The Effects of Aural and Visual Strategies on the Memorization of Beginning-Level String Students: An Exploratory Study

Dissertation

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Abstract

The purpose of the present study was to examine the relative effects of modality-specific strategies on the memorization of beginning-level string players. Modality was expressed in terms of visually and aurally emphasized memorization strategies. Performance achievement was expressed in terms of pitch and rhythmic errors. Beginning-level string students were asked to memorize a simple 8-bar melody in 15 minutes. Errors were assessed at the 5-, 10-, and 15-minute time intervals.

The present study examined three aspects of memorization regarding beginning-level string students: achievement, implementation, and motivation. Questions addressed were:

1) Do beginning-level string students exhibit a significantly different number of pitch errors when comparing their use of aural and visual memorization strategies? 2) Do beginning-level string students exhibit a significantly different number of rhythmic errors when comparing their use of aural and visual memorization strategies? 3) Do beginning-level string students use different strategies to memorize visual and aural musical material? 4) What are beginning-level string students’ attitudes toward memorization?

Results indicated that subjects in the visual treatment group performed significantly fewer pitch errors at the 15-minute assessment point than subjects in the aural treatment group. Subjects in the visual treatment group also performed fewer rhythmic errors at the 15-minute assessment point than subjects in the aural treatment group, but these results
were not significant. Findings suggest that beginning-level string students with 20 months of public school string instruction memorized pitches from a visual medium more efficiently than from an aural medium. Students, however, memorized rhythmic material equally well from both model mediums.

Findings regarding the beginning-level string students’ implementation of aural and visual strategies indicated that 67% to 80% of the rehearsal strategies used by the aural and visual treatment groups were similar; the remaining 20% to 33% were specific to their treatment groups. Two important trends were identified. Beginning-level string students knowingly used self-evaluation as their primary memory strategy; researchers suggest self-evaluation is a vital component of deliberate practice. Results also indicated that a segmental practice approach was more effective than a holistic practice approach in an aural memorization context. Both the segmented and holistic practice approaches were equally effective in a visual memorization context.

Regarding beginning-level string students’ attitude towards memorization, findings from the present study indicate that 61% of beginning-level string students enjoyed participating in the memorization task. Only 26% disliked the experience and 13% were indifferent. Researchers suggest that children participate in music activities because they derive pleasure from the experience. These findings suggest that implementing memorization strategies may encourage students to practice.
Dedication

Dedicated to my loving Father and Mother,
Michael David and Susan Cookson Dakon
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Cheers! Here’s to beginning a new chapter in life. I love you all!
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Fields of Study

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Cognate: String Pedagogy

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Chapter 1: Introduction

The ability to memorize music material is regarded as a fundamental skill in the performing musical arts (McPherson, 2005). This idea has piqued the interest of researchers, pedagogues, and performers alike for decades (Chaffin, et al., 2009; Hallam, 1997; Jesselson, 2009, 2010; McPherson, 1997, 2005; Mishra, 2002a, 2010a; Musco, 2010; Nuki, 1984; Sloboda, 1985; Synder, 2009, 2000). Memorization, however, remains largely misunderstood in the field of music education (Mishra, 2005). The following study will investigate three facets of memorization in beginning-level string students: achievement, implementation, and motivation.

Defining Memorization

Memory is a cognitive mechanism that describes the psychological and physiological processes used by organisms to encode, store, and retrieve mental representations of domain-specific experiences (Baddeley, et al., 2009; Lehmann & Ericsson, 1996; Sloboda, 1985; Snyder, 2000). Memorization is the act of committing information to memory. There are two forms of memorization: incidental and deliberate. Both occur as a result of mental and deliberate practice. Together, these practices develop the domain-specific mental representations needed to memorize information. Domain-specific mental representations are complex cognitive structures made up of higher-level chunks of information that develop as individuals participate in domain-specific
activities. Domain-specific activities are defined by specific constraints, such as features, patterns, vocabulary, and rules. These constraints limit choice; thereby defining the specific characteristics of a particular activity.

Incidental memorization refers to memory recall that occurs automatically (Eagle & Leiter, 1964; Mishra, 2005). It occurs when individuals engage in behaviors or activities pertinent to a specific domain. Researchers have observed this phenomenon in novices (McPherson, 1997, p. 70; see also Frewen, 2010; Hallam, 1997), collegiate students (Mishra, et al., 2010b), and expert musicians (Chaffin & Imreh, 1997; Lehmann & Ericsson, 1996; Miklaszewski, 1989).

If incidental memory does not yield sufficient results, musicians engage in meaningful strategies to memorize music. This phenomenon is known as deliberate memorization (Mishra, 2005; see also Ginsborg, 2004). Deliberate memorization has been studied at length in novices (Flowers, 1987; Frewen, 2010; McPherson, 1995, 1996, 2005), collegiate students (Hallam, 1997; Lehmann, 1997; Lim & Lippman, 1991; Mishra, 2002a; Nuki, 1984; Woody & Lehmann, 2010), experts (Chaffin, et al., 2007; Chaffin & Imreh, 1997; Hallam, 1997; Miklaszewski, 1989; Noice, et al., 2008), and idiot savants (Sloboda, et al., 1985).

*Mental and Deliberate Practice*

Incidental and deliberate memorizations occur as individuals participate in mental and deliberate practice of domain-specific material. Mental practice is defined as the cognitive process of encoding and rehearsing aural or visual input void of self-
perpetuated muscular movement or auditory feedback (Coffman, 1990; Highben & Palmer, 2004; Lim & Lippman, 1991; Mishra, 2005; Rubin-Rabson, 1941). Examples include visual score study or listening to a recording. Such practice develops melodic, harmonic, rhythmic, and formal awareness of a piece prior to applying the musical material to an instrument (Frewen, 2010).

Deliberate practice is a structured system of kinesthetic rehearsal behaviors. Individuals rehearse well-defined, level-appropriate tasks; gather informative feedback originating from self-reflection or other sources; and apply repetition to corrected passages (Ericsson, et al., 1993, p. 27). By engaging in deliberate practice behaviors, musicians apply conceptual knowledge to their instrument in a tactile manner, thereby developing domain-specific skills (Highben & Palmer, 2005). Researchers suggest using both mental and deliberate rehearsal behaviors during practice sessions to optimize skill development (Coffman, 1990; Duke, et al., 2009; Miksza, 2005; Ross, 1985; Theiler & Lippman, 1995).

Developing Mental Representations

The integration of mental and deliberate practice strategies develops domain-specific mental representations (Ericsson & Kintsch, 1995; Ericsson, et al., 1993). A mental representation is a complex structure of domain-specific features, patterns, vocabulary, and rules that are perceived as meaningful to an individual (Lehmann & Ericsson, 1997; Lilliestam, 1996; Sloboda, 1985). These features limit the choices that an individual can undertake, thereby defining the skill being performed. Mental representations vary in size and complexity depending on individuals’ level of experience
The more mental representations a musician cultivates over time from experience, the more efficiently they memorize musical material (Woody & Lehmann, 2010).

Rehearsal Behavior within a Temporal Continuum

Researchers suggest that the development of mental representations (i.e., performance ability) correlates with the amount of time musicians engage in deliberate practice behaviors (Ericsson, et al., 1993, p. 28-29). According to Ericsson, et al., (1993), musicians must accumulate approximately 10,000 hours of deliberate practice over 10 years to develop the mental representations needed to become an expert performer (see also Lehmann & Ericsson, 1997). Similar results have been found in children (O’Neill, 1997). O’Neill (1997) suggests that young musicians practice an average of 15 to 30 minutes per practice session. As they get older, their practice time increases, thereby developing expert-level, domain-specific mental representations (Ericsson & Kintsch, 1995; O’Neill, 1997).

Time engaged in deliberate practice is not the only factor to consider when examining the development of musical mental representations. Researchers suggest that no mental representation exists that controls all musical activities (Lehmann, 1997). Rather, mental representations are domain-specific and develop as musicians participate in activities that share similar performance constraints (Lehmann, 1997; Woody & Lehmann, 2010). Skills, such as memorization, improvisation, sight-reading, and transposition, develop at different rates, which are dependent on the manner of instruction one has received. For example, if a music teacher emphasizes visual modes of instruction,
students’ sight-reading skills may develop at a faster rate than improvisational skills. If, however, aural skills are emphasized, students’ improvisational skills may develop at a faster rate than sight-reading skills (Woody & Lehmann, 2010).

In summary, becoming an expert requires many hours of mental and deliberate practice of domain-specific activities (Ericsson, et al., 1993; Lehmann & Ericsson, 1997). Such repetition enables experts to group large amounts of knowledge and skills into complex mental representations. Novices do not possess such mental representations; therefore, they need more time to learn domain-specific knowledge and skills (Ericsson, 1997).

**Implementation: Memorization Strategies**

Implementing effective strategies during practice is significantly more determinative of students’ success than time spent practicing (Duke, Simmons, & Cash, 2009). Researchers, therefore, have examined the strategies musicians use to memorize musical material at length (Chaffin, et al., 2009; Chaffin & Imreh, 1997; Hallam, 1997; McPherson, 1997, 2005; Miklaszewski, 1989; Mishra, 2002a, 2002b, 2010a; Seddon & Biasutti, 2010).

*Multi-Modal Strategies*

Researchers have found that musicians memorize music significantly better when they use multi-modality strategies (i.e., strategies that use more than one modality) as opposed to single-modality strategies (Hallam, 1997; Lilliestam, 1996; Nuki, 1984; Williamon & Egner, 2004; Williamon & Valentine, 2002). Implementing multi-modality
encoding processes allow musicians to store large amounts of complex repertoire into memory at a more efficient rate (Lehmann & Ericcson, 1997). This phenomenon has been documented extensively in literature discussing mental practice (Coffman, 1990; Highben & Palmer, 2004; Lim & Lippman, 1991; Miksza, 2005; Ross, 1985; Theiler & Lippman, 1995).

Four types of mental practice have been examined: no practice, exclusive visual practice, visual practice combined with an aural model, and visual practice combined with physical practice. Results indicate that: 1) visual practice yields significantly better recall than no practice (Coffman, 1990; Ross, 1985; Theiler & Lippman, 1995); 2) combined forms of mental practice yield significantly better results than exclusive visual practice (Coffman, 1990; Lim & Lippman, 1991; Ross, 1985; Theiler & Lippman, 1995); and 3) physical practice combined with visual mental practice is more effective than exclusive physical practice (Coffman, 1990; Miksza, 2005; Ross, 1985; Theiler & Lippman, 1995). These findings strongly suggest that a relationship exists between memorization ability and the use of multi-modal memorization strategies.

**Modality-Specific Strategies**

The human senses work more efficiently as a unit (Coffman, 1990; Ross, 1985; Theiler & Lippman, 1995). It is, therefore, difficult to control modality when measuring student learning. As a result, the majority of memorization experiments examine memorization in quasi-experimental environments in which one modality-specific stimulus is emphasized over another. Most studies have examined collegiate musicians (Flowers, 1987; Hallam, 1997; Lehmann, 1997; Lim & Lippman, 1991; Mishra, 2002a;
and expert musicians (Chaffin & Imreh, 1997; Hallam, 1997; Jakobson, et al., 2008; Miklaszewski, 1989; Sloboda, Hermelin, & O’Connor, 1985). Fewer studies have examined memorization rehearsal behaviors in novice (i.e., child) musicians (Flowers, 1987; Frewen, 2010; McPherson, 2005; Révész, 1925). No such studies discuss memorization strategies used by beginning-level string players.

**Visual Memorization Strategies and Rehearsal Behaviors**

Visually emphasized memorization strategies use visualization as the primary encoding process without controlling for aural encoding. Placing a piece of music in front of a beginning-level student and asking him or her to memorize the material is an example of visually emphasized memorization. McPherson (2005) observed children ages 7 to 9 years of age performing music-specific tasks and identified several trends. When visually memorizing music, children study the contours of the melody and the note names, chant rhythms and pitch names, and try to sing the melody. The most successful children were those who sang the melody with accuracy and linked the sound to instrumental fingers while playing the musical work (McPherson, 2005, pp. 21-22).

Mishra (2002) observed collegiate students using four different rehearsal behaviors to visually memorize music: 1) holistic, 2) additive, 3) segmental, and 4) serial strategies. Subjects who used the holistic strategy performed the excerpt in its entirety from beginning to end several times. Subjects who used the additive strategy focused first on a large section of the excerpt. Next, they integrated the newly learned section into the whole work, which they then memorized holistically. Subjects who used the segmental
strategy separated the excerpt into several segments. Each segment was memorized and then linked to the preceding segment. Subjects who used a serial strategy started at the beginning during each trial and demonstrated no clear memorization methodology. The holistic and additive strategies were found to be the most efficient methods of memorization (Frewen, 2010; Hallam, 1997; Mishra, 2002a; Nuki, 1984).

Chaffin and Imreh (1997) found that experts learn music by recognizing and practicing familiar patterns and difficult passages, identifying the formal structure of a work, and connecting the rehearsed passages through more holistic forms of practice. Music memorization usually begins after these strategies have been implemented. Expert performers devise methods of using the musical work’s formal structure to retrieve basic, interpretive, and expressive features in the music (Chaffin & Imreh, 1997; Williamon & Egner, 2004; Williamon & Valentine, 2002). Similar results have been observed in young musicians’ rehearsal behaviors (Palmer & Drake, 1997).

**Aural Memorization Strategies and Rehearsal Behaviors**

Aurally emphasized memorization strategies use the auditory senses as the primary encoding process without controlling visualization. Aural memorization has been labeled playing by ear or ear playing in related literature (McPherson, 1995, 2005; Woody & Lehmann, 2010). Researchers suggest that playing by ear is one of the most fundamental music skills for any musician (McPherson, 1995; see also Campbell, 1995; Greene, 2002; Hamann & Gillespie, 2009; Lilliestam, 1996; Seddon & Biasutti, 2010; Woody & Lehmann, 2010).
Researchers have identified five rehearsal behaviors that musicians use to learn music by ear: instruction, copying, practicing, playing, and evaluation (Seddon & Biasutti, 2010; see also Campbell, 1995; Green, 2002; Lilliestam, 1996, citing Lord, 1960). Musicians receive instruction by listening or studying a work. Next, they copy the material by imitating the previous instructions. The imitated material is then practiced and performed while the performer self-evaluates. Musicians may adjust the order or use varying degrees of each behavior to suit their individual learning style (Seddon & Biasutti, 2010).

McPherson (2005) examined how children play by ear. Some children studied the contour of the melody or associated what they heard with a mental visualization of written notation. Other children chanted the rhythm of the piece or attempted to sing the melody. The children who most successfully memorized the melody chanted the rhythms, sang the melody, and fingered the melody on their instrument.

**Motivation: Students’ Attitude Toward Memorization**

Researchers suggest that children who enjoy their musical experiences are more likely to continue participating in such activities (Duke, Flowers, & Wolfe, 1997; Rife, et al., 2001). The more children practice domain-specific skills, the more likely they are to excel within that domain (Hallam, 2009, citing Gellrich, et al., 1986; Rife, et al., 2001). Since visual and aural memorizations are considered to be important components of music learning (McPherson, 1997, 2005), it seems reasonable to assume that researchers must investigate whether beginning-level musicians enjoy memorizing music. Currently, no research has been found that discusses such a phenomenon.
The Need for the Study

It is an unfortunate reality within public school music education that music programs must constantly advocate for their programs despite past successes (Benham, 2011). One of the most effective advocacy methods is to provide “a vibrant, dynamic, engaging learning experience” for all students (Major, 2010, p. 60). Major (2010) found that principals are more likely to cut a music program if it lacks quality instruction (ibid., pp. 62-63). Producing such quality instruction requires music instructors to teach efficiently within the confines of rehearsal time.

To increase instructional efficiency, researchers suggest that music teachers should teach students how to visually and aurally memorize music material (McPherson, 2005). McPherson (1997, 2005) suggests that aural and visual memorizations are two of five primary skills that every young musician should learn. Even audiences perceive memorized performances to be more expressive and of better quality (Williamon, 1999).

McPherson (1995, 1996) found significant correlations between memorization and sight-reading, which suggests that visual memorization strategies may develop students’ sight-reading abilities. Imitating aural models encourages students to play by ear (i.e., aurally memorize), which yields more accurate intonation and rhythmic performance outcomes (Dickey, 1991; Sang, 1987). Finally, the use of multi-modality memorization strategies (i.e., strategies that incorporate both aural and visual memorizations) have been found to yield significantly better results than using uni-modal memorization strategies (Coffman, 1990; Lim & Lippman, 1991; Miksza, 2005; Ross, 1985; Theiler & Lippman, 1995). Together, these findings suggest that using visual and
aural memorization strategies together, therefore, may increase the overall efficiency of teaching and learning in music classroom.

Much emphasis has been placed on demonstrating how and why aural and visual memorizations are important in music learning. No research, however, has been found that examines how well beginning-level musicians with 20 months of string instruction memorize music material. Understanding such ability levels will provide information on how to increases teaching and learning efficiency of music learning in a heterogeneous string-instructional setting.

**Visual and Aural Approaches**

One instructional approach used to teach string students in a heterogeneous instructional setting is through aural modeling (Hamann & Gillespie, 2009). Researchers suggest that aural modeling significantly increases instructional efficiency in music classrooms when compared to verbal instruction (Dickey, 1991; Sang, 1987). Researchers have found that: 1) modeling aural expectations develops students’ intonation and rhythmic accuracy more efficiently (Dickey, 1991; Sang, 1987); 2) successful teachers use aural modeling throughout their classes and lessons (Colprit, 2000; Duke, 1999; MacLeod, 2010); and 3) students who become aurally familiar with a melody prior to motoric production on an instrument learned the melody more quickly and accurately (Frewen, 2010; Lehmann & Ericcson, 1997). Hamann and Gillespie (2009, p. 38) state the following regarding efficient teaching of playing skills:

Students in early instrumental classes learn the most efficiently by watching teachers model the skills and then attempting to imitate on their instrument. String teachers will want to demonstrate the skill on a string instrument for the students and then give them an opportunity to try it.
A more traditional approach to teaching beginning string students has been through method books and sheet music (Ahmed, 1976; Contor, 1951; Woody & Lehmann, 2010). More than 45 method books have been published since the early twentieth century (Ahmed, 1976; Contor, 1951). It would be difficult to find a musician who was trained in a heterogeneous class setting and has not read music at some point in time. Sloboda (1978) suggests that reading music notation is one of the primary skillsets used to develop beginning-level musicians.

It is hardly necessary to state that a musician with sight-reading facility has an immense advantage over other musicians in nearly all walks of musical life. Many professional musicians could simply not perform their jobs without a high level of note-reading . . . Surely no one would wish to claim that musicians . . . would be worse off for being good readers (p. 4).

McPherson (1995, 1996) found a significant correlation between memorization and sight-reading. This suggests that memorization could develop students’ sight-reading skills.

Multi-modality memorization of musical material yields significantly better results than uni-modality memorization (Coffman, 1990; Lim & Lippman, 1991; Miksza, 2005; Ross, 1985; Theiler & Lippman, 1995). Lim and Lippman (1991) found that integrating aural stimuli into visually presented stimuli yielded significantly higher memory recall of musical material (i.e., pitch, dynamics, and phrasing components). Theiler and Lippman (1995) found this effect to be especially true for vocalists. Williamon and Egner (2004, p. 39) suggest that individual students may prefer to use one mode of learning to another. “One musician may rely more on visual associations, while another may rely more on aural or kinesthetic” (p. 39; see also Williamon & Valentine, 2002). Teaching students to memorize music using both aural and visual strategies addresses the needs of both student groups.
Glenn (1999) compared sight-reading (i.e., visual) and aural modeling (i.e., aural) instructional approaches in a public school heterogeneous music setting to examine if one medium was significantly more effective than the other. She found no significant difference between initial aural and visual instruction on subjects’ performance ability. Glenn, however, only assessed students’ sight-reading ability at the conclusion of the treatment. No attempt was made to assess students’ memorization skills. Further investigation is needed to examine what effects visual and aural memorizations have on students’ performance ability (i.e., pitch and rhythm).

Visual and Aural Strategies

Researchers have found that middle-school age musicians have difficulties describing the strategies that they use to practice (Rowher & Polk, 2006). Only a few researchers have documented these strategies (McPherson, 2005; see also Palmer & Drake, 1997). It, therefore, remains unclear as to what strategies beginning-level string students use to practice musical material (McPherson, 1997, 2005; see also Frewen, 2010).

Researchers have identified strategies that musicians use in both visual and aural memorization contexts; however, no research has been found that compares these strategies. For example, is it reasonable to assume that students who play by ear use a segmented or holistic approach to practicing? No research has been found to address this issue. The present study documents similarities and differences between visual and aural strategies used by beginning-level string students and addresses various trends.
Motivation and Memorization

Once memorization strategies have been implemented, teachers must motivate students to continue using these strategies. Research suggests that if students enjoy participating in a musical experience, they are more motivated to continue (Duke, Flowers, & Wolfe, 1997; Rife, et al., 2001). Currently, no research has examined young students’ attitude towards memorization. The present study will examine whether beginning-level string students like or dislike the process of memorization.

Maintaining an effective and efficient instructional environment is a vital component of retention in a string program. Hamann and Gillepsie (2009) state, “Teachers need to adapt their instruction to the ways their students best learn.” To achieve this goal, teachers must first understand how their students learn. It is reasonable to assume that some measure of learning can be assessed through memory recall. This study investigates factors that will advance teachers’ knowledge of the: 1) effects of aural and visual strategies on students’ ability to memorize musical material; 2) implementation of memorization through research-based strategies; and 3) key factors that motivate students to continue.

