to participate or to withdraw from the study at any time without penalty or loss of any benefit to which they might otherwise be entitled.

11. **Privacy:** This is a confidential study. Results of the study may be published, but no names or identifying information will be included in the publication. Participant identity will remain confidential unless disclosure is required by law.

12. **Financial Information:** There is no compensation for participating in this study, and there are no costs involved that may be incurred by participants. Course credit, if issued, will be applied to the students' grade for the semester immediately following their participation.

13. **Withdrawal:** Participants may withdraw from the research at any time with no consequences involved for them. The participant should be advised that termination of their participation should be done in a timely manner to limit adverse effects on the research.

14. **Removal:** Participants may be removed from the research study if it is proven in the pretest that they do not have sufficient university-level rhythmic abilities in music. Percussionists will also be removed from the study if they have not already been screened by their listing of applied area. Likewise, any performer exhibiting high levels of familiarity with the sticking motor skill may be removed from the study. Although the participant will be informed of these decisions, removal may take place without participant consent.

Signatures: The study has been discussed with me, and all of my questions have been answered. I may direct additional questions regarding study specifics to the investigators. If I have questions about subjects' rights or other concerns, I can contact Robert C. Mathews, Institutional Review Board, (225) 578-8692. I agree to participate in the study described above and acknowledge the investigators' obligation to provide me with a copy of this consent form if signed by me.

Signature of Subject	Date

APPENDIX C

COMPUTER PRESENTATION SLIDES FOR CONTROL TREATMENT GROUP

Thanks for participating in today's study.

- Make sure you are comfortable in the chair provided, and that you can clearly see the computer screen. All of the instructions and music for this study will be read from here.
- Today we're going to be working with some rhythms that should be familiar to you. You will be asked to play these rhythms using the mallets and the two drum pads in front of you.
- Pick up the mallets provided and experiment with a musical grip that will allow you to strike the drum pads in front of you.

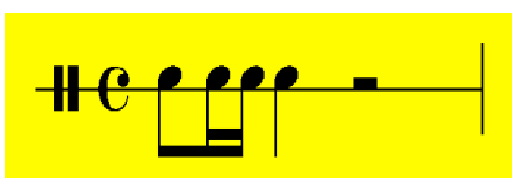
Left sticking will be played
HERE

Right sticking will be played
HERE

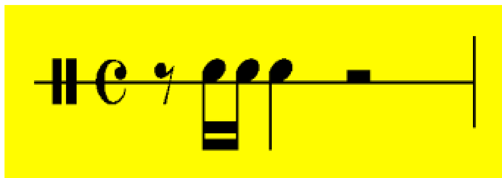
Now that you feel comfortable with the mallets and drum pads, you will begin playing some rhythms.

- The rhythms will appear one by one on the computer screen, and you will be given a verbal count-off for each.
- Try your best to play along with the metronome, which will be set to a tempo of 68 beats per minute.
- When you indicate that you are ready, the metronome will be started and you may begin.