Purpose Statement and Research Questions

The purpose of the present study is to examine the relative effects of modality-specific strategies on beginning-level string players’ memorization ability. Modality was expressed in terms of visually and aurally emphasized memorization strategies. Performance achievement was expressed in terms of pitch and rhythmic errors as they are considered fundamental aspects of music performance at all levels of music education.
Beginning-level string students were asked to memorize a simple 8-bar melody in 15 minutes. Errors were measured at the 5-, 10-, and 15-minute time intervals.

Specific research questions that were addressed in the present study are the following:

1. Do beginning-level string students exhibit a significantly different number of pitch errors when comparing their use of aural and visual memorization strategies?
2. Do beginning-level string students exhibit a significantly different number of rhythmic errors when comparing their use of aural and visual memorization strategies?
3. Do beginning-level string students use different strategies to memorize visual and aural musical material?
4. What are beginning-level string students’ attitudes toward memorization?

Limitations

The following limitations should be considered when interpreting the results of this study. The present study used a sample population of 25 subjects only. As a result, the statistical model was underpowered. The within-subjects variable time in the omnibus Analysis of Variance (ANOVA) model violated assumptions of sphericity and Levene’s Test of Equality of Error Variance. The conclusions should, therefore, be interpreted with caution.
In authentic scenarios, students may have more than 15 minutes to memorize a simple 8-bar melody. Many melodies consist of more than 8 measures. These data do not support generalizations regarding melodies comprised of 9 measures or more, harmony, or temporal constraints surpassing 15 minutes.

Subjects used in the present study indicated that they participated in general music activities while enrolled in elementary school. No efforts were made to measure the effects that such participation had on beginning-level string students’ ability to memorize musical material.

Subjects were interviewed and asked to describe the strategies they used to complete the memorization task. Interview data were verified using subjects’ practice session audio recordings. Strategies that could not be verified through audio recordings were discarded. Findings from the present study, therefore, cannot be generalized to strategies that are verifiable only through visual means.

This present study compares visual memorization with aural memorization. Prior research indicates that multi-modal memorization strategies yield significantly better results than uni-modal strategies. In the case of the present study, visual memorization uses visual, aural, and tactile modalities. Aural memorization uses only aural and tactile modalities. This issue may confound the results of hypotheses one and two.

Subjects’ ability to memorize may be affected by prior experience and enculturation (Mishra, 2005). Students who were enrolled in Suzuki, Music Learning Theory (MLT), or any other musical training prior to this experiment were not eligible to participate; however, no attempt was made to control prior experience resulting from
enculturation. It is possible that subjects may have had prior musical experiences resulting from culturally specific musical behaviors.

Subjects were asked to describe their attitude regarding the memorization task. Since no attempt was made to prepare subjects for the experiment, subjects’ responses may have been biased by the novelty of the experiment. For example, subjects may have reacted positively to questions in an attempt to please the researcher.

**Operational Definitions**

**Encoding**: The process of gathering stimuli from the environment using the sensory registers, and processing them into storable formats within the memory mechanism.

**Recall**: The process of retrieving previously encoded information from long-term memory without the aid of physical cues. Self-perpetuated cognitive search processes retrieve previously encoded mental cues that automatically elicit a target memory.

**Recognition**: The process of retrieving previously encoded information from long-term memory through physical sensory cues that trigger memory traces.

**Domain-Specific Activities**: Activities defined by specific constraints, such as features, patterns, vocabulary, and rules. These constraints limit choice, thereby defining the specific characteristics of a particular activity.

**Domain-Specific Mental Representations**: A complex cognitive structure made up of higher-level chunked information that develops as individuals participate in domain-
specific activities. These mental representations also have been labeled schemata and engrams.

**Mental Practice:** The process of encoding and rehearsing aural or visual input void of self-perpetuated muscular movement or auditory feedback.

**Deliberate Practice:** A structured system of kinesthetic rehearsal behaviors that requires musicians to rehearse well-defined, level-appropriate tasks; gather informative feedback originating from self-reflection or other sources; and apply repetition to corrected passages.

**Incidental Memorization:** The human capacity to memorize stimuli automatically without intent.

**Deliberate Memorization:** Practicing in a deliberate manner with intent to memorize.

**Aural Memorization:** The process of encoding musical information through the auditory sensory registers for the purpose of future recall void of visual cues from music notation. Kinesthetic and haptic encoding may be present when implementing aural memorization strategies; however aural learning must be emphasized.

**Playing by Ear (i.e., Ear-Playing):** A form of aural memorization that requires musicians to imitate music material and integrate it into their performance schema through repeated deliberate practice. Playing by ears requires four processes: instruction (i.e., encoding of information), copying, practice, playing, and evaluation. These processes may occur in any order and vary in degree of intensity.
**Visual memorization**: The process of encoding musical information through the visual sensory registers. Retrieval of information may include recognition and recall. Aural, kinesthetic, and haptic encoding may be present when implementing aural memorization strategies; however, visual learning must be emphasized.
Chapter 2: Review of Literature

Introduction

For decades, music educators have advocated that beginning-level musicians use memorization to learn musical concepts and skills (Applebaum, 1984; Gordon, 2007; Suzuki, 1969; see also Mishra, 2010a). The effects of memorization on beginning-level musicians, however, remain largely misunderstood (Glenn, 1999; Mishra, 2002a). The purpose of this chapter is to review pertinent literature regarding the effect of memorization strategies on beginning-level string students. Three facets of memorization were investigated: achievement, implementation, and motivation.

Defining Musical Memory

Memory is a cognitive mechanism of interconnected physiological processes in the human brain that facilitates encoding, storage, and retrieval of information (Baddeley, 2007; Baddeley, et al., 2009; Squire, 1992; Tulving, 1983). Memorization begins when neurons “alter the strength and number of their connections to each other” through various chemical processes (Bailey & Kandel, 2004; Snyder, 2000, p. 4). Over time, these processes cause physiological changes in the brain known as engrams. Engrams are the foundation of memories (Tulving, 1983). They have traditionally been described in terms of metaphorical structures (i.e., sensory, short-term, working, and long-term
memory) to conceptualize functionality and temporal capacity (Danziger, 2008; Nairne, 1990; Snyder, 2000, 2009).

Researchers define memorization from several different perspectives. In the most general sense, musical memorization has been interpreted as the act of committing to memory, remembering, and reproducing musical material (Nuki, 1984). McPherson (1997, 2005) defines memorization more exclusively. According to McPherson, memorization is visually specific. Students who memorize “provide a faithful reproduction of a pre-existing piece of music that was learned from notation but performed without notation” (McPherson, 2005, p. 9). Alternatively, aurally specific memorization has been labeled “playing by ear” or “ear playing” (McPherson, 2005, p. 10; Musco, 2010; Woody & Lehmann, 2010, p. 101). Playing by ear occurs when “a pre-existing piece of music [is] learned aurally without the aid of notation” (McPherson, 2005, p. 10). For the purposes of this study, memorization describes the general process of committing to memory both visual and aural stimuli within a musical context (Ericsson, et al., 1993; Ericsson & Kintsch, 1995; Tulving, 1983).

This survey of literature is divided into three parts. In Part I, I discuss memory theories, structures, processes, and the development of mental representations. In Part II, I discuss how mental and deliberate practices develop mental representations. In Part III, I discuss studies that are most closely related to performance achievement and memorization, the implementation of memorization, and motivation to memorize.
Part I

Memory Theories

Researchers have developed many theoretical models in an effort to accurately describe the processes involved in memorization. Atkinson and Shiffrin’s (1968) modal model was one of the first definitive milestones in the history of memory models. This highly influential paper perpetuated the multi-system memory paradigm. Rather than support previous models depicting a unitary memory structure, Atkinson and Shiffrin’s (1968) model consisted of three separate memory structures: sensory, short-term, and long-term (Atkinson & Shiffrin, 1968; see also Danziger, 2008).

Despite its utility, the modal model had limitations. It could not justify how individuals performed complex multi-stage procedures under the limited capacity restrictions of short-term memory. In response, Baddeley and Hitch (1974) introduced a multi-component working memory model. They suggested that working memory is part of short-term memory. The mechanism acts as a temporary storage system where task-specific information is held while related activities are performed. It is comprised of three components: a phonological rehearsal and storage loop; a visuo-spatial sketchpad; and an executive center. A fourth component, known as the episodic buffer, was recently added to the model (Baddeley, 2007). The working memory model remains a constant source of scholarly criticism and debate (Baddeley, 2007).

Chase and Ericsson (1982) developed the skilled-memory model in an attempt to explain expert performance of domain-specific skills. One of the foundational principles of this model is the skilled-memory effect. This effect describes experts’ superior recall
of familiar material when compared to those of novices. The model suggests “experts rely on acquired knowledge to recognize, encode, and retain large amounts of information” (Ericsson & Staszewski, 1989, p. 237). Novices do not possess such knowledge and, therefore, exhibit reduced retention of domain-similar information when compared to that of experts. The skilled-memory effect, however, only applies to familiar material. More specifically, experts only demonstrate the skilled-memory effect within their domain of expertise and when the medium is presented in familiar patterns (Ericsson & Staszewski, 1989).

Ericsson and Kintsch (1995) later revised the skilled-memory model to account for the increased amount of working memory research. It was renamed the long-term working memory (LT-WM) theory. The model suggested that, unlike short-term memory, the capacity of working memory increases as domain-specific knowledge is acquired and recalled over time. The increased storage and rehearsal space allows experts to encode, store, and retrieve more domain-specific information than novices, which accounts for the skilled-memory effect. The development, however, is domain-specific and does not always transfer to other fields. A more exhaustive description of this and other models reaches beyond the scope of this dissertation. For a discussion on the history and development of theoretical memory models see Cowen (1995).

Memory Structures

The question of how many memory structures (i.e., processes) exist in the human brain remains controversial (Baddeley, et al., 2009). Most scholars agree that four major memory systems make up the memory mechanism. These include sensory, short-term
(STM), working, and long-term memory (LTM). Each of these systems plays an important role in developing mental representations of domain-specific information.

**Sensory Memory System**

Sensory memory describes the brief storage of modality-specific information (visual, aural, kinesthetic, etc.). Rubin (2006) developed a theoretical model of sensory memory, which he labeled the basic-systems model. The model suggests that sensory memory is comprised of 15 systems used by the human brain to develop episodic, or event-specific memory. Each sensory system is “a separate network, with its own behavioral properties, storage, and neural substrates, [which] interact to produce episodic memories” (Rubin, 2006, p. 278). The most applicable of these systems in a musical context are visual, auditory, motor, structural,¹ linguistic, and emotional memory (Chaffin, et al., 2009). The present study focuses only on the visual and auditory systems.

Visual stimuli are encoded by iconic (i.e., visual) memory (for a review, see Sperling, 1963), whereas aural stimuli are encoded by echoic (i.e., auditory) memory (Crowder & Morton, 1969). According to Cowen (1995), there is a “marked difference” between the storage capacities of iconic and echoic sensory memory (p. 56). Iconic memory lasts for an estimated several hundred milliseconds before decaying (Atkinson & Shiffrin, 1968; Cowen, 1995; Snyder, 2000). Echoic sensory memory lasts for approximately 10-20 seconds (Cowen, 1990; Eriksen & Johnson, 1964; Snyder, 2000). The rate of decay for both sensory memory systems can vary depending on the degree of individuals’ focused attention (Snyder, 2000).

¹ Rubin (2006) refers to the structural memory system as the narrative system.
Short-Term Memory

Short-Term Memory (STM) is the cognitive mechanism responsible for applying meaning to incoming sensory information (Snyder, 2000). This process occurs when individuals become consciously aware of existing stimuli (ibid.). The information, however, decays rapidly due to STM’s limited temporal capacity. Atkinson and Shiffrin (1968) estimated that STM could retain incoming stimuli for approximately 30 seconds. Baddeley, et al., (2009) reduced this temporal capacity to a couple seconds. Snyder (2000) suggested similar estimates of approximately 3 to 5 seconds; however, decay could be prolonged if stimuli contain elements of novelty or complexity.

There is less debate over the information capacity of STM when compared to its temporal capacity. Most researchers agree that STM’s capacity is 7 units of information plus or minus 2 units (Miller, 1956; see also Atkinson & Shiffrin, 1968; Snyder, 2000, 2009). Information units may consist of more than one bit of information. These bundled bits of information are referred to as memory chunks. The amount of information held in STM, therefore, is dependent on the size of these chunks (Snyder, 2000; Williamon & Valentine, 2002).

Working Memory

An important component within STM is working memory, named for its functionality rather than its capacity (Baddeley, 2007; Baddeley & Hitch, 1974). Working memory is a temporary storage system that is used to hold task-specific information while related activities are performed. For example, when performing complex, multi-step problems, working memory stores information from step ‘A’ while the individual
performs step ‘B.’ The individual can then recall the pertinent information from step ‘A’ to complete the problem.

Memory models portray working memory as a three-component system (Baddeley & Hitch, 1974) that can increase in capacity (Ericsson & Kintsch, 1995). The first component of working memory is the visuo-spatial sketchpad. This mechanism helps individuals identify an object and determine where it exists in space. It is comprised of a limited storage and rehearsal mechanism designed specifically for visual and spatial information. The second component is the phonological loop. This system contains an articulatory rehearsal mechanism and a limited phonological store. The phonological loop is designed specifically to process novel vocabulary and acoustical stimuli. These two systems are controlled by a third component of working memory known as the executive control system. The executive control system’s primary function is to regulate what enters and leaves working memory. The most recent addition to the model is the episodic buffer (Baddeley, 2007). Baddeley suggests that the central executive system is incapable of storage and exists in a “purely attentional role” (p. 12). The episodic buffer “form[s] an interface between the three working memory subsystems and long-term memory. It serve[s] as the binding mechanism that allow[s] perceptual information from the subsystems and from long-term memory to be integrated into a limited number of episodes” (Baddeley, 2007, p. 13). Support for the episodic buffer can also be found in Ericsson and Kintsch’s (1995) long-term working memory theory.
Long-Term Memory

Long-term memory (LTM) is defined as a system or group of systems that stores information over long periods of time (Baddeley, et al., 2009, p. 10). There are two types of LTM: declarative and non-declarative memory (see Figure 2.1) (Squire, 1992; Tulving, 1972, 1983). Declarative memories are explicit, meaning the memorized information can be recalled or recognized and explained through verbal means (e.g., recalling the first president of the United States’ name). Non-declarative memories are implicit, meaning the memorized information cannot be verbalized (e.g., catching a ball).

Declarative memory consists of episodic and semantic memory. Episodic memory refers to experienced events, or episodes. Semantic memory refers to factual information no longer associated with experienced episodes. This delineation has earned declarative memory the name “fact-and-event memory” (Squire, 1992, p. 232; Tulving, 1972, 1983). Snyder (2000) hypothesized that all memory begins in episodic form. As transience occurs (i.e., forgetting over the passing of time), the least important information from the original event decays. The remaining predominant information becomes semantic memory.

There are two types of non-declarative memory: procedural (i.e., skill-learning, habits) and implicit non-procedural memory (i.e., priming, simple classic conditioning, and non-associative learning) (Squire, 1992; Squire, et al., 2004). Non-declarative memories are acquired through performance-based experiences. Originally, all non-declarative memory was labeled procedural memory. This term, however, received scrutiny because it was limited to skill-based learning. A “broader and more neutral term”
was needed to define learning abilities that were not procedural or declarative (Squire, 1992, p. 233). Squire and Zola-Morgan (1988) suggested procedural memory should be renamed non-declarative memory.

**Process of Memorization**

Baddeley, et al., (2009, p. 5) states that all memory systems, “whether physical, electronic, or human,” require three capacities: encoding, storage, and retrieval (see also Snyder, 2000). These processes consistently interact, distorting any temporal hierarchy.

During the process of encoding (i.e., entering information into the memory system), incoming environmental stimuli change into storable units of information. The
sensory registers collect the stimuli. Raw data are transmitted through nerve impulses and stored in their respective sensory memory systems. These data then undergo two encoding processes: feature extraction and perceptual categorization. During feature extraction, stimuli that have “various types of correlation or synchronization in time” are extracted from the various sensory memory systems (Snyder, 2000, p. 7). These data then undergo perceptual categorization, a process in which the extracted data are bound together to form perceivable events, or perceptual categories. For example, the color of a flame is processed by the iconic memory system. Shape and size are encoded in spatial memory. Echoic memory encodes the sound of the material being burned, and haptic memory encodes data regarding the amount of heat being produced. Each of these sensory memory systems works together to subconsciously form perceptual categories (Snyder, 2000).

Perceptual categories can take three different paths. They can either decay, transfer to short-term memory, and/or activate similar networks of memories stored in long-term memory. Perceptual categories decay in less than a second if they are not perceived as novel or important. Before they decay, however, they may activate LTM networks of information called conceptual categories (i.e., schemata or mental representations). Each time the activation process occurs, the neural network connections are strengthened (Bailey & Kandel, 2004). Snyder (2000, p. 8) suggests this process can occur at a subconscious level and may account for unconscious perception and memory.

If perceptual categories are encoded in short-term memory, they must be rehearsed within 5 seconds before they begin to decay (Snyder, 2000; Baddeley, et al.,
This rehearsal process occurs in working memory. Information is distributed to either the phonological loop or the visuo-spatial sketchpad, depending on its modality (Baddeley, 2007). During this process, information rehearsed and stored in working memory is reconstructed to information from long-term memory in preparation for permanent storage. These constructed bundles of information form new or altered conceptual categories (i.e., schemata or mental representations) (Lehmann, 1997; Sloboda, 1985; Snyder, 2000).

**Chunking**

One of the most widely accepted processes of information storage in memory is chunking (Miller, 1956; see also Chace & Ericsson, 1982). Chunking is “a way of reducing short-term memory load by coding [information] at a higher level” (Snyder, 2000, p. 257). Each level consists of five to nine chunks of information. These chunks vary in size and are linked by association (e.g., letters in the alphabet or musical pitches). Lower-level chunks contain relatively small chunks of information. Individuals at this level of development can only process a limited amount of information in STM at one time. Higher-level chunks contain larger amounts of information. Although the capacity of STM remains stable at five to nine chunks of information, the size of chunks controls the overall information capacity of STM and allows for faster information encoding.

Chase and Ericsson (1982) examined the chunking phenomenon. Subject SF was asked to memorize digit spans. After participating in the study for two years ($N = 264$), SF was able to memorize 82 digits during one session. When asked how he accomplished this feat, he stated that he was an avid runner and associated groups of digits with
meaningful running times. In essence, SF encoded and stored the digits as meaningful chunks of information that, due to their association to prior mental representations, could quickly be recalled. Chace and Ericsson (1982) concluded that SF retained the digit spans because he used a familiar domain-specific associative process to chunk digits together, thereby substantially decreasing the cognitive load that was placed on this short-term memory.

**Recognition and Recall**

Retrieval is the process of either recalling or recognizing information. The literature regarding these processes is vast, complex, and beyond the scope of this chapter. In this section, I will briefly define recognition and recall.

Recognition is the act of remembering or knowing previously encoded information. Physical sensory cues trigger memory traces that activate memories from long-term storage. For example, looking at a calendar acts as a reminder to attend an event.

Recall relies on self-perpetuated, organized search processes that attempt to retrieve previously encoded cues. These searches “automatically and fluently elicit the target memory” (Mayes & Roberts, 2001). For example, students who are asked to recite the structure of German sixth chord must search through various episodic and semantic memories to find the answer.

The act of recognition requires less of a cognitive load on performers and less time than recall (Baddeley, et al., 2009, p. 186). Recall, however, is used more often
because audiences perceive recall-based performances to be of better quality and expressiveness than recognition-based performance (Williamon, 1999).

The process of encoding directly impacts how information is retrieved. This is known as Tulving’s Encoding Specificity Principle. The principle suggests that memory retrieval is contingent on the contexts from which it was encoded. If the contexts during encoding and retrieval are similar, the probability of retrieval is high. If the contexts vary significantly, individuals may have difficulty retrieving information (Tulving, 1983). For example, learning and performing musical material by memory on the same instrument yields significantly better recall than when musicians change instruments (Mishra & Backlin, 2007). For further information on memory retrieval, see Ericsson and Kintsch (1995).

**Development of Mental Representations**

Encoding, storing, and retrieving information from memory results in the development of mental representations. Many different labels have been applied to mental representations. These labels include schemata (Bruning, et al., 2004), conceptual categories (Snyder, 2000), higher-level chunks of information (Sloboda, 1985; Williamon & Valentine, 2002), and engrams (Tulving, 1983).

Mental representations are cognitive depictions of domain-specific information stored in LTM. They are made up of low-level chunks of information which define contexts by “[limiting] the choices of what can be [performed]” and by cueing memory (Chaffin, et al., 2009; Lehmann & Ericsson, 1997; Rubin, 1995, p. 10; Sloboda, 1985). These lower-level chunks may be comprised of sensory-based features, patterns,
vocabulary, and/or domain-specific rules, among other cognitive material. Together these chunks make up a formula or a recognizable core of information that remains constant even when “exact performances of the formulas vary within given . . . frameworks” (Lilliestam, 1996, p. 203).

The size and complexity of mental representations play a major role in depicting one’s level of expertise. “Experts [rely] on acquired knowledge to recognize, encode, and retain large amounts of information” (Ericsson & Staszewski, 1989, p. 237). Mental representations form the foundation of such knowledge. Novices do not possess these sizable mental representations and, therefore, exhibit reduced retention of domain-similar information when compared to that of experts. This phenomenon is referred to as the skilled-memory effect.