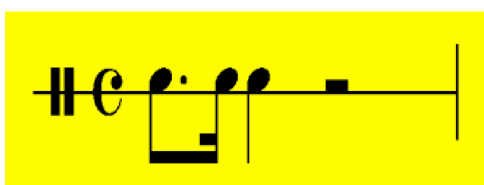
Rhythmic Unit #2



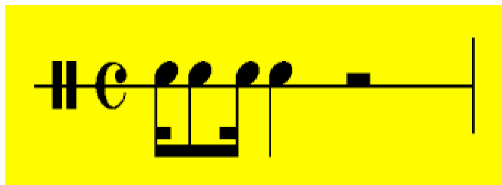
Rhythmic Unit #9



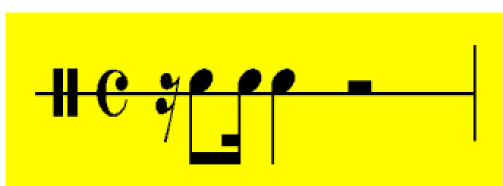
Rhythmic Unit #6



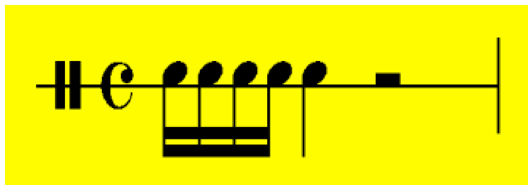
Rhythmic Unit #4



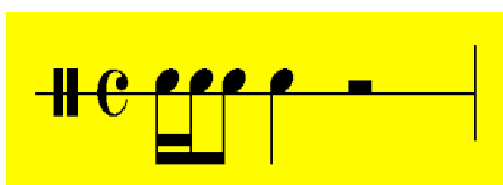
Rhythmic Unit #10



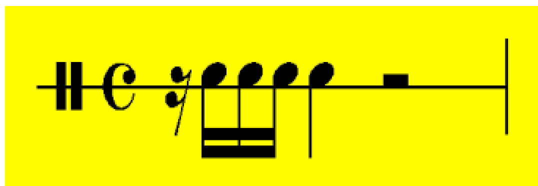
Rhythmic Unit #1



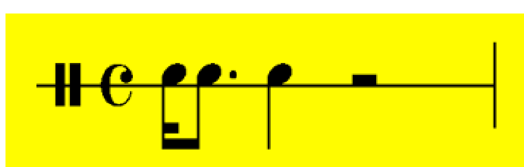
Rhythmic Unit #3



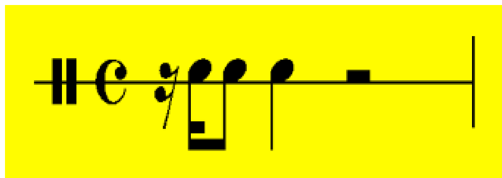
Rhythmic Unit #5



Rhythmic Unit #8



Rhythmic Unit #7



Now that you've played these rhythms correctly, you're going to learn sticking patterns that correspond to each one.

- Patterns will be written underneath the rhythms, with an "R" indicating a right hand, and an "L" indicating a left hand.
- As you can see below, these patterns are arranged so that the right hand always falls on the beat or on the "and" of the beat.

You will have 12 minutes to practice these rhythms and their corresponding sticking patterns.

- You will be given a two copies of the rhythms. One has the corresponding sticking patterns, and the other has the rhythms without the sticking patterns.
- You may use these copies and the metronome as you wish during this practice time. You are asked to stay seated and to do all practice playing on the practice pads in front of you.
- After the practice session, you'll perform retention and transfer tasks in which you will play the rhythms without the help of sticking patterns underneath. All of this playing will be done with the metronome, using the same tempo of 68 beats per minute.

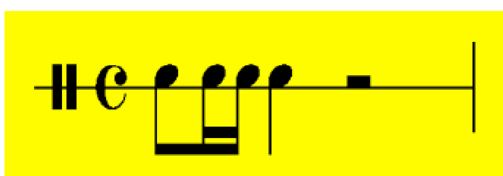
Thank you. You're now finished practicing these rhythms.

We will take a short break, then we will do some different tasks using the same rhythms.

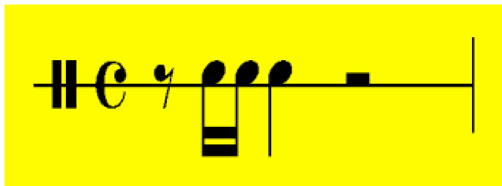
You're now going to play through each of the rhythms that you practiced earlier.

Try your best to remember the sticking patterns that go along with each rhythm.

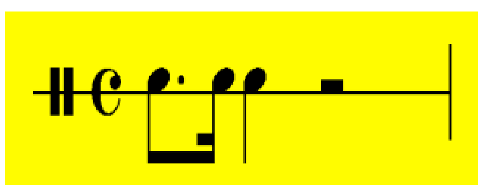
Retention #1, Rhythm #2



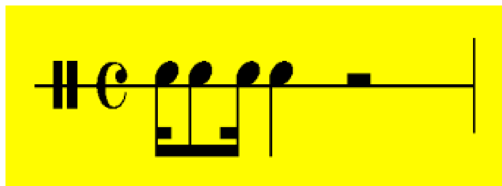
Retention #1, Rhythm #9



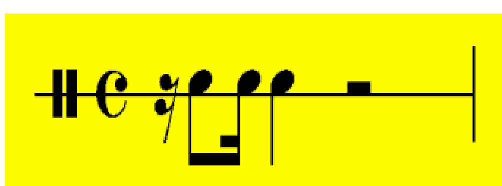
Retention #1, Rhythm #6



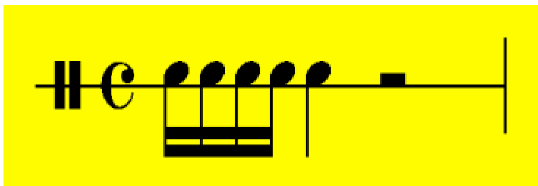
Retention #1, Rhythm #4



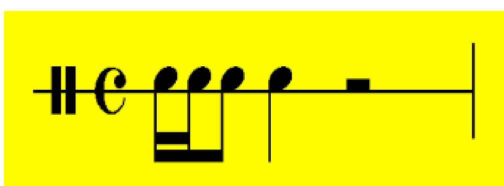
Retention #1, Rhythm #10



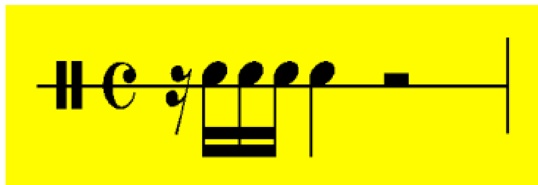
Retention #1, Rhythm #1



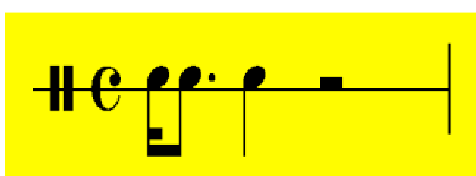
Retention #1, Rhythm #3



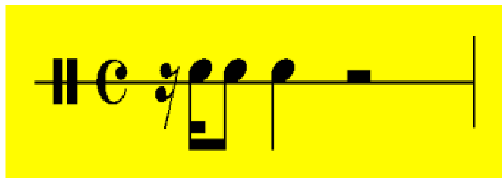
Retention #1, Rhythm #5



Retention #1, Rhythm #8



Retention #1, Rhythm #7



Now, we're going to transfer these rhythms to something new.

- You're going to see 12 measures of music on the computer screen. The music has all of the rhythms you've been playing, but they may appear back to back or continuously from beat to beat.
- You may look at the music for a few seconds, then you will be asked to play through the excerpt using the sticking patterns that you learned before. Try your best to play along with the metronome.

Transfer #1

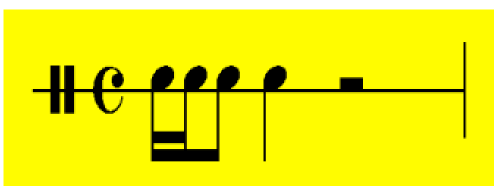
Thank you for your time today.

Before you leave, remember to
finalize your time for the next
portion of the study.

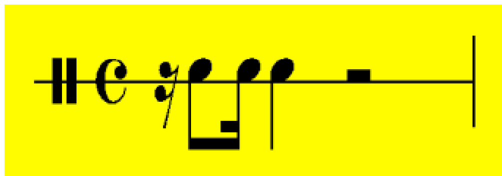
Welcome back.

- You're going to see the same rhythms as you did earlier.
- Just like before, the rhythms will appear on the computer screen, and you will receive a verbal count-off for you to begin.
- Try your best to play the hand pattern that goes along with each rhythm. Also, do your best to play in time with the metronome, which will be set to 68 beats per minute.