Experts, however, only demonstrate the skilled-memory effect within their domain of expertise and when the medium is presented in familiar patterns (Ericsson & Staszewski, 1989). Upon examining expert performance in chess players, Chase and Simon (1973) found that experts could recall the positions of chess pieces with significantly more accuracy than novices. The researchers concluded that this was due to the extensive pattern-based mental representations experts develop over years of experience. When the pieces were placed in random order, however, experts fared no better than novices at the recall task. In the absence of pattern relationships, experts could no longer rely on their mental representations (Chace & Simon, 1973; for a review, see Ericsson & Staszewski, 1989).
Mental representations are specific to the domain from which they were formed and do not necessarily transfer to other domains (Chase & Ericsson, 1982; Ericsson & Kintsch, 1993). Sloboda (1976) tested this hypothesis and found that musicians performed significantly better than non-musicians in a STM recall task involving music notation. Findings suggest that musicians were able to associate meaning and store information in short-term memory more efficiently than non-musicians. Non-musicians reported that they associated the musical notation with other domain-related contexts, which yielded little success. Sloboda (1976) concluded that musicians’ prior musical experience enabled them to access the LTM mental representations needed to apply meaning to musical stimuli in an efficient manner.

Sloboda’s experiment (1976) demonstrated that musicians develop mental representations by participating in domain-specific activities (Lehmann, 1997). Woody and Lehmann (2010) examined the ear-playing ability of formally trained (i.e., classical) collegiate musicians, who emphasize visual learning strategies when learning music, and vernacular (e.g., popular, jazz, folk, church bands) musicians who emphasize aural strategies when learning music. They found that vernacular musicians memorized aurally presented music stimuli more effectively than formally trained musicians. Woody and Lehmann (2010) attributed this finding to vernacular musicians’ ability to encode aural stimuli more efficiently than the formally trained musicians. Vernacular musicians were able to draw upon more, higher-level mental representations (i.e., chunks) to expedite the memorization process because they had more domain-specific experience.
Lehmann (1997) attempted to identify the domain-specific activities that develop piano accompaniment ability. To do this, he examined memorization, improvisation, sight-reading, and transposition skills of collegiate pianists. Findings indicated significant correlations between accompanying experience and improvisation ($r^2 = .55$) and accompanying experience and sight-reading ($r^2 = .70$). All other relationships (e.g., memorization and transposition skills) were non-significant (range of $r^2 = .22 - .41$). Lehmann (1997) concluded that performance abilities within a musical domain (i.e., accompaniment skills) develop through musical training activities, which “share some of the typical performance constraints of the respective skill” (pp. 153-154).

Although evidence suggests that many mental representations do not transfer from one domain to another, researchers have identified some degree of transfer that occurs when musicians participate in domain-similar activities (Gordon, 2007; Lehmann, 1997; Luce, 1965; McPherson, 1996; Nuki, 1984). McPherson (1995, 1996) examined seventh-through twelfth-grade clarinet and trumpet players’ ability to memorize, play by ear, sight-read, improvise, and perform rehearsed music. Findings indicated strong significant correlations between playing by memory (i.e., visually emphasized memorization), performing rehearsed music, improvising, sight-reading, and playing by ear (range of $r^2 = 0.64 - 0.77$); however, these findings varied by age of subjects. Younger subjects demonstrated fewer significant correlations than older subjects.

McPherson’s findings corresponded with prior findings from Luce (1965) and Nuki (1984), who reported significant correlations ($r^2 = .50$) between sight-reading and playing by ear in ninth- through eleventh-grade instrumental students (Luce, 1965) and
sight-reading and memorization ($r^2 = .49$) in collegiate composers and pianists (Nuki, 1984). Possible correlations also exist between memorization and sight-singing (Nuki, 1984).

In summation, mental representations are domain-specific cognitive depictions that develop as a result of encoding, storage, and retrieval of cognitive information. Mental representations are dependent on two features. They are domain-specific and develop when individuals participate in domain-specific activities. Mental representations from one domain, however, can enhance mental representations from other domains when activities share similar performance constraints.

The present study focused on recall using a short-term memory task. Beginning-level string students (ages 10 to 12) were presented a simple 8-measure melody and told to practice the melody for 15 minutes. They were then asked to recall the presented material without the aid of visual or aural cue structures. This task did not allow sufficient time to store the information completely into long-term memory.

The ability to encode material at deep and meaningful levels increases with expertise (for a review, see Ericsson & Kintsch, 1995). Hypothetically, beginning-level children will, therefore, not have extensive networks of higher-level chunks of information in place and will exhibit difficulties memorizing the melody. To ensure encoding specificity, subjects encoded and retrieved the musical material in the same environment and on the same instruments.
Part II

Memorization is the act of committing domain-specific information to memory. Researchers have examined two forms of music memorization: incidental and deliberate (Eagle & Leiter, 1964; Mishra, 2010b). These forms of memorization transpire as a result of mental practice and deliberate practice of domain-specific activities, the overall product of which is the development of mental representations.

Incidental and Deliberate Memorization

The human capacity to memorize stimuli with some degree of automaticity is labeled as incidental memorization. The sensory registers collect stimuli from the environment and process it through short-term, working, and long-term memories. This phenomenon has been observed in novice, collegiate, and expert musicians (Chaffin & Imreh, 1997; Eagle & Leiter, 1964; Hallam, 1997; Lehmann & Ericsson, 1996; McPherson, 1997; Miklaszewski, 1989; Mishra, 2005, 2010b).

When incidental memorization does not yield sufficient results, memorization must be practiced deliberately. Practicing with intent to memorize, thus, has been termed deliberate memorization (Ginsborg, 2004; Mishra, 2005, 2010b). Research indicates that deliberate memorization yields significantly stronger recall than incidental memorization (Eagle & Leiter, 1964). This is perhaps because individuals develop multiple cue structures during deliberate memorization to trigger one target memory (Chaffin, et al., 2009; Ericsson & Kintsch, 1995; Schacter, 2001; Williamon & Valentine, 2002).
Mental Practice

Mental practice (MP) has been defined as “the covert or imaginary rehearsal of a skill without muscular movement or sound” (Coffman, 1990, p. 187). In other words, MP consists of activities independent of kinesthetic or aural sensory registers (Lim & Lippman, 1991; Rubin-Rabson, 1941). Mishra (2005) suggests, however, that MP is generalizable to more than just the visual modality. It can also be presented in aural, kinesthetic, or mixed modalities (Highben & Palmer, 2004).

Coffman’s definition of mental practice (Miksza, 2005, p. 76) needs to be reconsidered due to two limitations. Coffman states mental practice is “the covert or imaginary rehearsal of a skill without muscular movement or sound” (Coffman, 1990, p. 187). The definition, while clear and concise, does not accurately explain the process used in the study. He neglects to consider the temporal positioning of encoding and rehearsal. According to Coffman’s definition, skills are rehearsed covertly through cognitive processes. In order to rehearse a cognitive skill, the information must first be encoded. Coffman’s definition, therefore, suggests that mental practice occurs after individuals encode visually or aurally presented material; this is impossible. The primary purpose of mental study is to encode information; therefore, Coffman asked subjects to practice mentally written notation as an encoding strategy, not as a rehearsal strategy.

Second, Coffman’s definition excludes aural mental practice (i.e., listening to a recording). This process is vital to the success of the Mother Tongue Method (Suzuki, 1969) and the Music Learning Theory (Gordon, 2007). Frewen (2010) found that when young children become aurally familiar with a melody prior to producing it on an
instrument, they learned the melody significantly faster and with better accuracy than children who are not aurally familiar with the melody (Frewen, 2010; Lehmann & Ericcson, 1997). Researchers also have found that aural models develop students’ intonation and rhythmic accuracy more efficiently (Dickey, 1991; Sang, 1987). Furthermore, successful teachers use aural modeling throughout their classes and lessons (Colprit, 2000; Duke, 1999; MacLeod, 2010). Hallam (1997) found that 47% of the novice musicians she interviewed used aural memorization strategies, whereas only 22% used visual strategies. These data indicate that teachers use aural stimuli to develop musical mental representations.

Mental practice, then, should be defined as the cognitive process of encoding and rehearsing aural or visual input void of self-perpetuated muscular movement or auditory feedback. Such a definition includes both visual and aural development of mental representations. It also circumvents issues resulting from unclear temporal positioning of encoding and retrieving sensory information.

Researchers have examined individuals’ ability to memorize and sight-read music using several forms of mental practice (MP): exclusive visual MP; visual MP with an aural model; various forms of MP, alternating with physical practice; and physical practice with and without auditory feedback. Results of these studies indicate that all forms of MP are effective, but vary in degrees of efficiency. The following results have been found in the music-specific MP literature:
1. The integration of physical practice (PP) with exclusive visual MP yielded significantly better results than no practice (Coffman, 1990; Ross, 1985; Theiler & Lippman, 1995).

2. Physical practice and PP combined with visual MP yielded significantly better results than exclusive visual MP (Coffman, 1990; Lim & Lippman, 1991; Ross, 1985).

3. Visual MP with an aural model yielded significantly better results than exclusive visual MP (Lim & Lippman, 1991). This was especially true for vocalists (Theiler & Lippman, 1995).

4. Physical practice combined with visual MP was as effective or slightly more effective than PP alone (Coffman, 1990; Miksza, 2005; Ross, 1985; Theiler & Lippman, 1995).

5. The effects of MP differ across musical genres (i.e., vocal and instrumental); therefore, the application of MP should be directed to accommodate the encoding needs of each genre (Theiler & Lippman, 1995).

These findings suggest that multi-modal mental practice yields significantly better results than uni-modal mental practice when memorizing musical material (Williamon & Valentine, 2002).

**Deliberate Practice**

Mental practice alone does not increase performance skill; it only increases memory recall. Physical practice develops performance skill (Sloboda & Parker, 1985).
Optimizing learner outcomes from mental practice, therefore, requires some infusion of physical practice (Coffman, 1990; Lim & Lippman, 1991; Ross, 1985).

Researchers have labeled the most efficient form of physical practice as deliberate practice (for a review, see Ericsson, et al., 1993; Lehmann & Ericsson, 1997). Evidence suggests that expert performance skills develop as a result of deliberate practice (ibid.). This phenomenon has been reported in several domains, such as sports, chess, and music (for a review, see Ericsson, et al., 1993).

Deliberate practice is defined by four criteria. It must include: 1) a well-defined and level-appropriate task; 2) informative feedback either from self or an external source; 3) opportunities for error correction; and 4) repetition of the corrected material (Lehmann & Ericsson, 1997, p. 27). To accommodate these criteria, musicians must have sufficient access to appropriate training experiences. This includes access to properly sequenced instruction by an expert or mentor and the provision of suitable training facilities.

Deliberate practice requires sustained effort and concentration. Researchers estimate that musicians must practice an average of 10,000 hours over the course of 10 years to become experts in their field (Ericsson, et al., 1993). This equates to 3 to 5 hours of deliberate practice per day; however, sustained concentration must be maintained throughout each practice session. Achieving this requires a certain degree of motivation on the part of the practitioner. Without such motivation, effort and concentration cannot be sustained. This results in inefficient practice (Lehmann & Ericsson, 1997).

Time spent practicing deliberately equates to experience; experience plays a substantial role in the development of mental representations and performance skill.
(Ericsson, et al., 1993). Lehmann (1997) found that performance skills are less pronounced in novice and amateur performers. Their overall automaticity and pattern recognition, therefore, are less efficient than those of experts, due to insufficient time spent deliberately practicing domain-specific skills (p. 158). As a result, musicians must deliberately practice domain-specific activities to increase their performance ability. Woody and Lehmann (2010) found that formally trained musicians rarely have the opportunity to play by ear (p. 111), whereas vernacular musicians play by ear on a regular basis. Vernacular musicians, therefore, performed significantly better on an aural memory task than formally trained musicians. Chaffin and Imreh (1994) found similar results. Concert performers begin their performance career with 10 to 15 concerti learned and at least six recital programs ready to perform (Williamon, et al., 2002, citing Chaffin & Imreh, 1994). These findings suggest that musicians develop mental representations of performance skill through deliberate practice of domain-specific activities.

A strong correlation between deliberate practice and performance achievement has also been found in young musicians between 8 and 18 years of age (O’Neill, 1997; Sloboda, et al., 1996; Sloboda & Davidson, 1996). Children typically practice 30 minutes per day (Ericsson, et al., 1993; Bloom, 1985b); however, they tend to perceive practice as not enjoyable because it requires high levels of concentrated effort (Howe, et al., 1996). Researchers have identified three factors that encourage young musicians to practice in a deliberate manner. First, Ericsson, et al., (1993) suggest that enjoyment is the most important pre-condition needed to encourage deliberate practice and achievement among young musicians (Duke, Flowers, & Wolfe, 1997; Rife, et al., 2001). Young musicians must perceive deliberate practice to be enjoyable or they will not pursue it. Second,
young musicians must derive intrinsic motivation from practice. This develops as they feel a sense of accomplishment (Sloboda, et al., 1996, p. 288). Finally, parents and teachers must substantially support young musicians during the initial training phases (Duke, 1999; Howe, et al., 1996; Price, 1979). Young musicians tend to practice more often and more efficiently when parents are involved in lessons and practice sessions. Moreover, practice time increases as students spend more time with a teacher (Sloboda, et al., 1996).

Researchers suggest that children need a blend of both formal and informal practice to remain motivated. Sloboda, et al., (1996) defined formal practice as the rehearsal of teacher-assigned tasks (e.g., scales, etudes, pieces). Informal practice is defined as the rehearsal of non-teacher assigned tasks (e.g., playing for fun, performing popular tunes, and improvising). He found that higher-achieving young musicians engage in a significantly larger amount of formal practice than lower-achieving young musicians. These findings correspond with Ericsson, et al., (1993), who found that expert violinists accrue approximately 10,000 hours of deliberate practice by the age of twenty.

**A Model for Developing Expert Performance**

Mental representations are cognitive depictions of domain-specific information. The development of mental representations requires individuals to participate in activities that are specific to a domain (Ericsson, et al., 1993; Ericsson & Kintsch, 1995). Such activities may involve both mental and deliberate practice.

Lehmann and Ericsson (1997) proposed a theoretical model to describe the development of expert performance capabilities. The model is comprised of three stages.
When combined, these stages increase performance ability (Ericsson, 1997). Each of these three stages is dependent on the other two. Desired outcomes cannot be achieved when stages are omitted (Miksza, 2005).

The first stage is goal imaging. This is the process of establishing how a musical event should sound. Performers derive these mental representations from visual and aural cues in written notation and aural models. The second stage is motor production. This defines the implementation of a goal image into physical movements and fine motor skills. Lehmann and Ericsson (1997) suggest that goal imaging and motor production must be “coupled” in order to achieve an expert level of performance (see also Sloboda & Parker, 1985; Woody & Lehmann, 2010). The third and last stage is self-monitoring. Performers must be privy to auditory feedback from their performance for reflection and self-evaluation to take place (Finney & Palmer, 2005). Only then can the necessary changes be made.

Parallels can be drawn between Lehmann and Ericsson’s model (1997) and research regarding mental practice, deliberate practice, and the development of mental representations. Goal imaging is the process of encoding visually and aurally presented information that then is cognitively rehearsed. This process is referred to as mental practice. Stage two is motoric production. When kinesthetic movement is added to mental practice, it becomes physical practice. Physical practice combined with a previously set goal partially fulfills the characteristics of deliberate practice. The remaining characteristics of deliberate practice are fulfilled in stage three, self-monitoring.
Evaluative feedback and repetition of corrected errors are both requisites of deliberate practice.

Once a goal image is created, transference into motoric production is not always immediate or simple. Researchers suggest that transference issues emerge when too much information is processed between goal imaging and motoric production. Woody and Lehmann (2010, p. 112) refer to this phenomenon as the “bottleneck” effect (see also Woody, 2003). The bottleneck effect occurs when the amount of encoded information required to complete a task surpasses the capacity of STM and working memory. The memory mechanism cannot process the information fast enough to ensure an accurate performance. As a result, progress is slow and limited. Transference between goal imaging and motoric production increases only after information is chunked at higher levels. Developing such higher-level chunks (i.e., mental representations) requires deliberate practice.

Summary

Memorization relies on the human capacity to develop mental representations (Lehmann, 1997, p. 152). These cognitive depictions of domain-specific material are created through the process of mental and deliberate practice. Mishra (2005) states, “Practicing, whether or not [it is] the ultimate goal, is memorization” (p. 78). It is, therefore, plausible that the conjoining of mental practice and deliberate practice define the act of memorization.
Part III: Relevant Studies

The relationship between modality and memorization has been a topic of much discussion by researchers and pedagogues for decades (Chaffin, et al., 2009; Hughes, 1915; Jesselson, 2009, 2010; Mishra, 2002b, 2005, 2010a; Musco, 2010; Sloboda, 1985; Snyder, 2000, 2009). The modalities most commonly discussed in music literature include visual, aural, kinesthetic (i.e., motoric), structural (i.e., narrative), linguistic, and emotional memory (Rubin, 2006; see also Chaffin, et al., 2009; Hallam, 1997; Jesselson, 2009; Mishra, 2010a; Nuki, 1984). The present study examines the effects of visual and aural strategies on beginning-level string students’ memorization ability.

Aural and Visual Memorization

Researchers suggest that music teachers should teach students how to visually and aurally memorize music material to increase efficiency of teaching and learning in music instructional environments (McPherson, 2005). McPherson (1997, 2005) states that aural and visual memorizations are two of five primary skills that every young musician should learn. McPherson (1995, 1996) found significant correlations between memorization and sight-reading, which suggests that visual memorization strategies may develop students’ sight-reading abilities. Aural memorization through the imitation of aural models encourages students to play by ear (i.e., aurally memorize), which yields more accurate intonation and rhythmic performance outcomes (Dickey, 1991; Sang, 1987). Finally, the use of multi-modality memorization strategies (i.e., strategies that incorporate both aural and visual memorizations) have been found to yield significantly better results than using uni-modal memorization strategies (Coffman, 1990; Lim & Lippman, 1991; Miksza,
2005; Ross, 1985; Theiler & Lippman, 1995). Using visual and aural memorization strategies together, therefore, may increase the overall efficiency of teaching and learning in music classroom.

Sight-reading and playing by ear are considered forms of visual and aural memorization. Researchers have examining at length how musicians learn to sight-read and play by ear (McPherson, 2005; Sloboda, 1976, 1978; Woody & Lehmann, 2010). An in-depth comparison of these skills is beyond the scope of this chapter. I will, instead, briefly review why sight-reading and playing by ear are important components of musical learning.

Researchers suggest that visualization is the learning modality most often used in the music instructional setting (Woody & Lehmann, 2010). Reading music notation is one of the primary skill sets used to develop beginning-level musicians’ visualization ability. Regarding the acquisition of sight-reading skills, Sloboda (1978) states:

It is hardly necessary to state that a musician with sight-reading facility has an immense advantage over other musicians in nearly all walks of musical life. Many professional musicians could simply not perform their jobs without a high level of note-reading . . . Surely no one would wish to claim that musicians . . . would be worse off for being good readers (p. 4).

Lehmann and McArthur (2002) reviewed sight-reading literature and found that practicing sight-reading enables students to maintain rhythm and meter, avoid looking at their hands, perceive the piece holistically, practice continuity in a performance context, and improvise (p. 145). Woody and Lehmann (2010) found that visually trained musicians memorize visually by analyzing the intervallic relationships, scale degrees, and exact instrumental fingerings used in the piece (Lehmann, 1997, p. 152). This suggests
that sight-reading and visual memorization teach students the detailed structural components of music (e.g., rhythmic structure and intervallic relations).

Researchers indicate that musicians who learn music aurally encode musical stimuli more efficiently than musicians who learn music visually (McPherson, et al., 2002; Woody & Lehmann, 2010). McPherson and Gabrielsson (2002) suggest that all children have a natural predisposition towards recognizing aural patterns. Correspondingly, Gordon (2007) states, “All learning begins with the ear, not the eye, and learning music is no exception” (p. 29). Woody and Lehmann found that musicians who play by ear tend to encode musical material in chordal and harmonic structures (Woody & Lehmann, 2010). Such structures are higher-level chunked units of information than those used in sight-reading and visual memorization. General music typically use

It is reasonable to assume that playing by ear teaches students to view music from a holistic perspective, whereas, visual memorization teaches students to view music from a more detailed perspective. Since researchers have identified the holistic approach as one of the most successful approaches to memorization (Mishra, 2002; see also Frewen, 2010), perhaps ear-playing should precede sight-reading.

Sloboda (1978) points out how practices in contemporary music education contradict these hypotheses:

No one would consider teaching a normal child to read while he was at a very early stage of learning spoken language. Yet it seems the norm is to start children off on reading at the very first instrumental lesson without establishing the level of musical awareness already present. Without some musical knowledge a beginner has no expectancies, which can be used in reading (p. 15).
Woody and Lehmann (2010) suggest that such an unbalanced curriculum stems from perceptions that the playing-by-ear skill should only be practiced by the most gifted of musicians.

McPherson and Gabrielsson (2002) suggest that stressing visual learning more than aural learning in a musical environment decreases the “aural sensitivity” of children’s predisposition to recognize such musical patterns (p. 105). Modeling a sound before introducing it within a written notation format establishes an aural expectation for students to imitate. For example, students play with better intonation when they can compare their applied pitch with an aural model. Students then self-evaluate and make the appropriate adjustments until they achieve the modeled pitch. If these aural expectations are in place when visual material is presented, musicians can associate aural mental images with presented visual stimuli. They can then self-evaluate and make the proper adjustments (Sloboda, 1978). Such activities develop students’ musical sensitivity (McPherson & Gabrielsson, 2002). Despite these findings, it still remains unclear as to which form of memorization (i.e., aural and visual) is superior to the others, either in terms of performance quality or efficiency (Mishra, 2002a).

Prior Instruction and Memorization

Researchers suggest innate modal superiority may not be the primary factor to consider when teaching musical material. Rather, a relationship may exist between mode of instruction and memorization ability (Ericsson & Kintsch, 1995; Woody & Lehmann, 2010). Woody and Lehmann (2010) found that performers who teach themselves by ear tend to memorize aural stimuli more efficiently than visual stimuli (Woody & Lehmann,
2010). Glenn (1999) compared the effects of visual and aural training in a heterogeneous string orchestra class setting. Subjects were divided into two treatment groups. The first group was taught for 3 months using rote strategies. Then they proceeded to learn from musical notation for “a few weeks” (Glenn, 1999, p. 53). The second group was taught using written notation. All subjects were assessed on their body position, instrument position, bow-hand shape, bowing, tone, intonation, correct notes, correct rhythms, and sight-reading. No memorization was required of subjects. Results indicated no significant difference between the two groups. While these findings are not generalizable to beginning-level string subjects’ ability to memorize musical material, Glenn (1999) found no evidence suggesting that one modality was more efficient than another modality. Results from these two studies conflict. More research is needed to clarify if mode of instruction is related memorization ability.

**Memorization Ability Regarding Pitch and Rhythm**

Pitch and rhythmic accuracy are important components of beginning-level performers’ memorization ability (Mishra, 2008) and overall musical development (Colprit, 2000; Hamann & Gillespie, 2009; Kotchenruther, 1998; Zhukov, 2008). Mishra (2008) identified three significant predictors of memorization efficiency: the number of pitches, number of beats, and the complexity of rhythmic patterns. Colprit (2000) found that intonation, pitch accuracy, rhythm, tempo, and style/articulation were discussed most often in Suzuki Method private lessons, a method notated for aural memorization. Kotchenruther (1998) examined rehearsal techniques used in the middle school string orchestra class. He found that middle school string orchestra teachers assess group
rehearsals by note-accuracy/intonation, rhythm, instrument position, and body posture. Zhukov (2008) examined rehearsal structures in collegiate studios. He found that rhythm was the fourth most rehearsed characteristic and pitch was ranked eighth. The first three topics discussed were technique, articulation, and expression. While only speculative, pitch could be rated below technique, articulation, expression, and rhythm because it is already developed at this stage of learning. These findings suggest that pitch and rhythm are fundamental components of performance ability in beginning-, intermediate-, and advanced-level string teaching environments.

**Pitch and Rhythmic Errors by Children**

Musicians at young age can recognize and correct pitch and rhythmic errors, albeit slower than intermediate-level musicians (Drake, et al., 1991, 2000; Palmer & Drake, 1997). Furthermore, children possess the ability to evaluate their performance and plan ahead during a performance. Both of these behaviors develop with skill acquisition (Drake, et al., 2000; Palmer & Drake, 1997).

Drake and Palmer (2000) compared the type of errors made by children and adult musicians. Children make more timing (i.e., rhythmic) errors because they pause frequently to process upcoming material and address errors (ibid., 2000; Williamson & Valentine, 2002). As a result, children tend to focus on melodic content more so than temporal constraints. Advanced musicians, however, make more pitch errors. They tend to focus more on the temporal elements than melodic content (Drake & Palmer, 2000).

Despite these findings, researchers suggest that melodic content is more susceptible to error (i.e., forgetting over a period of time) than rhythmic content (Drake,
Dowling, & Palmer, 1991; Drake & Palmer, 2000; Sloboda & Parker, 1985). Sloboda and Parker (1985) examined the melodic, harmonic, metric, and rhythmic accuracy of four musicians and four non-musicians, ages 19 to 22, while singing a melody. They found that metrical structure was the most preserved characteristic and that melody is highly susceptible to improvisation. These findings suggest that meter provides a structural framework for melodic recall (Sloboda & Parker, 1985, p. 159).

Drake, et al., (1991) also found that melody is highly dependent on the metric framework of a piece. The researchers gave subjects at 5, 7, 9, 11 years of age three trials each to sing a theme, sing a variation, tap the rhythm of a theme, and tap the rhythm of a variation. Each time, the theme and variation was introduced, the researchers displaced the downbeat. No significant difference was found between the treatment groups who sang and tapped the rhythms of the theme and variation. There, however, was a significant difference between the treatment groups who sang the pitches in the theme and variation. They concluded, once again, that meter provides a structural framework for melodic recall.

Drake and Palmer (2000) suggest that children make more rhythmic errors than pitch errors when learning musical material. Sloboda, et al., (1997) and Drake, et al., (1991) suggest that rhythm is the most preserved musical element during memorization. These findings are in disagreement with each other. The present study seeks to clarify this issue by examining whether pitch and rhythm are affected by modality during a memorization task.
Implementation: Modality-Specific Memorization Strategies

Practice strategies are an important part of developing musical skill. Using strategies produces higher-quality performance outcomes when compared to the duration of practice (Duke, et al., 2009). Researchers have examined extensively the strategies musicians use to memorize musical material (Chaffin, et al., 2009; Chaffin & Imreh, 1997; Hallam, 1997; McPherson, 1997, 2005; Miklaszewski, 1989; Mishra, 2002a, 2002b). The present study will examine and compare the strategies that beginning-level string students use when memorizing a simple 8-bar melody.

Researchers found that 70% of eighth-grade instrumentalists describe repetition as the strategy they use most often during practice (Rowher & Polk, 2006). Forty-four (44) percent pinpoint difficult sections; 27% adjust performance tempi; 27% analyze the key and meter; and 17% mark musical directions in their music. Eighth-grade instrumentalists could only describe using an average of three strategies ($M = 2.57$) during practice. It is unknown at this time if this phenomenon was due to a labeling issue or if subjects knew only a limited number of strategies to use.

Visual Memorization Strategies

Visual memorization strategies (VMS) are defined as rehearsal behaviors, which subjects demonstrate when asked to memorize musical material with their visual sensory registers (i.e., looking at sheet music). Researchers suggest that VMS are the most commonly used rehearsal behaviors in formal music educational settings, because music teachers primarily instruct students from written notation (Woody & Lehmann, 2010; Ginsborg, 2004).
Novice, collegiate, and expert musicians visually memorize musical material using holistic, additive, segmental or serial approaches (Mishra, 2002a; see also Hallam, 1997). The holistic approach involves practicing a musical work in its entirety several times over in succession. The additive approach involves learning a large section of a musical work, usually the most difficult material. Once learned, the section is reintroduced into the work and a holistic approach is used. The segmental approach is similar to the additive approach but lacks the holistic component. The work is separated into several segments. Each segment is memorized separately and then linked together with the other previously memorized segments. The serial approach lacks any clear memorization methodology. Of these four approaches, the holistic and additive approaches yield the most successful memory outcomes (Mishra, 2002a; see also Frewen, 2010; Hallam, 1997; Nuki, 1984).

Expert pianists visually memorize musical material in three stages (Chaffin & Imreh, 1997; Miklaszewski, 1989). They recognize familiar patterns, identify formal structure, and develop a retrieval scheme. During the recognition stage, experts play through the musical work to identify familiar melodic, harmonic, and rhythmic patterns. Difficult materials are practiced and fingered; solutions to technical problems are devised (Lehmann, 1997; Woody & Lehmann, 2010). Expert pianists usually memorize their fingerings to increase automaticity.

During the identification stage, experts identify the formal structure of a work to realize its holistic design. They practice linking the sections together through repetition of melodic and harmonic structural boundaries, which then act as retrieval structures. Works
devoid of such structural boundaries tend to be difficult to memorize (e.g., atonal, bi-tonal, or minimalistic music) (Nuki, 1984; Sloboda, et al., 1985).

Experts use three types of technical and musical structures to develop a retrieval scheme in preparation for memorized performance: 1) basic features (i.e., fingerings, technically difficult passages, and musical patterns) (Sloboda, 1978); 2) interpretive features (i.e., phrasing, dynamics, tempo, and pedaling); and 3) expressive features (i.e., expressive qualities or mood of a section). Such structures then are developed into larger hierarchical structures, which have been shown to increase retrieval and the overall quality of performance (Ericsson & Kintsch, 1993; Williamon & Valentine, 2002). Chaffin, et al., (2009) refers to these retrieval schemes as associative chains and content-addressable memories. Associative chains form incidentally as musical material is associated cognitively with previous stated material. Content-addressable memories form when individuals address content through deliberate memorization.

Children, like experts, have been observed using VMS when engaged in memory tasks. McPherson (2005) asked subjects to mentally study a melody for 30 seconds without playing their instruments. After 30 seconds, they were asked to perform the melody twice by memory without the aid of written notation. Each subject was interviewed to acquire data regarding their choice of strategies. Findings indicated that children memorize using the following strategies: 1) melodic contours, 2) note names, 3) rhythms or note names through chant, 4) melody by singing, and 5) melody by fingering through it. The most successful children sang and fingered the melody at the same time (pp. 21-22). These data support Lehmann and Ericsson (1997) and McPherson (1997):
Subjects who successfully transfer a goal image into motoric production quickly demonstrate more accurate performance outcomes than subjects who require more time.

The previously stated studies suggest that children, 7 to 9 years of age, visually memorize musical material by repeatedly playing patterns, chanting, singing, and fingerling through the musical material. They also isolate difficult sections, adjust tempi, and acknowledge key and meter. Hallam (1997) and Williamon, et al. (2002) suggest that children cannot recognize musical structure during the initial years of music instruction; however, it is implemented more often as skill acquisition increases (Palmer & Drake, 1997). Other than McPherson (2005), no other research has been uncovered that examines visual strategies used by children. The present study will elaborate on these findings.

**Aural Memorization Strategies**

Aural memorization strategies (AMS) are defined as rehearsal behaviors which subjects demonstrate when asked to memorize musical material with their auditory sensory registers (i.e., listening to a aural model). Aural memorization is a derivative of playing by ear, which is considered to be “an important, even foundational, musical skill” (Woody & Lehmann, 2010, p. 113; see also Luce, 1965; McPherson, 2005).

Like any skill, the ability to play by ear develops gradually over time from the deliberate practice of similar training activities (Lehmann & Ericsson, 1997). These activities include memorization, improvisation, singing, repeated listenings, and compositional training (Frewen, 2010; McPherson, 1997; Nuki, 1984; Sloboda & Parker, 1985; Woody & Lehmann, 2010).
Ear players learn musical material in five stages: instruction, copying, practice, playing, and evaluation (Seddon & Biasutti, 2010; see also Campbell, 1995; Green, 2002; Lilliestam, 1996). During instruction, performers listen to an aural model (i.e., recordings, expert musicians, or musical leader). They then attempt to copy the aural model, practice replicating it, and play it while adding personal elaborations. Finally, ear players evaluate their performance and decide whether it matches their perceived image of the piece. This cycle continues until the musician settles on an interpretation. There is no definitive sequence of these rehearsal behaviors (Seddon & Biasutti, 2010). Performers often deviate from the sequence to accommodate personal modes of learning. They also spend more time demonstrating instructional behaviors and less time demonstrating evaluative behaviors (ibid.).

McPherson (1997, 2005) examined the strategies used by children to play musical material by ear. Subjects were given a starting pitch and asked to listen to a recording of a melody four consecutive times. They were then asked to reproduce the melody twice, exactly as they heard it. Each subject was then interviewed to acquire data regarding their cognitive processes during the memorization process. Findings indicated that children: 1) memorize the melodic contours, 2) imagine how the notes look on sheet music, 3) chant the rhythm, 4) sing the melody, and 5) finger through the melody in segments. The most successful children coordinated the hand and ear by singing and fingering the melody on their instrument at the same time (pp. 22-23; Lehmann & Ericsson, 1997). Other than McPherson (2005), no other research has been uncovered that examines aural strategies used by children. The present study will elaborate on these findings.
Multi-Modal Strategies

Multi-modality memorization of musical material yields significantly better results than uni-modality memorization (Coffman, 1990; Lim & Lippman, 1991; Miksza, 2005; Ross, 1985; Theiler & Lippman, 1995). Lim and Lippman (1991) found that integrating aural stimuli into visually presented stimuli yielded significantly higher memory recall of musical material (i.e., pitch, dynamics, and phrasing components). Theiler and Lippman (1995) found this effect to be especially true for vocalists.

Shehan (1987) examined the effects of aural and audio-visual strategies to teach rhythmic patterns to young musicians. She found that when aural and visual strategies were combined, subjects required fewer trials to learn rhythmic patterns. Shehan (1987) also concluded that rhythmic music-reading skills are learned most efficiently when rhythmic sounds, associated mnemonics, and notational symbols are combined in a multifaceted approach.

Finney and Palmer (2005) found similar results. The researchers assessed two groups of adult pianists on their ability to memorize a musical excerpt visually. One treatment group practiced a musical excerpt with no auditory feedback (i.e., no sound). The other treatment group practiced the excerpt with auditory feedback. The researchers found no significant difference in performance achievement when subjects were assessed while performing from sheet music. When subjects were asked to recall the excerpt from memory, however, the auditory feedback treatment group performed significantly better than the non-auditory treatment group. Finney and Palmer (2005) termed this phenomenon the “encoding effect” (p. 61). Subjects performed significantly better when
tactile memory was integrated with aural memory. Williamon and Egner (2004, p. 39) stated “the association of retrieval cues to encoded musical information through various modalities is largely individual-specific (e.g., one musician may rely more on visual associations, while another may rely more on aural or kinesthetic)” (see also Williamon & Valentine, 2002).

Motivation: Beginning-Level Students’ Attitude Toward Memorization

Research suggests that musical achievement is correlated with individuals’ feelings of enjoyment and pleasure resulting from participation in musical acts (Rife, et al., 2001; see also Hallam, 2009, citing Gellrich, et al., 1986). Duke, Flowers and Wolfe (1997) found that piano students (ages 5 to 17) most often cited personal pleasure as the primary reason for taking piano lessons. Other reasons cited included development of concentration, discipline, and self-efficacy. Students also cited relaxation as a reason for taking private lessons (Duke, Flowers, & Wolfe, 1997, p. 74). When asked which aspect of playing they liked most, the majority of students cited the music that was assigned to them, popular music notated on sheet music, songs that they compose, and improvisation. Fewer than 6% of subjects selected playing by ear as their favorite aspect of lessons. No students cited memorization. The present study asked if students gain enjoyment from visual and aural memorization of musical material. There is an overall dearth of research that examines students’ attitude towards memorization. It remains unclear at this point in research whether beginning-level string students enjoy the process of memorization enough to continue using it in their practice.
Rife, et al., (2001) developed a 34-item Music Lesson Satisfaction Scale (MLSS) and used it to assess the attitudes of 568 children, 9 to 12 years of age. The researchers suggest that enjoyment plays an important role in a student’s decision to continue private lessons. Children enjoy being challenged and motivated. They also enjoy maintaining concentration. To achieve this, the researchers suggest that teachers increase the amount of performance time in a lesson.

Summary

Research Question No. 1: Do beginning-level string students exhibit a significantly different number of pitch errors when comparing their use of aural and visual memorization strategies?

Research Question No. 2: Do beginning-level string students exhibit significantly different number of rhythmic errors when comparing their use of aural and visual memorization strategies?

Researchers suggest that efficient memorization requires multi-modal forms of mental and deliberate practice. While this is important to consider, these conclusions are difficult for practitioners to implement in the field when they use multiple modes of instruction on a daily basis. There is a dearth of quasi-experimental research that examines the effects of emphasizing one modality over another during a memorization task. The present study examines the effects of visually and aurally emphasized memorization strategies on beginning-level string students’ performance pitch and rhythmic acuity.
One of the primary purposes of this study is to examine if beginning-level string students exhibit significantly different pitch and rhythmic errors when using aural and visual memorization strategies. Researchers suggest that melodic content is more susceptible to errors than rhythmic content (Drake, Dowling, & Palmer, 1991; Sloboda & Parker, 1985). Research, however, also suggests that children de-emphasize rhythm and meter in favor of pitch (Drake & Palmer, 2000). It appears these findings may be dependent on the age of subjects being examined. The present study investigates if modality has an effect on beginning-level musicians’ (ages 10 and 11) pitch and rhythmic acuity.

While ancillary to the primary hypotheses, research suggests that a relationship may exist between prior instruction and memorization ability (Woody & Lehmann, 2010; see also Ericsson & Kintsch, 1995). Glenn (1999) found this not to be the case when analyzing beginning-level string players’ ability to sight-read after visually or aurally emphasized instruction. The present study builds on prior research by examining how the initial mode of instruction affects beginning-level string players’ ability to memorize musical material.

Research Question No. 3: Do beginning-level string students use different strategies to memorize visual and aural musical material?

Researchers have investigated at length what strategies novice, collegiate, and expert musicians use when memorizing musical material. There is, however, insufficient data comparing visual and aural strategies within identical research perimeters. The present student compares aural and visual memorization strategies used by beginning-
level string players to perform a simple 8-bar melody. Similarities, differences, and trends will be identified.

*Research Question No. 4: What are beginning-level string students’ attitudes toward memorization?*

Researchers suggest that when children enjoy a musical activity, they are more likely to continue participating in that activity. Furthermore, music students enjoy practicing music that was assigned to them, popular music notated on sheet music, songs that they compose, and improvisation. Fewer than 6% of subjects selected playing by ear as their favorite aspect of lessons and no students cited memorization. Currently, no research has been found that examines beginning-level string students’ attitudes toward memorization. As a result, it remains unclear as to whether or not students enjoy memorizing musical material and if memorization can be used as a strategy to motivate practice.
Chapter 3: Methodology

Purpose

The purpose of this study was to examine the relative effects of visual and aural memorization strategies on the pitch and rhythmic accuracy of beginning-level string players. Answers to the following hypotheses were addressed:

1. \( H_{01} \): \( \mu_{Ap} = \mu_{Vp} \) There is no significant difference between the number of mean aural and visual pitch errors

   \( H_{A1} \): \( \mu_{Ap} \neq \mu_{Vp} \) Beginning-level string students will display a significantly different number of pitch errors when using aural and visual memorization strategies.

2. \( H_{02} \): \( \mu_{Ar} = \mu_{Vr} \) There is no significant difference between the number of mean aural and visual rhythmic errors.

   \( H_{A2} \): \( \mu_{Ar} \neq \mu_{Vr} \) Beginning-level string students will display a significantly different number of rhythmic errors when using aural and visual memorization strategies.

3. \( H_{03} \): There is no difference between aural and visual strategies used by beginning-level string students to memorize.

   \( H_{A3} \): Aural and visual memorization requires beginning-level string students to use different strategies.
4. $H_{04}$: Subjects will feel indifferent to the process of memorization.

$H_{A4}$: Subjects will enjoy the process of memorization.

Pilot Study

Melody Characteristics

For the pilot study, the researcher composed three different 16-bar melodies to ensure subjects had not heard them prior to the study. Each melody was composed using three specific criteria: 1) the melodies were written in the key of G major and only used pitches on the ‘D’ and ‘A’ strings; 2) the melodies consisted mostly of stepwise motion with small intervalllic leaps (i.e., thirds and fourths), and beginning-level duple rhythmic patterns; 3) the melodies were composed in binary form (i.e., A-A¹) and contained two 8-bar phrases. Each 8-bar phrase was identical in pitch and rhythm except for cadences (see Figure 3.1a, 3.1b, and 3.1c).

![Melody 1](image)

*Figure 3.1a. Melody 1*
Pitches on the ‘D’ string (D-E-F#-G) and the ‘A’ string (A-B-C♮-D) were chosen because contemporary pedagogical methods recommend they be taught first to a heterogeneous class of beginning-level string players (Hamann & Gillespie, 2009). The ‘G’ major scale was chosen because it is a beginning-level scale (ibid., 2009) and incorporates two different finger patterns. Violinists and violists use a 1-2-3-4 on the ‘D’ string (e.g., open D, first-finger E, high second-finger F#, and third-finger G) and a 12-3-4 on the ‘A’ string (e.g., open A, first-finger B, low second-finger C♮, and third-finger D) (see Figure 2a and 2b). Cellists use a 1-3-4 finger pattern on the ‘D’ string (e.g., open
‘D’, first-finger E, third-finger F#, and fourth-finger G) and a 1-2-4 finger pattern on the ‘A’ string (e.g., open A, first-finger B, second-finger C♮, and fourth-finger D) (Hamann & Gillespie, 2009, p. 58). Two different finger patterns were used to determine if subjects’ finger placements were representative of the treatment stimuli or if subjects were relying on muscle memory from prior experience.

Popular melodies, or melodies that are singable and memorable, consist mostly of stepwise motion, small leaps, and simple rhythmic patterns within a one-octave pitch range (Farish, 2009, pp. 52-53). The melodies used in this experiment contained intervallic seconds (53.7%), thirds (16.6%), unisons (11.4%), fourths (9.7%), fifths (6.8%), octaves (1.2%), and sixths (0.6%) (see Table 3.1). Sixty percent (60%) of the intervallic relationships in the melodies had upward and downward stepwise motion; forty percent (40%) were upward and downward leaps (see Table 3.2). The majority of the leaps were major and minor thirds.