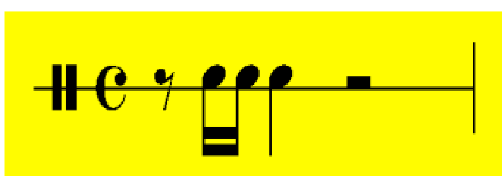
Retention #2, Rhythm #3



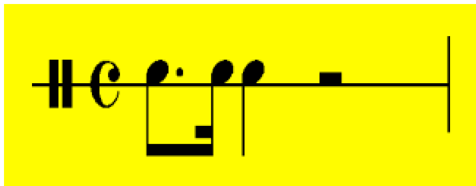
Retention #2, Rhythm #10



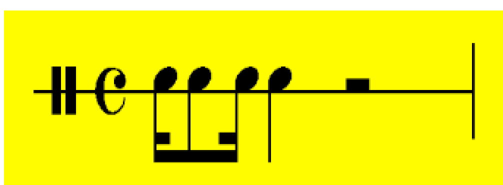
Retention #2, Rhythm #9



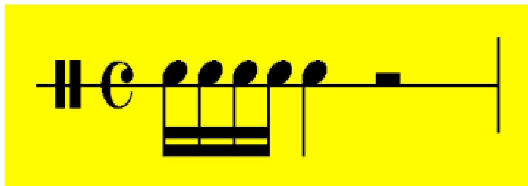
Retention #2, Rhythm #6



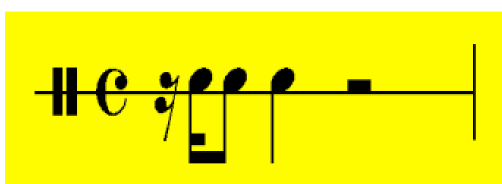
Retention #2, Rhythm #4



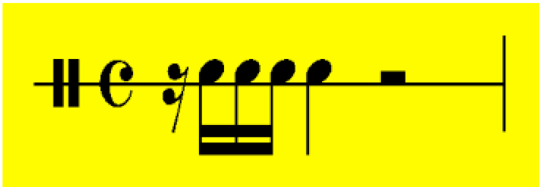
Retention #2, Rhythm #1



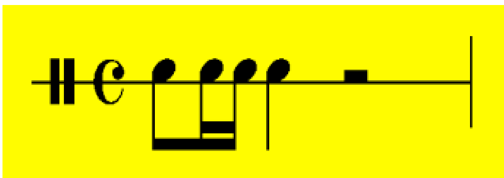
Retention #2, Rhythm #7



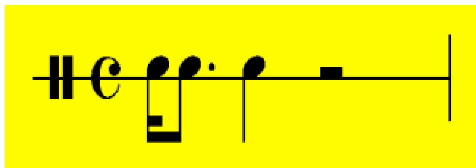
Retention #2, Rhythm #5



Retention #2, Rhythm #2



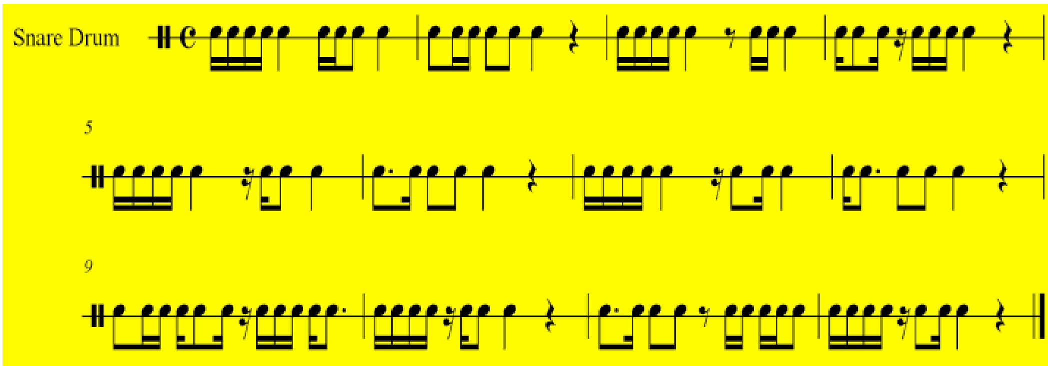
Retention #2, Rhythm #8



Now, we're going to transfer these rhythms to something new.

- You're going to see 12 measures of music on the computer screen. The music has all of the rhythms you've been playing, but they may appear back to back or continuously from beat to beat.
- You may look at the music for a few seconds, then you will be asked to play through the excerpt using the sticking patterns that you learned before. Try your best to play along with the metronome.

Transfer #2



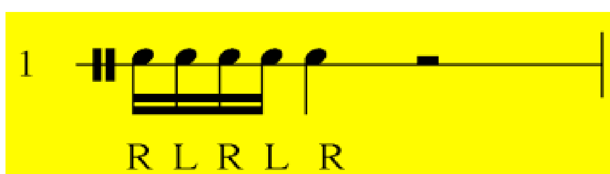
Thank you for your time once again today.

APPENDIX D

REPRESENTATIVE COMPUTER PRESENTATION SLIDES FOR BLOCKED TREATMENT GROUP

Now that you've played these rhythms correctly, you're going to learn sticking patterns that correspond to each one.

- Patterns will be written underneath the rhythms, with an "R" indicating a right hand, and an "L" indicating a left hand.
- As you can see below, these patterns are always arranged so that the right hand always falls on the beat or on the "and" of the beat.



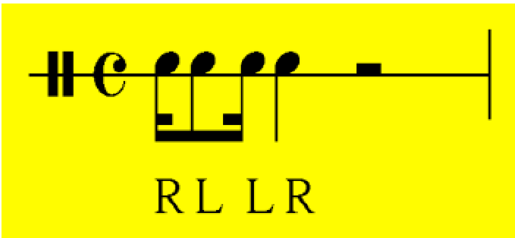
Try your best to remember the sticking patterns that go along with each rhythm.

- At times during this practice, you will be asked to play the rhythms without the patterns provided.

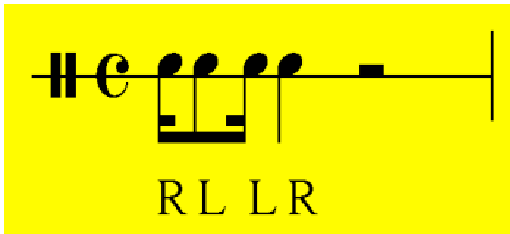
- After the practice session, you'll perform retention and transfer tasks in which you will play the rhythms without the help of sticking patterns underneath. All playing will be done with the metronome, using the same tempo of 68 beats per minute.