Melodies were composed in simple-duple meter (4/4 time) and contained basic rhythmic patterns comprised of quarter, half, and eighth notes. Quarter rests and half rests also were used. The most complex rhythm was the dotted quarter-eighth note pattern (♩ ♪). Syncopation was not included. Melodies 1 and 3 consisted of eight rhythmic patterns (see Table 3.3). Melody 2 consisted of four rhythmic patterns.
Validity of Melodies

The validity of the melodies was established in two ways: 1) singability, and 2) playability. Research indicates that students often sing to memorize music (McPherson, 2005; Nuki, 1984). To determine singability, the researcher contacted a National Board Certified elementary school general music teacher with 18 years of public school teaching experience. This teacher was asked to review each melody carefully. She then was asked to answer a series of questions regarding the singability of the melodies on a third-, fourth-, and fifth-grade level (see Appendix A). Only the intervallic relationships between pitches were considered. Pitch range was ignored because it was specific to pitches on the ‘D’ and ‘A’ string of the violin, viola, and cello, rather than a child’s voice. This teacher verified that all three melodies were singable on a third-, fourth-, and fifth-grade level.
Table 3.1

*Number of Intervals*

<table>
<thead>
<tr>
<th></th>
<th>Unisons</th>
<th>2nds</th>
<th>3rds</th>
<th>4ths</th>
<th>5ths</th>
<th>6ths</th>
<th>Octaves</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Melody 1</td>
<td>8</td>
<td>26</td>
<td>10</td>
<td>7</td>
<td>4</td>
<td>1</td>
<td>0</td>
<td>56</td>
</tr>
<tr>
<td>Melody 2</td>
<td>6</td>
<td>39</td>
<td>7</td>
<td>3</td>
<td>2</td>
<td>0</td>
<td>0</td>
<td>57</td>
</tr>
<tr>
<td>Melody 3</td>
<td>6</td>
<td>29</td>
<td>12</td>
<td>7</td>
<td>6</td>
<td>0</td>
<td>2</td>
<td>62</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>20</strong></td>
<td><strong>94</strong></td>
<td><strong>29</strong></td>
<td><strong>17</strong></td>
<td><strong>12</strong></td>
<td><strong>1</strong></td>
<td><strong>2</strong></td>
<td><strong>175</strong></td>
</tr>
<tr>
<td><strong>Percentage</strong></td>
<td><strong>11.4</strong></td>
<td><strong>53.7</strong></td>
<td><strong>16.6</strong></td>
<td><strong>9.7</strong></td>
<td><strong>6.8</strong></td>
<td><strong>0.6</strong></td>
<td><strong>1.2</strong></td>
<td></td>
</tr>
</tbody>
</table>

Table 3.2

*Motion of Steps and Leaps*

<table>
<thead>
<tr>
<th></th>
<th>US</th>
<th>DS</th>
<th>Total (%)</th>
<th>UL</th>
<th>DL</th>
<th>Total (%)</th>
<th>Grand Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Melody 1</td>
<td>10</td>
<td>15</td>
<td>= 25 (53.0%)</td>
<td>13</td>
<td>9</td>
<td>= 22 (47.0%)</td>
<td>47</td>
</tr>
<tr>
<td>Melody 2</td>
<td>16</td>
<td>23</td>
<td>= 39 (76.5%)</td>
<td>8</td>
<td>4</td>
<td>= 12 (23.5%)</td>
<td>51</td>
</tr>
<tr>
<td>Melody 3</td>
<td>6</td>
<td>23</td>
<td>= 29 (52.0%)</td>
<td>15</td>
<td>12</td>
<td>= 27 (48.0%)</td>
<td>56</td>
</tr>
<tr>
<td><strong>Total (%)</strong></td>
<td><strong>32</strong></td>
<td><strong>61</strong></td>
<td>= <strong>93 (60.0%)</strong></td>
<td><strong>36</strong></td>
<td><strong>25</strong></td>
<td>= <strong>61 (40.0%)</strong></td>
<td><strong>154</strong></td>
</tr>
</tbody>
</table>

*Note.* US = Upward step; DS = Downward Scale; UL = Upward Leap; DL = Downward Leap.
Table 3.3
*Rhythmic Patterns used in Melodies*

<table>
<thead>
<tr>
<th>Melody</th>
<th>Rhythm</th>
<th>Number</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>♩ ♩ ♩ ♩</td>
<td>4</td>
<td>16</td>
</tr>
<tr>
<td></td>
<td>♩ ♩ ♩ ♩</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td></td>
<td>♩ ♩ ♩ ♩</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td></td>
<td>♩ ♩ ♩ ♩</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td></td>
<td>♩ ♩ ♩ ♩</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td></td>
<td>♩ ♩ ♩ ♩</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td></td>
<td>♩ ♩ ♩ ♩</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>♩ ♩ ♩ ♩ ♩</td>
<td>4</td>
<td>16</td>
</tr>
<tr>
<td></td>
<td>♩ ♩ ♩ ♩ ♩</td>
<td>6</td>
<td></td>
</tr>
<tr>
<td></td>
<td>♩ ♩ ♩ ♩ ♩</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td></td>
<td>♩ ♩ ♩ ♩ ♩</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>♩ ♩ ♩ ♩ ♩</td>
<td>4</td>
<td>16</td>
</tr>
<tr>
<td></td>
<td>♩ ♩ ♩ ♩ ♩</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td></td>
<td>♩ ♩ ♩ ♩ ♩</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td></td>
<td>♩ ♩ ♩ ♩ ♩</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td></td>
<td>♩ ♩ ♩ ♩ ♩</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td></td>
<td>♩ ♩ ♩ ♩ ♩</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td></td>
<td>♩ ♩ ♩ ♩ ♩</td>
<td>1</td>
<td></td>
</tr>
</tbody>
</table>

69
To determine playability, three string teacher evaluators with public school string teaching experience ($M = 8.33$ years, $SD = 2.08$) and string performance experience ($M = 17.30$ years, $SD = 5.50$) examined the melodies. Evaluators assessed the melodies to determine if they were playable by students with 1.5 and 2.5 years of string playing experience. Playability was rated on a scale from 1 to 4, with 1 representing “inappropriate” and 4 representing “very appropriate.” All three evaluators verified that the melodies were playable by students with 1.5 and 2.5 years of experience. Melody 1 was considered the most playable (see Table 3.4).

Table 3.4

*Analyses Measuring the Difficulty Level of Melodies Played on String Instruments*

<table>
<thead>
<tr>
<th>Performance Experience</th>
<th>1.5 Years</th>
<th>2.5 Years</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Recording</strong></td>
<td>$M$ ($SD$)</td>
<td>$M$ ($SD$)</td>
</tr>
<tr>
<td>Melody 1</td>
<td>3.67* (0.57)</td>
<td>4.00* (0.00)</td>
</tr>
<tr>
<td>Melody 2</td>
<td>3.00 (1.00)</td>
<td>3.67 (0.57)</td>
</tr>
<tr>
<td>Melody 3</td>
<td>3.00 (0.00)</td>
<td>4.00* (0.00)</td>
</tr>
</tbody>
</table>

*Note.* 1 = inappropriate; 4 = very appropriate; * notates most appropriate melodies.

Recordings were made of the three melodies. An expert violinist, violist, and cellist ($M = 17$ years of experience, $SD = 4.73$) from a large mid-western university recorded each of the three 16-bar melodies five times. Performers were asked to record the melodies without vibrato, dynamics, or phrasing to control for expressivity. All
performances were recorded using a TASCAM Linear PCM Digital Recorder, Model DR-05. The recorder was placed approximately 4 feet from the performer.

Next, all recordings were grouped by melody number (i.e., 1, 2, or 3), randomly ordered, burned to CD, and submitted to the same three string teacher evaluators for rating. Evaluators assessed the pitch accuracy, rhythmic accuracy, tempo consistency, appropriateness of the overall tempo, tone, phrasing, and dynamics of each recording. Pitch and rhythmic accuracy, tempo consistency, general tempo, and tone were rated on a scale of 1 to 7, with 1 being “inappropriate/inaccurate” and 7 being “appropriate/accurate.” Phrasing and tone were rated on a scale of 1 to 7, with 1 being “no expression” and 7 being “most expression.”

Coefficient \( \alpha \) (alpha) between the three evaluators was calculated and found to be 0.949, suggesting a high internal consistency between scores. Viola recordings were discarded for two reasons. First, the evaluators rated them lower than the violin recordings for accuracy and tone. Second, the researcher deemed the violin and viola timbres in the recordings as indistinguishable. The most accurate violin and cello recordings of melodies 1, 2, and 3 that had the clearest tone void of vibrato, phrasing, and dynamics chosen by the researcher for the pilot study.

Two versions of each violin and cello recording of the three melodies were created using the Audacity 1.3.13-Beta Audio Editor. Version 1 consisted of all 16 measures of each melody. Version 2 consisted of only the last 8 measures of each melody. The tempo of each recording was adjusted to 103-104 beats per minute without affecting pitch. This adjustment was made to control for variations in tempi between
recordings. Background noise was eliminated to control for environmental sounds. All other features of the recordings were preserved.

Pilot Experiment

The purpose of the pilot experiment was to collect baseline data regarding the selection of the most appropriate melody for the present study and to establish the appropriate length of the melody. Subjects included sixth- and seventh-grade students ($N = 9$) with only 20 months of public school string orchestra instruction. A mid-western suburban middle school was selected based on the researcher’s personal relationship with the string teacher at the school and the teacher’s consent to participate in the study.

Subjects provided an instrument and bow (i.e., violin, viola, or cello). The school provided a chair and music stand. The researcher provided a stopwatch, a TASCAM Linear PCM Digital Recorder (Model DR-05), compact disks (CD-R), and a Jenson Portable Stereo Compact Disk player (Model CD-472A). Data on the subjects were recorded on a Post-Experiment Interview Form developed by the researcher.

Nine subjects were randomly divided into three groups with three subjects in each melody group (i.e., melody 1, melody 2, and melody 3). Experimentation occurred over the course of two school days. On day 1, subjects aurally memorized an assigned 8-bar melody in 15 minutes. Each subject was assessed at the end of the 15-minute time period and then interviewed. Subjects were asked about the strategies they used during the memorization process and how they felt during the memorization process. On day 2, each group was assigned a different melody. This time, subjects memorized a 16-bar melody in 15 minutes. Subjects were assessed at the end of the 15-minute time period and
interviewed again. The melody and version of the melody (i.e., 8- or 16-bar) that exhibited the fewest pitch and rhythmic errors was used in the study. Only an aural memorization treatment was used because previous research indicated that aural memorization was more difficult for visually trained musicians (Woody & Lehmann, 2010; see also Ginsborg, 2004). In the present study, subjects’ musical training was largely based on written notation.

The mean pitch and rhythmic error scores and standard deviations were calculated for each group. The percentage of errors was also calculated from each mean (see Table 3.5). Findings indicated that the subjects had difficulty memorizing both the entire 8- and the 16-bar melodies. The 8-bar melodies, however, yielded lower percentages of pitch and rhythmic errors than the 16-bar melodies (see Table 3.5). More errors occurred during the second phrase of the 16-bar melodies compared to the first phrase. Memorization of the second cadence also appeared to interfere with the first cadence.

Of the three melodies, melody 1 yielded the fewest number of pitch and rhythmic errors. Subjects who played melody 2 and 3 tended to improvise or quit playing more frequently during the assessment.

To organize qualitative data, subjects’ verbal responses were coded using terminology that best described their answers. For example, when asked how the process of memorization made them feel, one subject replied, “I was scared at first, but then as I got going I got more sure of myself.” This response was coded as “increased confidence.” Another subject stated, “The CD made me frustrated. I just couldn’t get it even though I
Table 3.5

_Pilot Study Results (N = 9)_

<table>
<thead>
<tr>
<th></th>
<th>Pitch Errors</th>
<th>Rhythm Errors</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>8 measures</td>
<td>16 measures</td>
</tr>
<tr>
<td></td>
<td>M (SD) %</td>
<td>M (SD) %</td>
</tr>
<tr>
<td>Melody 1</td>
<td>9.00 (3.00) 30</td>
<td>32.00 (8.00) 56</td>
</tr>
<tr>
<td>Melody 2</td>
<td>10.00 (3.00) 34</td>
<td>37.00 (6.24) 64</td>
</tr>
<tr>
<td>Melody 3</td>
<td>17.67 (2.52) 54</td>
<td>47.00 (3.61) 75</td>
</tr>
</tbody>
</table>

listened to it over and over.” This response was coded as “frustration.” Similar responses were grouped together and polarized. Next, the total numbers of positive and negative responses were added together (see Table 3.6).

An analysis of qualitative data from the interviews revealed that subjects tended to become more frustrated and confused when trying to memorize the 16-bar melody because it was too long. By the end of the melody, subjects forgot how it began.
Alternatively, subjects stated that they enjoyed the challenge and experienced an increase in confidence when they memorized the 8-bar melodies. As a result, the 8-bar version of melody 1 was selected for the study experiment (see Figure 3.3).

Table 3.6

<table>
<thead>
<tr>
<th>Response</th>
<th>8-measure</th>
<th>16-measure</th>
</tr>
</thead>
<tbody>
<tr>
<td>Enjoyable</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>Challenging (Positive)</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Increased Confidence</td>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td>Confusion</td>
<td>0</td>
<td>-2</td>
</tr>
<tr>
<td>Too Difficult</td>
<td>-1</td>
<td>-2</td>
</tr>
<tr>
<td>Frustration</td>
<td>-1</td>
<td>-2</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>5</strong></td>
<td><strong>-3</strong></td>
</tr>
</tbody>
</table>

*Figure 3.3. The Experimental Melody*
Pilot Summary

Three melodies were composed for the pilot study. Content validity was established through expert verification of melodies’ singability and playability. All melodies were perceived as singable for fifth-grade students; melody 1 was perceived as the most playable of the three melodies by beginning-level string players.

Expert performers recorded each melody. The recordings were submitted to expert string teachers for evaluation. The most accurate and least expressive recordings were used for the pilot study. The selected recordings then were edited using the Audacity 1.3.13-Beta Audio Editor to control for tempo variations and background noise.

The composed melodies were tested with nine sixth- and seventh-grade subjects to determine the most appropriate melody for the present study and to determine the appropriate length. Results of the pilot test indicated that subjects had difficulty memorizing the entire 8- and 16-bar melodies and that melody 1 yielded the fewest pitch and rhythmic errors. The 8-bar version of melody 1 was selected for the study experiment.

Minor changes were made as a result of the pilot test. First, test instructions read to the subjects were re-worded for clarity. For example, aural subjects were told they could listen to the melody as many times as they wished during practice sessions. Subjects also were told the researcher would leave the room during their practice sessions. The phrase, “Do not speak while the recorder is turned on,” was changed to, “Do not speak during the test until the recorder is turned off.” This enabled students to speak, chant, or sing note names and rhythms during practice sessions.
Next, two subjects reported they took piano lessons despite efforts to control for previous musical experience in the subject pool. To monitor this issue in the principle study, the following question was added to the post-experiment interview form: “What musical experiences did you have before joining string orchestra class?”

**Study Experiment**

Following the pilot test revisions, the researcher conducted the study experiment. It began with selection of schools.

*Selection of Schools*

Three middle school orchestra programs in two mid-western suburban school districts were selected for the study, based upon the answers to two questions: 1) Did the school district, their principals, and the teacher all agreed to participate in the study, and 2) Did each school have an ample population of potential subjects?

String orchestra teachers were surveyed to acquire data specifying the amount of class time per week they spent with sixth- and seventh-grade students. Results indicate that one teacher met with students 3 days a week for 40 minutes each day. Two teachers indicated they met with students every other day for 45 minutes each day (i.e., five classes bi-weekly).

Teachers also were asked to approximate the amount of class time they devoted to visual and aural instruction each week. Visual instruction was defined as reading musical notation from a music textbook or sheet music. Aural instruction was defined as playing musical excerpts or melodies by ear without the aid of written notation. Class time was
measured on a 7-point scale, with 1 indicating “no time,” 4 indicating “half time,” and 7 indicating “whole time.” (see Appendix B). Results indicated teachers spent more than half of the week teaching visually and less than half of the week teaching aurally.

**Subjects**

Using G*Power Software, version 3.1.2 (Faul, et al., 2009), it was determined that 10 subjects were required in each treatment group to create a power of 80 percent. The researcher ran an F-test ANOVA: repeated measures, within-between interactions, with a moderate effect size 0.50 under Cohen’s standards for two groups and three measurements. The alpha error probability was set at five percent (5%). G*Power assumes equal correlation between repeated measures; therefore, the correlation among representative measures was five-tenths (0.50).

The researcher crosschecked these data with Rochon (1991) to gather more evidence in support of the $n$ value. Rochon (1991) suggests a much more conservative sample size. If the minimum standardized interaction effect ($\theta_{\min}$) was 1.1 ($\mu_1 - \mu_2 = 10, \sigma = 7$) and the correlation between any two adjacent repeated measures ($\rho$) was .05 between three measures ($T = 3$), then a sample of 18 subjects was recommended for each treatment group (Rochon, 1991, p. 1395).

A volunteer sampling process was used to select subjects for the study. Eligibility requirements specified that subjects could have no more than 20 months of string instrument experience and no musical training prior to joining a school string class. Exceptions were made for musical experiences that occurred in elementary school general music courses. These specifications limited the subject pool to sixth- and
seventh-grade beginning-level string students. Subjects who met these exact specifications were given parental permission forms. They had 14 days to return forms signed by parents or guardians. Thirty (30) parental consent forms were returned ($N = 30$, $n = 15$). This sample size was considered moderate by Rochon’s standards (1991).

Subjects ($N = 30$) included 9 males and 21 females, ages 11 to 13 years ($M = 11.87$, $S = 0.78$). Eighteen (18) subjects were White-Caucasian ethnicity (60%), one subject was Black-American (3%), three were Asian (10%), three were Hispanic (10%), and five were Indian (17%). Instrumentation consisted of 21 violinists, 3 violists, and 6 cellists.

Subjects were randomly assigned to treatment groups using a multistage sampling strategy. First, subjects were grouped into clusters by school. Subjects within each cluster were then randomly assigned to a treatment group (see Table 3.7). A manual shuffling technique was used to randomize subjects. The researcher shuffled the parental consent forms and then drew subjects’ names one at a time from within the stack. Names drawn were written on an ordered list that alternated between aural and visual treatment groups (e.g., 1A, 2V, 3A, 4V, etc.). A number and treatment code were assigned to each subject to protect anonymity.

Conducting the Experiment

Two experiment sites were set up at each school to expedite the data collection process. Each recording site was a room that was quiet and large enough to accommodate the needs of the experiment. Subjects provided an instrument and a bow (i.e., violin,
Table 3.7

*Group Contents by School*

<table>
<thead>
<tr>
<th>Cluster</th>
<th>Visual ($n = 15$)</th>
<th>Aural ($n = 15$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>School 1</td>
<td>6</td>
<td>5</td>
</tr>
<tr>
<td>School 2</td>
<td>6</td>
<td>7</td>
</tr>
<tr>
<td>School 3</td>
<td>3</td>
<td>3</td>
</tr>
</tbody>
</table>

viola, or cello). Schools provided a chair and a music stand. The researcher provided a stopwatch, a TASCAM Linear PCM digital recorder (Model DR-05), compact disks (CD-R), and a Jenson Portable Stereo Compact Disk player (Model CD-472A). The experimental melody was presented to subjects in either written notation or as an audio recording on a CD-R disk.

Upon entering the room, the subject was seated in a chair. The visual treatment group was provided a music stand and a copy of the melody notated on manuscript paper. The manuscript was turned face down so that the subject could not see the notation. The aural treatment group was provided with an audio recording of the melody on CD-R and a CD player. The digital recorder was placed approximately 4 feet in front of each subject.
Once the subject was seated, the researcher read the following instructions.

(Visual Group) On the stand in front of you is a melody. When the experiment begins, you will be allowed 40 seconds to study the melody. You may finger through the melody without making any sound. Afterwards, you will then be given 15 minutes to memorize the melody using any means possible. Your progress will be tested at three separate times: 5 minutes, 10 minutes, and 15 minutes. I will leave the room during the 5 minutes before and between tests so you can practice. After each 5-minute practice session, I will return to test your progress. During each test you will have two attempts to play as much of the melody as you can by memory. After each test, you will be asked to choose which trial you liked best. Each test will be recorded. Please do not speak during the tests until the recorder is turned off. You may speak during practice sessions. Do you have any questions? Are you ready?

(Aural Group) On the table next to you is a CD player. Please press ‘play’ on the CD player. Please press ‘stop.’ Do you have any questions on how to operate the CD player? When the experiment begins, you will be given two hearings of the melody on the CD. At this time, you may finger along with the CD but not make any sound. Afterwards, you will be given 15 minutes to memorize the melody using any means possible. You may listen to the CD as many times as you wish. Your progress will be tested at three separate times: 5 minutes, 10 minutes, and 15 minutes. I will leave the room during the 5 minutes before and between tests so you can practice. After each 5-minute practice session, I will return to test your
progress. During each test you will have two attempts to play as much of the melody as you can by memory. After each test, you will be asked to choose which trial you liked best. Each test will be recorded. Please do not speak during the tests until the recorder is turned off. You may speak during practice sessions. The first note of the melody is ‘G’ on the ‘D’ string. Please play a ‘G.’ Do you have any questions? Are you ready?

When subjects indicated they were ready to begin, visual subjects were instructed to turn over the sheet music on the music stand and mentally study it for 40 seconds. Aural subjects were told to turn on the CD player and listen to the melody twice. At the conclusion of this mental study session, the researcher turned on the recorder, started the stopwatch, and left the room to avoid any effect that might result from the researcher’s presence while subjects were practicing. Subjects were then given 5 minutes to practice the melody.

At the conclusion of the 5-minute practice session, the researcher re-entered the room and asked subjects to play the melody twice by memory. Each trial was recorded separately. At the conclusion of the assessment, the researcher started the recorder and the stopwatch and then left the room again for 5 minutes. Assessments occurred at the 5-, 10-, and 15-minute time intervals (see Figure 3.4). The recorder was stopped and started between each practice session and assessment trial.

After the final assessment (i.e., 15 minutes), subjects were interviewed. Demographic information was collected and subjects were asked what strategies they used to memorize the melody. Subjects were also asked how they felt while memorizing
Figure 3.4. Experiment Procedure: There were five stages to the experiment: a mental practice session, three practice sessions, three assessments, and an interview. Each practice session was separated by intervals of five minutes.

The melody. To decrease the chance of biased responses, subjects were informed that their answers would not hurt the researcher’s feelings and that they must answer truthfully. Each interview session was recorded. At the conclusion of the interview, the subject was dismissed from the room. The experiment and interview together lasted approximately 25-30 minutes per student (see Figure 3.4).

Finalization of Data Collection

In preparation for assessment by external evaluators, each subject’s recordings were exported from the TASCOM digital recorders onto a MacBook laptop. The audio files were labeled by a subject code and separated into three folders: 1) practice sessions, 2) assessments, and 3) interviews. Each subject had three practice session recordings, three assessment recordings, and one interview recording. All assessment recordings were randomized using a random number generator, downloaded into iTunes, version 10.3.1, recoded (i.e., 1, 2, 3, 4, . . . 89), and burned to a CD-R.

An assessment package was sent to three evaluators. The package included a CD of the melody, CD of each subject’s assessment recordings, instructions, assessment
forms, score sheets, and an orange and yellow highlighter (see Appendix C1, C2, and C3). The evaluators were asked to submit their results to the researcher within 1 week of receiving the packet. They were paid $100 for their time.

The assessment tool included a copy of the melody and two highlighters (yellow and orange). Evaluators were instructed to mark rhythmic errors in orange and pitch errors in yellow. Pitch errors were defined as pitches missed beyond a reasonable doubt or by an interval of a minor second (half step). Rhythmic errors were defined as duration errors (e.g., the performer holds a pitch longer than its set duration or leaves a pitch before its set duration). Tempo consistency was not measured. The evaluation rules for external evaluators are listed below (see Table 3.8).

Evaluators were given three researcher-developed training recordings of the melody with answer keys to practice the assessment process. To develop the training recordings, pitch and rhythm errors for each of the three recordings were planned and documented on an assessment form. The researcher performed the planned errors on violin and recorded them on a TASCAM Linear PCM Digital Recorder, Model DR-05. The training recordings were edited using the Audacity 1.3.13-Beta Audio Editor to control for tempo variations and background noise. Then they were downloaded into iTunes, version 10.3.1, and burned to a CD alongside subjects’ assessment recordings.

To develop the answer keys, the researcher assessed each training recording three times. The results were triangulated with the original planned errors, and unplanned errors were added to the answer key. Once the answer keys were finalized, they were added to the assessment package.
Quantitative data from the external evaluators were analyzed using SPSS Statistical Package, version 19. A complete analysis of the data is reported in Chapter Four.

To organize and analyze qualitative data, the researcher transcribed subjects’ post-experimental interviews and listened to subjects’ practice session recordings ($N_A = 39; N_V = 35$). For verification purposes, interview data were triangulated with data from subjects’ practice session recordings. Subjects’ descriptions of practice strategies and emotional attitudes towards memorization were grouped by their similarities, labeled, and counted. Subject behaviors observed in the practice recordings were also grouped by their similarities, labeled, and counted. A complete qualitative analysis of the data is reported in Chapter Four.
Table 3.8

Pitch and Rhythm Evaluation Rules Given to External Evaluators

Pitch:

1. Errors in pitch include:
   a. A pitch that is a half-step above or below the printed pitch.
   b. A pitch that is not played.
   c. Improvised performance. Be sure to mark where improvisation begins and ends with a bracket.

2. Non-errors in pitch include:
   a. “Start-over” sections: A student plays a series of pitches and starts over after realizing they made one or several mistakes. Mark any errors that occur in the final performance of the “start-over.”
   b. Corrected pitches: The subject plays the incorrect pitch and corrects it either immediately or in the “start-over.”
   c. Rests: Rests do not count as pitch errors. There are 30 pitches in the melody and 35 rhythms.
   d. Repeated pitches: Repeated pitches are rhythmic errors. They result from right-hand issues as opposed to left-hand issues.
   e. Pauses: A pause is defined as an unintended stop in the subject’s sound production. If a pitch is maintained longer than the printed rhythm, this is a rhythmic error as opposed to a pitch error.

Rhythm:

1. Errors include:
   a. A pitched or silent rhythm (quarter-, half-, eighth-notes, and rests) that is held longer or shorter than its specified duration. Be reasonably liberal in your assessment, since these are beginning-level subjects. Tempo consistency is not being evaluated.
   b. A rhythm or a rest that is not played.
   c. An added pitched-rhythm: The subject plays two quarter-note ‘Ds’ instead of one quarter-note ‘D.’
   d. A repeated pitched-rhythm: The subject plays two eighth-note ‘Ds’ instead of one quarter-note ‘D.’
   e. The subject plays through a rest: This outcome counts as an error for both the pitched-rhythm and the rest.

2. Non-errors include:
   a. “Start-over” sections: A student plays a series of rhythms and starts over after realizing they made one or several mistakes. Mark any errors that occur in the final performance of the “start-over.”
   b. Corrected rhythms: The subject plays the incorrect rhythm and corrects it either immediately or in the “start-over.”
c. Pauses: A pause is defined as an unintended stop in the subject’s sound production. If a pitch is maintained longer than the printed rhythm, mark it as a rhythmic error.

Table 3.8 continued
Chapter 4: Results

Purpose

The purpose of this study was to examine the relative effects of visual and aural memorization strategies on the pitch and rhythmic accuracy of beginning-level string players. The following hypotheses were addressed:

1. $H_{01}: (\mu_{Ap} = \mu_{Vp})$ There is no significant difference between the number of mean aural and visual pitch errors
   $H_{A1}: (\mu_{Ap} \neq \mu_{Vp})$ Beginning-level string students will display a significantly different number of pitch errors when using aural and visual memorization strategies.

2. $H_{02}: (\mu_{Ar} = \mu_{Vr})$ There is no significant difference between the number of mean aural and visual rhythmic errors.
   $H_{A2}: (\mu_{Ar} \neq \mu_{Vr})$ Beginning-level string students will display a significantly different number of rhythmic errors when using aural and visual memorization strategies.

3. $H_{03}: \text{There is no difference between aural and visual strategies used by beginning-level string students to memorize.}$
   $H_{A3}: \text{Aural and visual memorization requires beginning-level string students to use different strategies.}$
4. \( H_{O4} \): Subjects will feel indifferent to the process of memorization.

\( H_{A4} \): Subjects will enjoy the process of memorization.

Data were collected from 30 subjects enrolled in three middle school orchestra programs. Subjects had no more than 20 months of public school string orchestra instruction and no musical training prior to joining their public school string orchestra. Subjects were randomly assigned to two treatment groups. The visual treatment group memorized an 8-bar melody from written notation. The aural treatment group memorized an 8-bar melody using an audio recording of the melody. Subjects were assessed at three separate times: 5 minutes, 10 minutes, and 15 minutes. Assessment recording data were compiled and sent to three external adjudicators for evaluation.

The external evaluators averaged 7 years of public school string teaching experience. All three were violinists and averaged 26 years of performance experience. Evaluators were asked to assess each subject’s three practice assessment recordings \( (n = 89) \) within one week of receiving the packet. Once data were returned, inter-judge reliability was calculated. Coefficient \( \alpha \) (alpha) between the three evaluators was 0.975, suggesting high internal consistency between the evaluators’ scores. See Chapter 3 for more procedural details.

**Subjects**

Subjects eligible to participate in the present study had no more than 20 months of public school string orchestra instruction and no musical training prior to joining a school string class. Exceptions were made for musical experiences that occurred in elementary school general music courses. Twenty-five (25) out of 30 subjects were included in the
analysis. These subjects comprised of 8 males and 17 females between 11 and 13 years of age ($M = 11.88$, $SD = 0.78$). Seventeen (17) subjects were violinists, 3 were violists, and 5 were cellists.

Five subjects (one male, four females) were eliminated from the quantitative and qualitative analyses. Two subjects studied a string instrument for 34 or more months. Three subjects took private piano or violin lessons for 1 or more years prior to participating in the study. Data from these individuals were used in case studies (see Chapter 5).

**String Teachers’ Mode of Instruction**

String orchestra teachers were surveyed to acquire data that approximated the amount of class time they devoted to visual and aural instruction each week (see Appendix B). Visual instruction was defined as reading musical notation from a music textbook or sheet music. Aural instruction was defined as playing musical excerpts or melodies by ear without the aid of written notation. Time was measured on a 7-point scale, with 1 indicating “no time,” 4 indicating “half time,” and 7 indicating “whole time.” Results indicated teachers spent more than half of the week teaching visually and less than half of the week teaching aurally (see Table 4.1).
Table 4.1

Amount of Weekly Class Time Devoted to Visual and Aural Training

<table>
<thead>
<tr>
<th></th>
<th>6th grade (n = 3 classes)</th>
<th>7th grade (n = 2 classes)*</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean (SD)</td>
<td>Mean (SD)</td>
</tr>
<tr>
<td>Visual Instruction</td>
<td>5.00 (1.00)</td>
<td>6.00 (0.00)</td>
</tr>
<tr>
<td>Aural Instruction</td>
<td>2.33 (0.57)</td>
<td>2.00 (0.00)</td>
</tr>
</tbody>
</table>

Note. Data based on a 7-point scale. Seven indicated “whole time;” one indicated “no time.”

*Seventh grade statistics were based on data from two of the three teachers.

Quantitative Analysis

A 2x6 between-subjects, within-subjects factorial design was used in the present study. The between-subjects factor was “modality” (A1 = visual; A2 = aural). The within-subjects factors were “performance constructs” (B1 = rhythm; B2 = pitch) and “time interval” (C1 = 5 minutes; C2 = 10 minutes; C3 = 15 minutes). The dependent variables were pitch and rhythm errors.

Quantitative Results

Assumption Violations in the Omnibus Model

The within-subjects variable time in the omnibus Analysis of Variance (ANOVA) model violated the assumption of sphericity, Mauchly’s W = .698, p = .019. The model also failed Levene’s Test of Equality of Error Variance at the 10-minute pitch level, \( F_{a=.05}(1, 23) = 5.166, p \leq .033 \); 15-minute pitch level, \( F_{a=.05}(1, 23) = 28.276, p \leq .001 \); and 15-minute rhythm level, \( F_{a=.05}(1, 23) = 7.740, p \leq .011 \). The Huynh-Feldt method
was used to adjust for sphericity violations in time ($\epsilon = .848$) because it yielded the greatest power (Keppel & Wickens, 2004, p. 378). To account for the violations of homogeneity of error covariance, the omnibus $\alpha$ (alpha) level was halved ($\alpha = 0.025$), thereby making the test more stringent and reducing the likelihood of type-one error (Keppel & Wickens, 2004, p. 152).

Outcomes with the Huynh-Feldt Epsilon Adjustment

Only 48% of 25 subjects ($n_A = 5$, $n_V = 7$) were able to memorize the 8-bar melody successfully (see Table 4.2). Two criteria were used to determine whether subjects successfully memorized the melody: 1) subjects played the entire melody by memory, and 2) subjects achieved an average of $\leq 7$ pitch and rhythmic errors.

An analysis of the between-subject factor (i.e., modality) indicated no significant effects, $F_{\alpha=.025}(1, 23) = 4.856$, $p = .038$, although substantial difference was present. Within-subject analyses revealed a significant main effect between all levels of time, $F_{\alpha=.025}(1.697, 39.024) = 34.033$, $p \leq .001$, and performance constructs, $F_{\alpha=.025}(1, 46) = 19.173$, $p \leq .001$. Partial Eta Squared ($\omega^2$) was .597 for time and 0.455 for performance constructs. These are medium effect sizes by Cohen’s standards. No other significant effects were found.
Table 4.2

*Subjects’ 15-Minute Assessment Pitch and Rhythmic Error Scores*

<table>
<thead>
<tr>
<th>Subject</th>
<th>Aural (Pitch)</th>
<th>Aural (Rhythm)</th>
<th>Aural (Mean)</th>
<th>Visual (Pitch)</th>
<th>Visual (Rhythm)</th>
<th>Visual (Mean)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>29.33</td>
<td>29.00</td>
<td>29.17</td>
<td>1*</td>
<td>4.67</td>
<td>5.33</td>
</tr>
<tr>
<td>4*</td>
<td>4.33</td>
<td>6.67</td>
<td>5.50</td>
<td>5</td>
<td>4.00</td>
<td>12.00</td>
</tr>
<tr>
<td>6</td>
<td>27.67</td>
<td>27.67</td>
<td>27.67</td>
<td>7*</td>
<td>5.00</td>
<td>9.00</td>
</tr>
<tr>
<td>8</td>
<td>10.00</td>
<td>7.33</td>
<td>8.67</td>
<td>9</td>
<td>6.33</td>
<td>19.33</td>
</tr>
<tr>
<td>10*</td>
<td>7.33</td>
<td>6.67</td>
<td>7.00</td>
<td>12</td>
<td>7.00</td>
<td>12.33</td>
</tr>
<tr>
<td>13*</td>
<td>3.67</td>
<td>5.00</td>
<td>4.33</td>
<td>14*</td>
<td>3.00</td>
<td>4.67</td>
</tr>
<tr>
<td>15</td>
<td>14.00</td>
<td>16.33</td>
<td>15.17</td>
<td>16*</td>
<td>3.00</td>
<td>0.67</td>
</tr>
<tr>
<td>17</td>
<td>26.00</td>
<td>29.00</td>
<td>27.50</td>
<td>18</td>
<td>4.00</td>
<td>10.67</td>
</tr>
<tr>
<td>19</td>
<td>27.33</td>
<td>31.00</td>
<td>29.17</td>
<td>20</td>
<td>7.00</td>
<td>7.33</td>
</tr>
<tr>
<td>21</td>
<td>8.67</td>
<td>10.33</td>
<td>9.50</td>
<td>22*</td>
<td>3.67</td>
<td>2.33</td>
</tr>
<tr>
<td>23*</td>
<td>2.67</td>
<td>7.00</td>
<td>4.83</td>
<td>26*</td>
<td>3.00</td>
<td>10.33</td>
</tr>
<tr>
<td>27</td>
<td>16.33</td>
<td>15.00</td>
<td>15.67</td>
<td>28*</td>
<td>3.00</td>
<td>0.67</td>
</tr>
<tr>
<td>29*</td>
<td>8.33</td>
<td>3.67</td>
<td>6.00</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Note.* * denotes subjects who successfully completed the memorization task.
Table 4.3

Omnibus Statistics for Between- and Within-Group Effects: $Ax(BxCxS)$

<table>
<thead>
<tr>
<th>Effect</th>
<th>df</th>
<th>MS</th>
<th>$F$</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Modality (A)</td>
<td>1</td>
<td>228.687</td>
<td>4.856</td>
<td>.038</td>
</tr>
<tr>
<td>Performance Constructs (B)</td>
<td>1</td>
<td>236.362</td>
<td>19.173</td>
<td>&lt; .001*</td>
</tr>
<tr>
<td>Time (C)</td>
<td>1.697**</td>
<td>1687.440</td>
<td>34.033</td>
<td>&lt; .001*</td>
</tr>
<tr>
<td>Modality*PerfCon</td>
<td>1</td>
<td>13.387</td>
<td>1.086</td>
<td>.308</td>
</tr>
<tr>
<td>Time*Modality</td>
<td>1.697**</td>
<td>78.820</td>
<td>1.590</td>
<td>.219</td>
</tr>
<tr>
<td>Time*PerfCon</td>
<td>2</td>
<td>3.867</td>
<td>1.523</td>
<td>.229</td>
</tr>
<tr>
<td>Time<em>Modality</em>PerfCon</td>
<td>2</td>
<td>6.331</td>
<td>2.494</td>
<td>.094</td>
</tr>
<tr>
<td>S/A (Error)</td>
<td>46</td>
<td>42.062</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>BxCxS/A (Error)</td>
<td>46</td>
<td>2.539</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

*Note. * $p \leq .025$. ** denotes use of the Huynh-Feldt Adjustment.
Table 4.4

Planned Contrasts of Within-Group Effects for the Omnibus Model

<table>
<thead>
<tr>
<th>Effect</th>
<th>Time</th>
<th>df</th>
<th>MS</th>
<th>F</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time</td>
<td>5 min vs. 10 min</td>
<td>1</td>
<td>1131.916</td>
<td>27.893</td>
<td>&lt;.001*</td>
</tr>
<tr>
<td></td>
<td>10 min vs. 15 min</td>
<td>1</td>
<td>368.052</td>
<td>16.157</td>
<td>.001*</td>
</tr>
<tr>
<td>Time*Modality</td>
<td>5 min vs. 10 min</td>
<td>1</td>
<td>26.458</td>
<td>.652</td>
<td>.428</td>
</tr>
<tr>
<td></td>
<td>10 min vs. 15 min</td>
<td>1</td>
<td>40.933</td>
<td>1.792</td>
<td>1.194</td>
</tr>
<tr>
<td>Time*PerfCon</td>
<td>5 min vs. 10 min</td>
<td>1</td>
<td>15.217</td>
<td>1.905</td>
<td>.181</td>
</tr>
<tr>
<td></td>
<td>10 min vs. 15 min</td>
<td>1</td>
<td>2.199</td>
<td>.241</td>
<td>.628</td>
</tr>
<tr>
<td>Time<em>Mod</em>PerfCon</td>
<td>5 min vs. 10 min</td>
<td>1</td>
<td>7.010</td>
<td>.877</td>
<td>.359</td>
</tr>
<tr>
<td></td>
<td>10 min vs. 15 min</td>
<td>1</td>
<td>19.335</td>
<td>2.116</td>
<td>.159</td>
</tr>
<tr>
<td>S/A (Error)</td>
<td>5 min vs. 10 min</td>
<td>23</td>
<td>40.580</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>10 min vs. 15 min</td>
<td>23</td>
<td>22.842</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>CxBxS/A (Error)</td>
<td>5 min vs. 10 min</td>
<td>46</td>
<td>7.990</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>10 min vs. 15 min</td>
<td>46</td>
<td>9.139</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

Note. * p ≤ .025.
Figure 4.1. Time x Modality (Omnibus Model)

Hypothesis 1

H01: ($\mu_{Ap} = \mu_{Vp}$) There is no significant difference between the number of mean aural and visual pitch errors

HA1: ($\mu_{Ap} \neq \mu_{Vp}$) Beginning-level string students will display a significantly different number of pitch errors when using aural and visual memorization strategies.

When rhythmic errors were removed from the model, a planned comparison between pitch error and modality revealed a main effect of modality, $F_{a=.025}(1, 39.597) = 6.979, p = .015$. Within-subject analyses revealed a significant main effect between all levels of time, $F_{a=.025}(1.722, 39.597) = 32.124, p \leq .001$. No other significant effects were found. Based on these data, the null hypothesis is rejected in favor of the alternative
hypothesis. Subjects in the aural group committed significantly more pitch errors than subjects in the visual group. All subjects committed significantly fewer pitch errors at each level of time.

Table 4.5

*Statistics for Between- and Within-Group Effects (Modality*Pitch Errors)*

<table>
<thead>
<tr>
<th>Effect</th>
<th>df</th>
<th>MS</th>
<th>F</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Modality (A)</td>
<td>1</td>
<td>276.096</td>
<td>6.979</td>
<td>.015*</td>
</tr>
<tr>
<td>Time (B)</td>
<td>1.722**</td>
<td>747.727</td>
<td>32.124</td>
<td>&lt; .001*</td>
</tr>
<tr>
<td>Time*Modality</td>
<td>1.722**</td>
<td>66.343</td>
<td>2.850</td>
<td>.077</td>
</tr>
<tr>
<td>S/A</td>
<td>23</td>
<td>39.561</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>BxS/A</td>
<td>39.597**</td>
<td>23.276</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

*Note. * p ≤ .025. ** denotes use of the Huynh-Feldt Adjustment.*

Table 4.6

*Planned Contrasts of Within-Group Effects in the Pitch Model*

<table>
<thead>
<tr>
<th>Effect</th>
<th>Time</th>
<th>df</th>
<th>MS</th>
<th>F</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time</td>
<td>5 min vs. 10 min</td>
<td>1</td>
<td>1004.480</td>
<td>22.791</td>
<td>&lt;.001*</td>
</tr>
<tr>
<td></td>
<td>10 min vs. 15 min</td>
<td>1</td>
<td>341.117</td>
<td>17.159</td>
<td>&lt;.001*</td>
</tr>
<tr>
<td>Time*Modality</td>
<td>5 min vs. 10 min</td>
<td>1</td>
<td>41.830</td>
<td>0.949</td>
<td>.340</td>
</tr>
<tr>
<td></td>
<td>10 min vs. 15 min</td>
<td>1</td>
<td>73.899</td>
<td>3.717</td>
<td>.066</td>
</tr>
<tr>
<td>BxS/A (Error)</td>
<td>5 min vs. 10 min</td>
<td>23</td>
<td>44.074</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>10 min vs. 15 min</td>
<td>23</td>
<td>19.879</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

*Note. * p ≤ .025.*
Figure 4.2. Time x Modality (Pitch Errors)

Hypothesis 2

H_{O2}: (\mu_{Ar} = \mu_{Vr}) There is no significant difference between the number of mean aural and visual rhythmic errors.