- When you indicate that you are ready, the metronome will be started and you may begin.

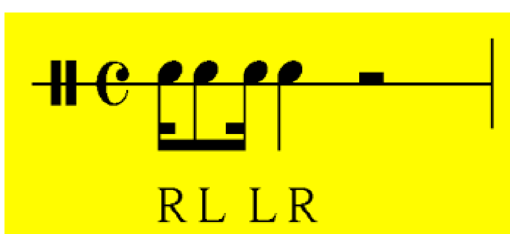
Rhythm #4, Trial #1



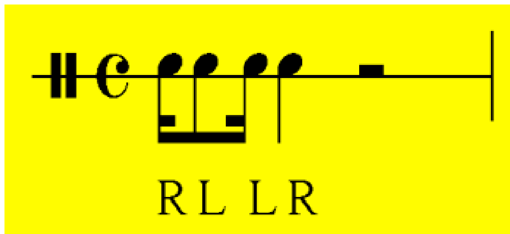
Rhythm #4, Trial #2



Rhythm #4, Trial #3



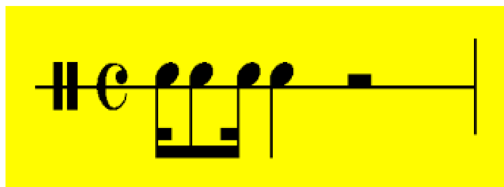
Rhythm #4, Trial #4



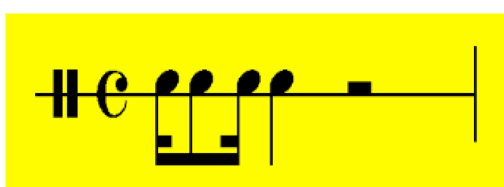
Now you're going to play the rhythms again without the sticking patterns written underneath.

Try your best to play the correct sticking pattern for the rhythm provided.

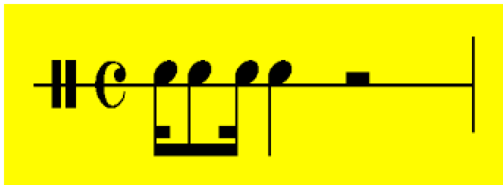
Rhythm #4, Trial #5



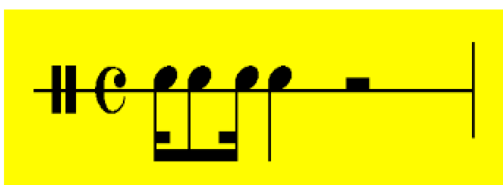
Rhythm #4, Trial #6



Rhythm #4, Trial #7



Rhythm #4, Trial #8



APPENDIX E

REPRESENTATIVE COMPUTER PRESENTATION SLIDES FOR VARIED TREATMENT GROUP

Try your best to remember the sticking patterns that go along with each rhythm.

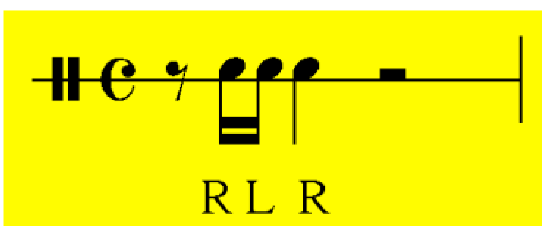
- At times during this practice, you will be asked to play the rhythms without the patterns provided.

- After the practice session, you'll perform retention and transfer tasks in which you will play the rhythms without the help of sticking patterns underneath. All playing will be done with the metronome, using the same tempo of 68 beats per minute.

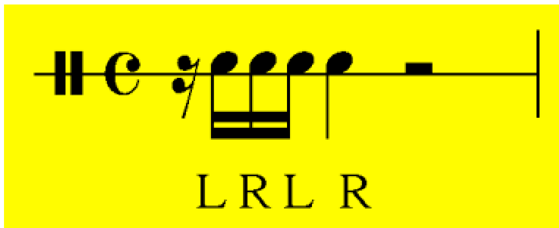
- When you indicate that you are ready, the metronome will be started and you may begin.

Rhythm #6, Trial #1

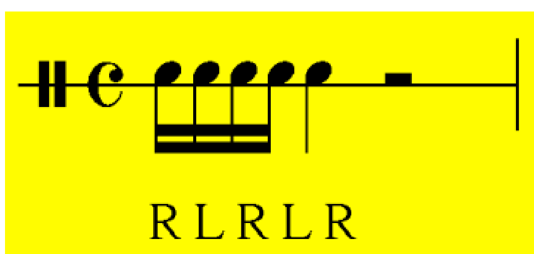
Rhythm #9, Trial #1



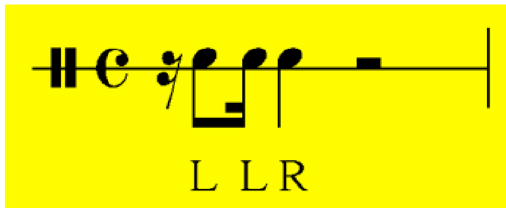
Rhythm #5, Trial #1



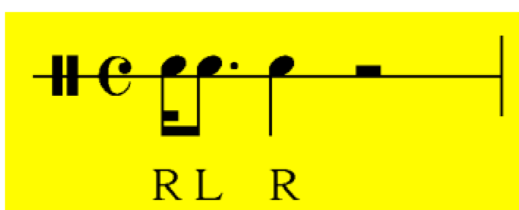
Rhythm #1, Trial #1



Rhythm #10, Trial #1

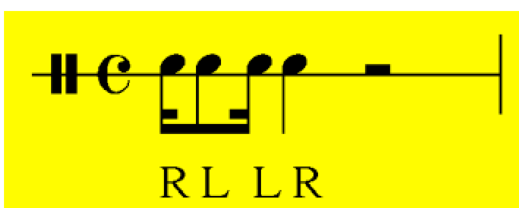


Rhythm #8, Trial #1

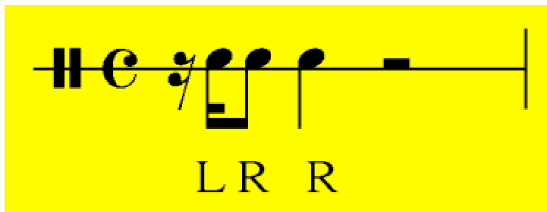


Rhythm #3, Trial #1

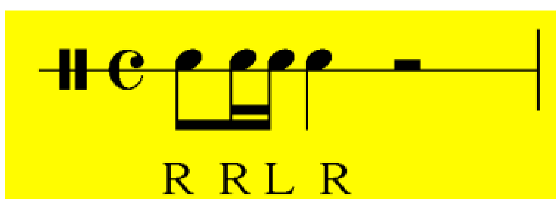
Rhythm #4, Trial #1



Rhythm #7, Trial #1



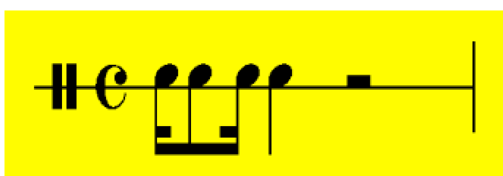
Rhythm #2, Trial #1



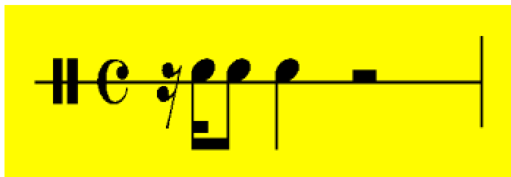
Now, you're going to play the rhythms without the sticking pattern written underneath.

Try your best to play the correct sticking pattern for the rhythm provided.