H_{A2}: (\mu_{Ar} \neq \mu_{Vr}) Beginning-level string students will display a significantly different number of rhythmic errors when using aural and visual memorization strategies.

When pitch errors were removed from the model, a planned comparison between rhythmic errors and modality revealed no significant effects, \(F_{a=.05}(1, 23) = 3.162, p = .089\). These data suggest the null hypothesis cannot be rejected and should be retained. Within-subjects effects analyses revealed a significant main effect between all levels of
time, $F_{a=.025}(1.679, 38.624) = 32.231, p \leq .001$. Although the number of rhythmic errors did not differ significantly, the aural group committed more rhythmic errors than the visual group. All subjects, however, committed significantly fewer rhythmic errors at each level of time.

Table 4.7

*Statistics of Between- and Within-Group Effects (Modality*Rhythmic Errors)*

<table>
<thead>
<tr>
<th>Effect</th>
<th>df</th>
<th>MS</th>
<th>$F$</th>
<th>$p$-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Modality (A)</td>
<td>1.000</td>
<td>185.741</td>
<td>3.162</td>
<td>.089</td>
</tr>
<tr>
<td>Time (B)</td>
<td>1.679**</td>
<td>942.944</td>
<td>32.231</td>
<td>&lt; .001*</td>
</tr>
<tr>
<td>Time*Modality</td>
<td>1.679**</td>
<td>19.161</td>
<td>.655</td>
<td>.499</td>
</tr>
<tr>
<td>S/A (Error)</td>
<td>23.000</td>
<td>58.734</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>BxS/A (Error)</td>
<td>38.624**</td>
<td>29.256</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

*Note.* $* p \leq .025$. ** denotes use of Huynh-Feldt Adjustment.

Table 4.8

*Planned Contrasts of Within-Group Effects for the Rhythmic Model*

<table>
<thead>
<tr>
<th>Effect</th>
<th>Time</th>
<th>df</th>
<th>MS</th>
<th>$F$</th>
<th>$p$-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time</td>
<td>5 min vs. 10 min</td>
<td>1</td>
<td>1266.962</td>
<td>30.840</td>
<td>&lt;.001*</td>
</tr>
<tr>
<td></td>
<td>10 min vs. 15 min</td>
<td>1</td>
<td>398.087</td>
<td>13.106</td>
<td>.001*</td>
</tr>
<tr>
<td>Time*Modality</td>
<td>5 min vs. 10 min</td>
<td>1</td>
<td>14.591</td>
<td>0.355</td>
<td>.557</td>
</tr>
<tr>
<td></td>
<td>10 min vs. 15 min</td>
<td>1</td>
<td>17.635</td>
<td>0.581</td>
<td>.454</td>
</tr>
<tr>
<td>BxS/A (Error)</td>
<td>5 min vs. 10 min</td>
<td>23</td>
<td>41.081</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>10 min vs. 15 min</td>
<td>23</td>
<td>30.375</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

*Note.* $* p \leq .025$. 99
Figure 4.3. Time x Modality (Rhythmic Errors)

Post-Hoc Blocking Factor

A post-hoc blocking factor “grade level” was introduced into the model to examine if 1 year of chronological maturation between sixth grade ($n = 16$) and seventh grade ($n = 9$) had an effect on subjects’ ability to memorize the melody. Seventh-grade subjects were 1 year older than sixth-grade subjects; subjects from both grades had no more than 20 months of public school string orchestra instruction.

Between-subject data indicated a significant main effect of modality, $F_{a=.025}(1, 21) = 10.107, p = .005$, and grade level, $F_{a=.025}(1, 21) = 9.796, p = .005$. Within-subjects effects analyses revealed a significant main effect between performance construct, $F_{a=.025}(1, 21) = 15.598, p = .001$, and time, $F_{a=.025}(1.919, 40.333) = 25.665, p \leq .001$. A
significant interaction was found between modality and grade level, $F_{a=.025} (1, 21) = 11.011, p = .003$. No other significant effects were found.

Results indicated that sixth-grade subjects in the visual group committed relatively the same number of errors as the seventh-grade subjects. Conversely, sixth-grade subjects in the aural group performed significantly less errors than seventh-grade subjects (see Figure 4.4). While sixth-grade subjects’ number of errors were equivalent between groups, seventh-grade subjects in the aural groups committed nearly twice as many errors than seventh-grade subjects in the visual group on all levels of time (see Table 4.11).

The interaction between grade level and time was not significant. It, however, was substantial ($p = 0.37$).\(^2\) Sixth- and seventh-grade subjects committed relatively the same number of mean errors at the 5-minute level of time. Sixth-grade subjects committed significantly fewer errors than the seventh-grade subjects between the 5- and 10-minute levels of time, $F_{a=.025} (1, 21) = 6.761, p = .017$. The interaction between the 10- and 15-minute levels of time was not significant (see Figure 4.5). These data suggests that older beginning-level string students do not necessarily memorize aurally presented music material better than younger students with the same amount of instruction.

\(^2\) To account for heterogeneity of variance in the 10- and 15-minute levels of time, the $p$-value was reduced to 0.025, thereby decreasing the risk of making a type-one error.
Table 4.9

_Omnibus Statistics for Between- and Within-Group Effects with Grade Level as a Post-Hoc Blocking Factor: AxB(CxDxS)_

<table>
<thead>
<tr>
<th>Effect</th>
<th>df</th>
<th>MS</th>
<th>F</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Modality (A)</td>
<td>1</td>
<td>236.257</td>
<td>10.107</td>
<td>.005*</td>
</tr>
<tr>
<td>Grade Level (B)</td>
<td>1</td>
<td>228.986</td>
<td>9.796</td>
<td>.005*</td>
</tr>
<tr>
<td>Performance Constructs (C)</td>
<td>1</td>
<td>207.708</td>
<td>15.598</td>
<td>.001*</td>
</tr>
<tr>
<td>Time (D)</td>
<td>1.919**</td>
<td>1047.669</td>
<td>25.665</td>
<td>&lt;.001*</td>
</tr>
<tr>
<td>Modality*Grade Level</td>
<td>1</td>
<td>257.390</td>
<td>11.011</td>
<td>.003*</td>
</tr>
<tr>
<td>Modality*PerfCon</td>
<td>1</td>
<td>11.687</td>
<td>.878</td>
<td>.360</td>
</tr>
<tr>
<td>Modality*Time</td>
<td>1.919**</td>
<td>34.137</td>
<td>.836</td>
<td>.436</td>
</tr>
<tr>
<td>Grade Level*Time</td>
<td>1.919**</td>
<td>148.337</td>
<td>3.634</td>
<td>.037</td>
</tr>
<tr>
<td>Grade Level*PerfCon</td>
<td>1</td>
<td>2.325</td>
<td>.175</td>
<td>.680</td>
</tr>
<tr>
<td>Time*PerfCon</td>
<td>2.000**</td>
<td>3.846</td>
<td>1.544</td>
<td>.225</td>
</tr>
<tr>
<td>Modality<em>GdLvl</em>Time</td>
<td>1.919**</td>
<td>.663</td>
<td>.016</td>
<td>.981</td>
</tr>
<tr>
<td>Modality<em>GdLvl</em>PerfCon</td>
<td>1</td>
<td>.927</td>
<td>.070</td>
<td>.794</td>
</tr>
<tr>
<td>Modality<em>PerfCon</em>Time</td>
<td>2.000**</td>
<td>5.956</td>
<td>2.391</td>
<td>.104</td>
</tr>
<tr>
<td>GdLvl<em>PerfCon</em>Time</td>
<td>2</td>
<td>2.711</td>
<td>1.088</td>
<td>.346</td>
</tr>
<tr>
<td>S/AxB (Error)</td>
<td>21</td>
<td>23.377</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>CxS/AxB (Error)</td>
<td>21</td>
<td>13.316</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>DxS/AxB (Error)</td>
<td>40.333**</td>
<td>40.820</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>CxDxS/AxB (Time)</td>
<td>42.000**</td>
<td>2.491</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

_Note._ *p ≤ .025. ** denotes use of the Huynh-Feldt Adjustment.
Table 4.10

Planned Contrasts: Grade Level x Time

<table>
<thead>
<tr>
<th>Effect</th>
<th>Time</th>
<th>df</th>
<th>MS</th>
<th>F</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>GrdLvl*Time</td>
<td>5 min vs. 10 min</td>
<td>1</td>
<td>226.687</td>
<td>6.761</td>
<td>.017*</td>
</tr>
<tr>
<td></td>
<td>10 min vs. 15 min</td>
<td>1</td>
<td>0.872</td>
<td>0.035</td>
<td>.854</td>
</tr>
<tr>
<td>DxS/AxB (Error)</td>
<td>5 min vs. 10 min</td>
<td>21</td>
<td>33.527</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>10 min vs. 15 min</td>
<td>21</td>
<td>24.96</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

Note. * p ≤ .025.
Figure 4.5. Grade Level x Time
Table 4.11

Descriptive Statistics for Grade Level as a Blocking Factor

<table>
<thead>
<tr>
<th>Errors: Time</th>
<th>Aural (N = 13)</th>
<th>Visual (N = 12)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>6th (n = 7)</td>
<td>7th (n = 6)</td>
</tr>
<tr>
<td>Pitch: 5-min</td>
<td>17.62 (5.38)</td>
<td>25.61 (3.18)</td>
</tr>
<tr>
<td>Pitch: 10-min</td>
<td>9.10 (4.31)</td>
<td>24.61 (4.15)</td>
</tr>
<tr>
<td>Pitch: 15-min</td>
<td>7.00 (3.89)</td>
<td>22.78 (7.78)</td>
</tr>
<tr>
<td>Rhythm: 5-min</td>
<td>19.38 (5.83)</td>
<td>30.45 (2.30)</td>
</tr>
<tr>
<td>Rhythm: 15-min</td>
<td>7.95 (4.22)</td>
<td>23.17 (9.67)</td>
</tr>
</tbody>
</table>

Qualitative Results

Subjects were asked to answer two questions during the interview process: 1) What strategies did you use to memorize this melody, and 2) How did the process of memorizing the melody make you feel? Interview data were collected from 23 of 25 subjects. Subjects 1-Visual (V) and 20-V were excluded from the analysis due to equipment failure.

For analysis purposes, recordings from subjects’ interviews were downloaded from the recorder, stored in iTunes, separated by modality, and transcribed using Microsoft Word for Mac 2011, version 14.1.2. The researcher then listened to each
subject’s three practice session recordings and documented their practice behaviors. All
interview responses were triangulated with data from subjects’ practice session
recordings ($n_A = 39; n_V = 35$). Interview data that could not be supported by practice
session data were removed from the analysis.

Hypothesis 3

$H_{O3}$: There is no difference between aural and visual strategies used by beginning-level
string students to memorize.

$H_{A3}$: Aural and visual memorization requires beginning-level string students to use
different strategies.

Interview data from three subjects were removed from the analysis because it
could not be verified by listening to practice session recordings. Subjects 2-Aural (A),
13-A, and 19-A each reported that they replayed the melody in their minds to memorize
the melody.

Subject 2-A: I tried to repeat the rhythms in my head.

Subject 13-A: I played [the melody] in my head when I played it.

Subject 19-A: I kind of sang it in my mind.

Subject 23-A reported using mental imagery to memorize the melody: “I tried listening to
[the melody] first . . . [to] make it ring in my head, and then I tried playing it with my
head vision of the song.” Only one of these four subjects successfully memorized the
melody. All other self-reported strategies were successfully verified by listening to
practice session recording data.
Aural Group Strategies

Interview data indicated that subjects in the aural treatment group described using one to five strategies ($M = 2.85, SD = 1.35$) to memorize the melody (see Table 4.12). The most commonly expressed strategies, in order of frequency, included copying (i.e., practicing with the recording), self-evaluation (i.e., practicing without the recording), instruction (i.e., listening to the recording), segmental practice, repetition, and mental practice (i.e., repeating the melody in their mind) (see Table 4.13).

Data from the practice session recordings indicated that subjects in the aural treatment group performed three to five strategies ($M = 4.77, SD = 0.77$) to memorize the melody (see Table 4.12). The most commonly performed strategies included repetition, instruction, copying, and self-evaluation. Other strategies included singing with the recording and alternating between arco (i.e., pulling the bow across the string) and pizzicato (i.e., plucking the string) (see Table 4.13).

Practice session recordings verified that six subjects in the aural group used holistic practice and seven subjects used segmental practice to memorize the melody. Holistic practice is defined as practicing the melody from beginning to end repeatedly throughout the practice sessions with few attempts to practice individual segments of musical material. Segmental practice is defined as practicing the melody in small or large sections prior to practicing the melody holistically.

Data suggest that segmental practice is more effective than holistic practice when memorizing aurally presented music material. Four (57%) out of the seven subjects who practiced using a segmental strategy successfully memorized the music material. Only
one (16%) out of the six subjects who practiced using a holistic strategy successfully memorized the music material (see Table 4.13).

**Visual Group Strategies**

Interview data indicated that subjects in the visual treatment group described using two to five strategies \((M = 3.00, SD = 1.16)\) to memorize the melody (see Table 4.12). The most commonly expressed strategies, in order of frequency, included self-evaluation, repetition, segmented practice, and holistic practice (see Table 4.13).

Data from the practice session recordings indicated that subjects in the visual treatment group performed three to five strategies \((M = 4.42, SD = 1.24)\) to memorize the melody (see Table 4.12). All subjects used repetition and evaluated themselves by removing the written notation from sight (i.e., turning the page over) or by closing their eyes. Other strategies included alternating between pizzicato and arco, singing or humming the pitches in rhythm, chanting pitch names in rhythm, vocalizing the rests, and altering the practice tempo (see Table 4.13).

Practice session recordings verified that five subjects used holistic practice and seven subjects used segmental practice to memorize the melody. Data suggest that both practice strategies were equally effective. Four (57%) out of seven subjects who practiced using a segmental strategy successfully memorized the music material. Three (60%) out of five subjects who practiced using a holistic strategy successfully memorized the music material (see Table 4.13).
Table 4.12

Average Number of Strategies

<table>
<thead>
<tr>
<th>Modality Group</th>
<th>Mean (SD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aural (n = 13)</td>
<td></td>
</tr>
<tr>
<td>From Interviews</td>
<td>2.85 (1.35)</td>
</tr>
<tr>
<td>From Practice Sessions</td>
<td>4.77 (0.44)</td>
</tr>
<tr>
<td>Visual (n = 12)</td>
<td></td>
</tr>
<tr>
<td>From Interviews⁸</td>
<td>3.00 (1.16)</td>
</tr>
<tr>
<td>From Practice Sessions</td>
<td>4.42 (1.24)</td>
</tr>
</tbody>
</table>

Mean Interview Strategies 2.93 (0.11)
Mean Practice Session Strategies 4.59 (0.25)

Note. ⁸n = 10.

Data indicate that six out of the nine strategies used by the treatment groups (67%) were similar. These strategies included repetition, self-evaluation, segmental practice, and holistic practice. Subjects from both treatment groups also sang and alternated between pizzicato and arco (see Table 4.13). The remaining strategies were specific to their treatment groups. The aural group tended to use copying and instruction. The visual group chanted pitch names in rhythm, vocalized the rests, and adjusted practice tempi. These results suggest that the alternative hypothesis should be rejected in favor of the null hypothesis. Aural and visual strategies used by beginning-level string students to memorize musical material were substantially more similar than different.
Table 4.13

Strategies Derived from Interview and Practice Session Recording Data

<table>
<thead>
<tr>
<th>Subjects</th>
<th>Aural (n = 13)</th>
<th>Visual (n = 12)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Interview (n = 13)</td>
<td>Prac. Sess. (n = 13)</td>
<td>Successful (n = 5)</td>
</tr>
<tr>
<td>*Repetition</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Copying (Practicing with CD)</td>
<td>9</td>
<td>6</td>
</tr>
<tr>
<td>*Self-Evaluation (Practicing without CD)</td>
<td>6</td>
<td>12</td>
</tr>
<tr>
<td>Instruction (Only Listening to CD)</td>
<td>5</td>
<td>12</td>
</tr>
<tr>
<td>*Segmental Practice</td>
<td>5</td>
<td>7</td>
</tr>
<tr>
<td>*Alternation between Pizzicato and Arco</td>
<td>3</td>
<td>6</td>
</tr>
<tr>
<td>*Holistic Practice</td>
<td>1</td>
<td>6</td>
</tr>
<tr>
<td>*Singing with CD recording</td>
<td>0</td>
<td>3</td>
</tr>
<tr>
<td>**Mental Practice</td>
<td>4</td>
<td>-</td>
</tr>
<tr>
<td>**Fingered along with CD</td>
<td>1</td>
<td>-</td>
</tr>
<tr>
<td>**Moved bow along with melody</td>
<td>1</td>
<td>-</td>
</tr>
<tr>
<td>Visual (n = 12)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Interview (n = 10)</td>
<td>Prac. Sess. (n = 12)</td>
<td>Successful (n = 7)</td>
</tr>
<tr>
<td>*Repetition</td>
<td>5</td>
<td>12</td>
</tr>
<tr>
<td>*Self-Evaluation</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(Turn Page Over/Closed Eyes)</td>
<td>6</td>
<td>8</td>
</tr>
<tr>
<td>*Segmental Practice</td>
<td>4</td>
<td>7</td>
</tr>
<tr>
<td>*Holistic Practice</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>*Alternation between Pizzicato and Arco</td>
<td>1</td>
<td>4</td>
</tr>
<tr>
<td>*Singing/Humming Pitches in Rhythm</td>
<td>1</td>
<td>4</td>
</tr>
<tr>
<td>Chanting Pitch Names in Rhythm</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td>Vocalizing the Rests</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Tempo Alterations</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>**Mental Practice</td>
<td>1</td>
<td>-</td>
</tr>
<tr>
<td>**Formal Analysis</td>
<td>1</td>
<td>-</td>
</tr>
<tr>
<td>**Watched Fingers while Practicing</td>
<td>1</td>
<td>-</td>
</tr>
<tr>
<td>**Watched Bow while Practicing</td>
<td>1</td>
<td>-</td>
</tr>
<tr>
<td>**Counting</td>
<td>1</td>
<td>-</td>
</tr>
</tbody>
</table>

Note. * denotes strategies that are similar between treatment groups. ** denotes interview strategies that could not be verified by subjects’ practice session recordings.
Hypothesis 4

H<sub>04</sub>: Subjects will feel indifferent to the process of memorization.

H<sub>A4</sub>: Subjects will enjoy the process of memorization.

Subjects’ responses to question number 2 regarding their attitude toward memorization were analyzed for key words that best described their answers. For example, subject 10-A stated, “. . . It makes me feel good . . . because I actually think I did pretty good on that . . . I have a pretty bad memory, so it made me feel happy.” This comment was coded as “sense of accomplishment.” Subject 27-A stated, “It made me feel frustrated that I kept on messing up . . . It was hard to concentrate because it was timed.” This comment was coded “frustration.” Subject 12-V stated, “I don’t know. It didn’t make me feel bad. It didn’t make me feel happy. It just like, I don’t know.” This comment was coded “indifferent.” The total positive, negative, and indifferent comments were summed up and percentages were derived from the data (see Table 4.14).

Data from the aural group (n = 13) indicated that 69% of subjects had a positive attitude towards memorization, 23% had a negative attitude, and 8% were indifferent. Interview data from the visual group (n = 10) indicated that 50% of subjects had a positive attitude toward the memorization task, 30% of subjects had a negative attitude, and 20% felt indifferent. Overall, 14 out of 23 subjects enjoyed memorizing the melody (M = 61%), 6 subjects (26%) did not enjoy memorizing the melody, and 3 subjects (13%) were indifferent (see Table 4.14). Based on these data we reject our null hypothesis in favor of the alternative hypothesis.
Subjects cited the following reasons for enjoying the process of memorization: the process was challenging \((n = 2)\); liked the melody \((n = 2)\); felt the experiment was interesting \((n = 2)\); and believed they played more accurately by memory \((n = 1)\) (see Table 4.15).

The following reasons were cited by subjects who doubted their ability to complete the memorization task: subjects in the aural group stated they were better visual learners \((n = 2)\); the time constraint made it hard to concentrate \((n = 2)\); subjects claimed they had a bad memory \((n = 1)\); or they could not remember the whole melody when being tested \((n = 1)\). Subjects in the visual group stated they were pressured by the time constraints \((n = 2)\); they did not like to memorize \((n = 1)\); they felt uncomfortable memorizing music on their own \((n = 1)\); or they were nervous \((n = 1)\) (see Table 4.15).

**Change in Attitude**

Thirty-five \((35)\) percent of subjects indicated their attitude changed from a negative to positive polarity as the experiment progressed \((n_A = 6, n_V = 2)\). Of these subjects, four successfully memorized the melody and four did not successfully memorize the melody (see Table 4.16). Data suggest subjects initially experienced nervousness, stress, agitation, and doubt during the initial stages of the experiment. These feelings subsided as they progressed through the experiment. Subject 19-A stated, “I was nervous at first, but then I got less nervous . . . I felt like the first time I knew it less and when I knew it more, I felt like . . . yeah!” Subject 29-A experienced some degree of stress: “It’s kind of stressful. As I learned the song . . . it became un-stressful because I learned it . . . [and] played it a lot better.” Subject 7-V expressed initial agitation: “At
first I was . . . annoyed. I don’t like memorizing things . . . and then as I got familiar with
the piece it got a little easier and then I got into it.” Subject 23-A doubted their ability to
complete the memory task: “It kind of made me feel proud of myself because I didn’t
think I could do it . . . I am surprised at myself right now.”