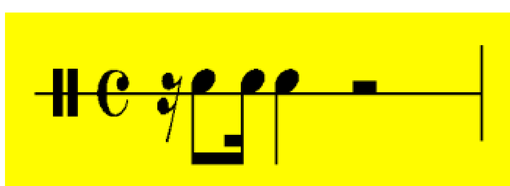
Rhythm #4, Trial #3



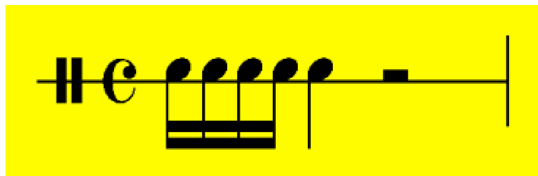
Rhythm #7, Trial #3



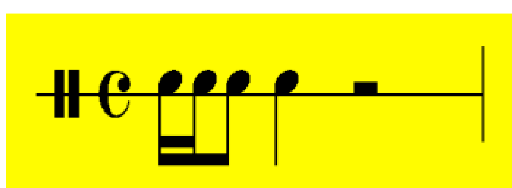
Rhythm #10, Trial #3



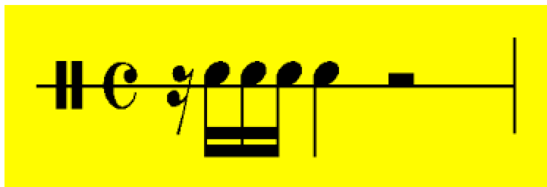
Rhythm #1, Trial #3



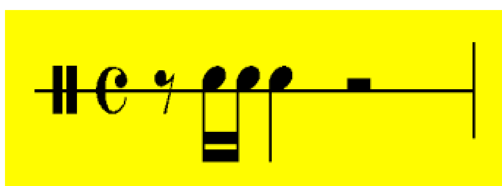
Rhythm #3, Trial #3



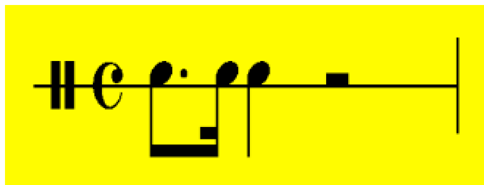
Rhythm #5, Trial #3



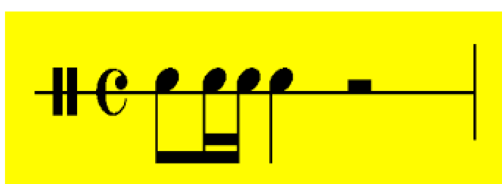
Rhythm #9, Trial #3



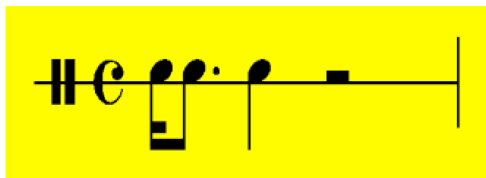
Rhythm #6, Trial #3



Rhythm #2, Trial #3



Rhythm #8, Trial #3



APPENDIX F

iED01 ION ELECTRONIC DRUM KIT

APPENDIX G

REPRESENTATIVE EXAMPLES OF TRANSFER TASK GRADING

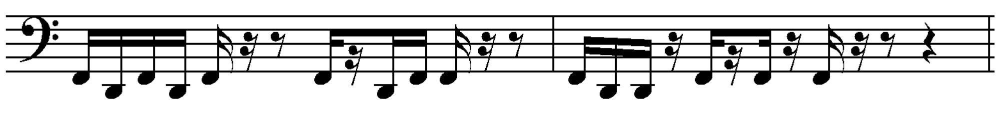
Bars 1-2 of Transfer Task

Note that rhythmic units are underlined.
Rhythmic and Pattern Accuracy are graded as correct or incorrect underneath.

Example 1

Rhythm:	Correct	Correct	Correct
Pattern:	Correct	Correct	Correct

Example 2



Rhythm:	Correct	Correct	Incorrect
Pattern:	Correct	Incorrect	Correct

Example 3

Rhythm:	Correct	Incorrect	Correct
Pattern:	Correct	Correct	Correct

APPENDIX H

MEANS TABLE: RHYTHM AND PATTERN ACCURACY SCORES BY TREATMENT, APPLED AREA, AND TASK

Treatment	Applied Area	Task	Rhythmic Accuracy Mean	S. D.	Pattern Accuracy Mean	S. D.	*N*
Blocked	Nonmanual	Pretest	81.88	16.42	15.00	15.49	16
Blocked	Unimanual	Pretest	90.83	10.84	33.33	16.14	12
Blocked	Bimanual	Pretest	93.33	8.88	34.17	24.29	12
Varied	Nonmanual	Pretest	72.86	20.91	17.86	17.62	14
Varied	Unimanual	Pretest	92.86	12.04	26.43	24.05	14
Varied	Bimanual	Pretest	88.33	18.01	28.33	24.80	12
Control	Nonmanual	Pretest	66.88	24.14	13.13	18.87	16
Control	Unimanual	Pretest	88.33	14.03	40.83	21.51	12
Control	Bimanual	Pretest	82.50	16.03	22.50	21.79	12
Blocked	Nonmanual	Retention 1	80.00	20.98	78.75	19.96	16
Blocked	Unimanual	Retention 1	92.50	12.15	85.00	15.67	12
Blocked	Bimanual	Retention 1	97.50	4.52	93.33	11.55	12
Varied	Nonmanual	Retention 1	89.29	17.30	82.86	21.99	14
Varied	Unimanual	Retention 1	94.29	11.58	90.00	13.01	14
Varied	Bimanual	Retention 1	90.83	17.30	89.17	20.65	12
Control	Nonmanual	Retention 1	64.38	25.81	67.50	24.36	16
Control	Unimanual	Retention 1	91.67	12.67	95.83	7.93	12
Control	Bimanual	Retention 1	90.83	9.96	85.83	15.05	12
Blocked	Nonmanual	Transfer 1	61.72	25.60	63.02	17.00	16
Blocked	Unimanual	Transfer 1	76.04	17.42	64.93	24.13	12
Blocked	Bimanual	Transfer 1	83.33	14.10	71.88	18.04	12
Varied	Nonmanual	Transfer 1	61.31	17.10	53.27	19.89	14
Varied	Unimanual	Transfer 1	81.85	14.76	75.00	12.45	14
Varied	Bimanual	Transfer 1	84.03	19.77	74.65	18.25	12
Control	Nonmanual	Transfer 1	53.39	25.38	57.81	24.00	16
Control	Unimanual	Transfer 1	81.25	20.06	82.29	18.04	12
Control	Bimanual	Transfer 1	77.43	20.52	74.65	21.06	12

Treatment	Applied Area	Task	Rhythmic Accuracy Mean	S. D.	Pattern Accuracy Mean	S. D.	*N*
Blocked	Nonmanual	Retention 2	83.13	17.40	80.63	15.26	16
Blocked	Unimanual	Retention 2	95.00	7.98	85.83	7.30	12
Blocked	Bimanual	Retention 2	94.17	9.96	89.17	17.30	12
Varied	Nonmanual	Retention 2	82.86	20.91	80.71	23.69	14
Varied	Unimanual	Retention 2	93.57	10.08	92.14	8.93	14
Varied	Bimanual	Retention 2	88.33	17.49	84.17	25.75	12
Control	Nonmanual	Retention 2	74.38	27.80	75.63	23.37	16
Control	Unimanual	Retention 2	94.17	9.00	95.83	6.69	12
Control	Bimanual	Retention 2	85.83	14.43	84.17	18.89	12
Blocked	Nonmanual	Transfer 2	63.80	27.33	63.54	17.97	16
Blocked	Unimanual	Transfer 2	81.60	11.85	70.49	18.16	12
Blocked	Bimanual	Transfer 2	81.60	15.64	75.69	16.07	12
Varied	Nonmanual	Transfer 2	63.99	19.38	59.52	21.58	14
Varied	Unimanual	Transfer 2	80.65	18.02	73.81	14.93	14
Varied	Bimanual	Transfer 2	80.90	21.72	78.82	22.36	12
Control	Nonmanual	Transfer 2	48.96	23.74	52.86	18.74	16
Control	Unimanual	Transfer 2	79.17	16.57	83.68	12.37	12
Control	Bimanual	Transfer 2	80.56	16.12	79.86	13.74	12

VITA

A native of Russellville, Kentucky, Leslie Paige Rose graduated from Russellville High School in 1990. Majoring in music education, she completed her Bachelor of Music Education degree from Louisiana State University in Baton Rouge in 1994. While there, she studied percussion with John Raush, and was a member of the Louisiana State University Tiger Marching Band, concert bands, and percussion ensembles. She also performed as a percussionist with the Star of Indiana Drum and Bugle Corps.

In the fall of 1994, Rose accepted a position at Jennings High School in Jennings, Louisiana. She served as director of the marching band, concert band, jazz band, percussion ensemble, and color guard, and also taught art and music in a fine arts survey course. In 1997, she was recognized as the Jeff Davis Parish Arts Council's "Arts Teacher of the Year."

Following seven years at Jennings High School, Rose returned to graduate school, completing the Master of Music Education degree in 2002 from McNeese State University in Lake Charles, Louisiana. Rose studied with Jeffrey Lemke and Judith Hand, completing a thesis entitled "Meeting the National Standards for Music Education through Interdisciplinary Study: Integrating Music Literature and American History In the High School Concert Band." She was also a guest lecturer in the women's studies program, presenting research on Katharine Lee Bates and *America the Beautiful.*

Rose returned to Louisiana State University in 2002 to pursue her doctorate in music education, with a minor area in music history. While serving as a graduate teaching assistant, she also taught in elementary and high school settings around the Baton Rouge area. As a student of James Byo, she presented research at the 2004 and 2006 biennial meetings of MENC: The National Association for Music Education. Most recently, her manuscript entitled "The Freedom Singers of the Civil Rights Movement: Music functioning for freedom" was accepted for

publication in *Update: Applications of Research in Music Education.* Rose will graduate from Louisiana State University in 2006, and has accepted a tenure track position as assistant professor of music education at the University of Central Arkansas in Conway, Arkansas.