Table 4.14

Subjects’ Attitudes Regarding Memorization

<table>
<thead>
<tr>
<th>Positive</th>
<th>Aural (N = 13)</th>
<th>#</th>
<th>Visual (N = 10)</th>
<th>#</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sense of Accomplishment</td>
<td>3</td>
<td></td>
<td>Fun (Challenging)</td>
<td>2</td>
</tr>
<tr>
<td>Increased Confidence</td>
<td>2</td>
<td></td>
<td>Increased Confidence</td>
<td>1</td>
</tr>
<tr>
<td>Sense of Pride</td>
<td>1</td>
<td></td>
<td>Interesting</td>
<td>1</td>
</tr>
<tr>
<td>Interesting</td>
<td>1</td>
<td></td>
<td>Annoyed, then Relaxed</td>
<td>1</td>
</tr>
<tr>
<td>Easy</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hard, but Not Bad</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Treatment Group Total (%)</td>
<td>9 (69%)</td>
<td></td>
<td>5 (50%)</td>
<td></td>
</tr>
<tr>
<td>Combined Total (%)</td>
<td>14 (61%)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Negative</th>
<th>Aural (N = 13)</th>
<th>#</th>
<th>Visual (N = 10)</th>
<th>#</th>
</tr>
</thead>
<tbody>
<tr>
<td>Frustrating</td>
<td>2</td>
<td></td>
<td>Confusing</td>
<td>1</td>
</tr>
<tr>
<td>Difficult and Confusing</td>
<td>1</td>
<td></td>
<td>Stressful and Difficult</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Terrified and Anxious</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Treatment Group Total (%)</td>
<td>3 (23%)</td>
<td></td>
<td>3 (30%)</td>
<td></td>
</tr>
<tr>
<td>Combined Total (%)</td>
<td>6 (26%)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Indifferent</th>
<th>Aural (N = 13)</th>
<th>#</th>
<th>Visual (N = 10)</th>
<th>#</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
<td></td>
<td>Indifferent</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Treatment Group Total (%)</td>
<td>1 (8%)</td>
<td></td>
<td>2 (20%)</td>
<td></td>
</tr>
<tr>
<td>Combined Total (%)</td>
<td>3 (13%)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*a denotes that only 10 of the 12 subjects’ interviews could be used due to equipment malfunction*
<table>
<thead>
<tr>
<th>Rationales</th>
<th>Subject</th>
<th>Supporting Quotation</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Positive</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Challenging</td>
<td>21-A, 28-V</td>
<td>“It was kind of fun . . . It was almost challenging to memorize it.”</td>
</tr>
<tr>
<td>Interesting</td>
<td>4-A, 17-A</td>
<td>“It [was] actually very interesting . . . I actually wish I had the music because I like the tune.”</td>
</tr>
<tr>
<td>Liked the melody</td>
<td>4-A, 9-V</td>
<td>“I like it a lot because it was easy and I like the song . . . it was easy to play with.”</td>
</tr>
<tr>
<td>Play more</td>
<td>5-V</td>
<td>“. . . you . . . play better if you . . . remember it accurately than having a sheet [of music] in front of you.”</td>
</tr>
<tr>
<td><strong>Negative</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Considered themselves visual</td>
<td>2-A, 6-A</td>
<td>“I didn’t feel that well . . . I’m better at visual memory.”</td>
</tr>
<tr>
<td>learners</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Claimed to have a bad memory</td>
<td>2-A, 10-A</td>
<td>“It [made] me feel good . . . I actually think I did pretty good on that . . . I have a pretty bad memory, so it makes me feel . . . happy.”</td>
</tr>
<tr>
<td>Could not remember the entire</td>
<td>15-A</td>
<td>“Uh, kind of frustrated because I couldn’t remember the whole thing . . . I played it once pretty good but then on the trials I couldn’t do it.”</td>
</tr>
<tr>
<td>melody</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Did not like to memorize</td>
<td>7-V</td>
<td>“At first, I was like annoyed. I don’t like memorizing things . . . and then as I got familiar with the piece it got a little easier and then I got into it.”</td>
</tr>
<tr>
<td>Uncomfortable memorizing on</td>
<td>18-V</td>
<td>“I think it made me feel awkward. It was weird but it was fun . . . ‘cause, uh, I had to memorize it on my own.”</td>
</tr>
<tr>
<td>their own</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nervous</td>
<td>26-V</td>
<td>[Researcher] “How did it make you feel?” [Subject] “Um, kinda’ terrified . . . still a little anxious.”</td>
</tr>
</tbody>
</table>
Table 4.15 continued

Pressured by time constraints 27-A, 29-A, 16-V, 22-V “Sort of stressful because . . . I had to memorize it really quick.”

Table 4.16

*Subjects Who Experienced a Change in Attitude*

<table>
<thead>
<tr>
<th>Subject</th>
<th>Modality</th>
<th>Error Score</th>
<th>Successful</th>
</tr>
</thead>
<tbody>
<tr>
<td>2-A</td>
<td>Aural</td>
<td>29.17 (0.24)</td>
<td>No</td>
</tr>
<tr>
<td>8-A</td>
<td>Aural</td>
<td>8.67 (1.89)</td>
<td>No</td>
</tr>
<tr>
<td>19-A</td>
<td>Aural</td>
<td>29.17 (2.59)</td>
<td>No</td>
</tr>
<tr>
<td>21-A</td>
<td>Aural</td>
<td>9.50 (1.18)</td>
<td>No</td>
</tr>
<tr>
<td>23-A</td>
<td>Aural</td>
<td>4.83 (3.06)</td>
<td>Yes</td>
</tr>
<tr>
<td>29-A</td>
<td>Aural</td>
<td>6.00 (3.30)</td>
<td>Yes</td>
</tr>
<tr>
<td>7-V</td>
<td>Visual</td>
<td>7.00 (2.83)</td>
<td>Yes</td>
</tr>
<tr>
<td>16-V</td>
<td>Visual</td>
<td>1.83 (1.65)</td>
<td>Yes</td>
</tr>
</tbody>
</table>

*Case Study: Subjects’ Previous Musical Experiences*

Five subjects were eliminated from the study because of previous musical experience. Four of the five subjects successfully memorized the melody. Each of these four subjects achieved an average score of less than or equal to five errors, which were among the lowest number of error scores in the overall sample population. Subject 11-A
scored the lowest overall aural error score; subject 30-V scored the lowest overall visual score. Both subjects also successfully memorized the melody at the 10-minute assessment point (see Table 4.17).

A case study analysis was performed on these two subjects. Subject 11-A, Mary, was a sixth-grade violinist who was asked to memorize the melody aurally. She attended string orchestra class 5 days bi-weekly. Each class was 45 minutes in length. Mary had played violin for approximately 20 months in her public school string orchestra class. During the study interview, she reported starting violin and piano lessons at 7 years of age (i.e., second grade). Mary quit violin lessons at the age of 9 years of age but continued piano lessons. She stated she “forgot everything” about playing the violin prior to joining her school string orchestra class.

Mary: I started [violin] when I was in fifth grade, but before that I played it for 3 years, but then I didn’t play it for 2 years, and then I forgot everything.

Mary was the only subject to play the melody by memory without committing any errors at the 15-minute assessment point (see Table 4.17). When asked what strategies she used to achieve this, Mary stated:

I listened to it a couple times and then the first note was ‘G’ and then the sound was ‘B’ so I don’t know. I just listened to it . . . and then I tried playing it and . . . if something didn’t sound right, I tried a different note.

Mary tried to create a mental image of the pitches dictated by the recording. She then practiced them, evaluated her attempt, and made the necessary adjustments. These data suggest that Mary did not “forget everything” that she had learned several years before. It
may be reasonable to assume, based on this data, that Mary still possessed a series of domain-specific mental representations that allowed her to excel beyond her peers.

Subject 30-V, Beth, was a sixth-grade violinist who was asked to memorize the melody visually. Beth participated in string orchestra class 3 days a week. Each class was 40 minutes in length. Beth had played violin for approximately 20 months in her public school string orchestra class. She reported starting piano lessons at 8 years of age (i.e., third grade) and also indicated that memorization of assigned music was expected of her on a regular basis.

Researcher: Keeping in mind that you will not hurt my feelings and that you must be very honest, how did the process of memorizing the melody make you feel?

Beth: The practice, well it’s not that bad . . . because I . . . compete in piano competitions where I have to memorize the songs, so I’m pretty good at it.

Beth attained a pitch and rhythmic error score of 0.67 at the 10-minute assessment point (see Table 4.17). She reported initially practicing holistically to memorize the melody. She then changed to segmental practice and repetition to learn the difficult sections.

Beth: I kind of looked [the melody] over. I played it once, then the parts that were kind of hard I kept practicing over and over again.

Beth gained memorization experience prior to participating in this experiment. Once again, it is reasonable to assume that Beth drew upon her previous experiences to complete this memorization task. The needed mental representations were already in place from her prior experiences. This allowed Beth to excel beyond her peers.

Overall, four of the five subjects who were disqualified from the analysis because of prior musical experience successfully completed the memory task, two of whom
performed the melody without errors. Only 12 (48%) of the 25 eligible subjects were successful. No eligible subjects were able to perform the melody void of errors. This evidence suggests that prior experience is a primary factor in determining beginning-level string students’ ability to memorize musical material (Ericsson & Kintsch, 1995), more so, perhaps, than students who are one year older.

Table 4.17

*Case Study: Subjects’ Pitch and Rhythmic Error Scores*

<table>
<thead>
<tr>
<th>Subject</th>
<th>Pitch Errors</th>
<th>Rhythm Errors</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>5-min</td>
<td>10-min</td>
</tr>
<tr>
<td>3-V*</td>
<td>27.00</td>
<td>6.00</td>
</tr>
<tr>
<td>11-A (Mary)*</td>
<td>4.33</td>
<td>.00</td>
</tr>
<tr>
<td>24-V*</td>
<td>18.00</td>
<td>.67</td>
</tr>
<tr>
<td>25-A</td>
<td>22.00</td>
<td>7.33</td>
</tr>
<tr>
<td>30-V (Beth)*</td>
<td>9.33</td>
<td>.67</td>
</tr>
</tbody>
</table>

*Note.* * denotes the subjects who successfully memorized the melody. * The total mean error score is averaged from the 15-minute assessment point pitch and rhythmic error scores.
Chapter 5: Discussion

Purpose Statement

The purpose of this study was to examine the relative effects of visual and aural memorization strategies on the pitch and rhythmic accuracy of beginning-level string players. Answers to the following questions were addressed:

1. Do beginning-level string students exhibit a significantly different number of pitch errors when comparing their use of aural and visual memorization strategies?

2. Do beginning-level string students exhibit a significantly different number of rhythmic errors when comparing their use of aural and visual memorization strategies?

3. Do beginning-level string students’ memorization strategies differ between visual and aural modalities?

4. What are beginning-level string students’ attitudes toward memorization?

Findings from the present study should be interpreted with caution because they are based on a sample population of 25 subjects only. As a result, the statistical model was underpowered. The within-subjects variable time in the omnibus analysis of variance (ANOVA) model violated the assumption of sphericity and failed Levene’s test of equality of error variance at the 10-minute pitch level, 15-minute pitch level, and 15-
minute rhythm level. The Huynh-Feldt method was used to adjust for sphericity violations in time (Keppel & Wickens, 2004, p. 378). To account for the violations of homogeneity of error covariance, the $\alpha$ (alpha) level was halved ($\alpha = 0.025$) to reduce the likelihood of type-one error (Keppel & Wickens, 2004, p. 152).

**Summary of the Results**

*Alternative Hypothesis No. 1: There is a significant difference between the means of aural and visual pitch errors.*

Subjects in the visual treatment group performed significantly fewer pitch errors at the 15-minute assessment point than subjects in the aural treatment group ($M_{V(15\text{min})} = 4.47, SD = 8.72; M_{A(15\text{min})} = 14.28, SD = 9.99$). The alternative hypothesis, therefore, was accepted.

*Alternative Hypothesis No. 2: There is a significant difference between the means of aural and visual rhythmic errors.*

Subjects in the visual treatment group performed fewer rhythmic errors at the 15-minute assessment point than subjects in the aural treatment group ($M_{V(15\text{min})} = 7.88, SD = 5.52; M_{A(15\text{min})} = 14.97, SD = 10.50$); however, these results were not significant. As a result, the null hypothesis was not rejected.
Alternative Hypothesis No. 3: Aural and visual memorizations require beginning-level string students to use different strategies.

Results indicated that subjects used similar strategies across modalities. They also used a similar number of strategies to memorize the melody. These findings suggest that the null hypothesis should be rejected in favor of the alternative hypothesis.

At least six (67%) out of the nine strategies used by the treatment groups were similar. These strategies, in order of frequency, included repetition, self-evaluation, segmental practice, holistic practice, alternation between pizzicato and arco, and singing. The remaining strategies were specific to their treatment groups. The aural group tended to use copying and instruction; the visual group tended to chant pitch names in rhythm, vocalize notated rests, and adjust practice tempi.

Data from the interviews indicated that subjects from both treatment groups described their using an average of three strategies to memorize the melody ($M = 2.93$, $SD = 0.11$). The most common strategies cited, in order of frequency, were self-evaluation, segmental practice, repetition, and holistic practice. Data from practice session recordings validated subjects’ use of these strategies.

Data from practice session recordings indicated that both treatment groups used an average of five strategies when completing the memorization task ($M = 4.6$, $SD = 0.25$). These strategies, in order of frequency, included repetition, self-evaluation, segmental practice, and holistic practice. Subjects from both treatment groups also sang and alternated between pizzicato and arco.
Data indicated that segmental practice was more effective than holistic practice when students memorized aurally presented music material. Four (57%) of the seven subjects from the aural group successfully memorized the melody using a segmental strategy; one (16%) out of six subjects from the aural group successfully memorized the melody using a holistic strategy.

Conversely, when students memorized the melody from visually presented material, segmental and holistic practices were equally as effective. Four (57%) of the seven subjects from the visual group who successfully memorized the melody used a segmental strategy; three (60%) out of five subjects from the visual group who successfully memorized the melody used a holistic strategy.

*Alternative Hypothesis No. 4: Subjects will enjoy the process of memorization.*

Fourteen (61%) out of 23 subjects enjoyed memorizing the melody. Six (26%) out of 23 subjects did not enjoy memorizing the melody. Three (13%) subjects were indifferent.

Eight (35%) out of 23 subjects indicated a change in attitude as the experiment progressed ($n_A = 6$, $n_V = 2$). Each of these subjects described initial feelings of nervousness, stress, agitation, or doubt regarding their ability when asked to memorize the melody. As the experiment progressed, subjects reported feeling optimistic and proud of their achievements. Only four out of the eight subjects who changed attitudes successfully memorized the melody.
Additional Results

Time

Data indicated a significant decrease in pitch and rhythmic errors across levels of time (Drake, Dowling, & Palmer, 1991). Differences between the 5-minute and 15-minute assessment points ranged from a decrease of 7.03 to 13.06 errors (see Table 5.1).

Mode of Instruction and Memorization

Teachers in the present study spent more than half of the school week using visual instruction strategies with students and less than half of the school week using aural instruction strategies. Correspondingly, the visual memory treatment group produced fewer pitch and rhythmic errors than the aural memory treatment group. A relationship, therefore, may exist between the modal format of instruction used by string teachers and students’ ability to recall musical material.

Maturation and Prior Experience

Sixth- and seventh-grade subjects in the present study had no more than 20 months of public school string instruction; seventh-graders, however, were one year older than sixth-grade students. Results indicated that sixth-grade subjects in the visual group committed relatively the same number of errors as the seventh-grade subjects. Conversely, sixth-grade subjects in the aural group performed significantly less errors than seventh-grade subjects. Sixth-grade subjects’ numbers of errors were equivalent between groups; seventh-grade subjects in the aural groups committed nearly twice as many errors than seventh-grade subjects in the visual group on all levels of time. These
Table 5.1

Mean Pitch and Rhythmic Errors Over Time

<table>
<thead>
<tr>
<th>Assessment Points</th>
<th>Pitch Aural M (SD)</th>
<th>Pitch Visual M (SD)</th>
<th>Rhythm Aural M (SD)</th>
<th>Rhythm Visual M (SD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>5-minutes</td>
<td>21.31 (5.98)</td>
<td>17.53 (8.01)</td>
<td>24.48 (7.22)</td>
<td>20.61 (10.47)</td>
</tr>
<tr>
<td>10-minutes</td>
<td>16.26 (9.01)</td>
<td>9.89 (5.36)</td>
<td>18.13 (9.10)</td>
<td>12.72 (7.99)</td>
</tr>
<tr>
<td>15-minutes</td>
<td>14.28 (9.99)</td>
<td>4.47 (1.55)</td>
<td>14.97 (10.50)</td>
<td>7.89 (5.52)</td>
</tr>
<tr>
<td>Difference</td>
<td>7.03</td>
<td>13.06</td>
<td>9.51</td>
<td>12.72</td>
</tr>
<tr>
<td>Mean Errors</td>
<td>17.28</td>
<td>10.63</td>
<td>19.20</td>
<td>13.74</td>
</tr>
</tbody>
</table>

data suggest that older beginning-level string students do not necessary memorize music material with more pitch and rhythmic accuracy than younger students with the same amount of instruction.

Data from the case study suggest that experience may be a stronger predictor of memorization achievement than chronological maturation. Four of the five subjects who had more than 20 months of musical experience successfully memorized the simple 8-bar melody.
Implications of the Study

Memorization Ability: Pitch and Rhythmic Recall in Modal Contexts

Visual and aural memorizations are considered essential components of a young child’s music education (Chaffin & Imreh, 1997; Drake & Palmer, 2000; Frewen, 2011; Hallam, 1997; Lilliestam, 1996; McPherson, 2005; Mishra, 2002a, 2005; Nuki, 1984; Sloboda, 1978). Researchers suggest that integrating and implementing both modalities into instruction also increases the overall level of instructional efficiency in the classroom.

To teach beginning-level string students aural and visual skill, string teachers commonly used aural modeling (Hamann & Gillespie, 2009; see also Dickey, 1991; Sang, 1987) and sight-reading (Ahmed, 1976; Contor, 1951; Woody & Lehmann, 2010). Researchers suggest that aural modeling significantly increases instructional efficiency in music classrooms when compared to verbal instruction (Dickey, 1991; Hamann & Gillespie, 2009; Sang, 1987). Finding includes the following: 1) aural modeling musical expectations develop students’ intonation and rhythmic accuracy more efficiently (Dickey, 1991; Sang, 1987); 2) successful teachers use aural modeling throughout their classes and lessons (Colprit, 2000; Duke, 1999; MacLeod, 2010); and 3) students who become aurally familiar with a melody prior to motoric production on an instrument learned the melody more quickly and accurately (Frewen, 2010; Lehmann and Ericson, 1997).

Despite the fact that visual learning is a more traditional approach to teaching beginning-level string students, there has been little research to examine the effects of
visual memorization through method books and sheet music (Ahmed, 1976; Contor, 1951; Woody & Lehmann, 2010). McPherson (1995, 1996) found that visual memorization significantly correlates with sight-reading. This is logical when considering that students must memorize the names of pitch, rhythms and various melodic, harmonic and rhythmic patterns in order to increase sight-reading ability.

Integrating visual and aural memorization (i.e., learning) strategies together to learn music material is important for music comprehension. Researchers have found that multi-modality memorization strategies yields significantly better outcomes than uni-modality memorization when memorizing music material (Coffman, 1990; Lim & Lippman, 1991; Miksza, 2005; Ross, 1985; Theiler & Lippman, 1995). Using visual and aural modalities together could, therefore, increase the efficiency at which students learn music material.

Glenn (1999) compared sight-reading (i.e., visual) and aural modeling (i.e., aural) instructional approaches in a public school heterogeneous music instructional setting to examine if one medium was significantly more effective than the other. She found no significant difference between initial aural and visual instruction on subjects’ performance ability. Only students’ sight-reading ability was assessed at the conclusion of the treatment. No other research studies have been found that examine the effectiveness of visual instructional methods in comparison to aural instructional methods; nor has a study been found that examines possible relationships between beginning-level string students’ memorization ability and teachers’ mode of instruction. One of the purposes of this experiment was to examine if visual and aural sensory
memory mechanisms develop at equal rates when visual instruction is emphasized in an instructional setting.

Woody and Lehmann (2010) investigated the relationship between musicians’ ability to memorize and mode of instruction. They found that aurally trained musicians who teach themselves music by playing by ear memorize aural material more efficiently than visually trained musicians. A relationship, therefore, might exist between mode of instruction and the ability to memorize stimuli (Woody & Lehmann, 2010). This corresponds with an overwhelming amount of research that suggests experience in a domain is a key factor to learning domain-specific activities (for a review, see Ericsson & Kintsch, 1995).

String teachers in the present study were surveyed to determine what modes of instruction they use to teach their string classes. They reported spending more than half of their weekly instructional time emphasizing visual materials (e.g., music textbooks and sheet music) and less than half of the school week emphasizing aural training (e.g., playing by ear without the aid of written notation).

Results from the present study indicated that beginning-level string students recalled aurally and visually presented pitched stimuli at significantly different rates. The visual treatment group performed significantly fewer pitch errors at the 15-minute assessment point than subjects in the aural treatment group. This finding conflicts with Glenn (1999) but corresponds with Woody and Lehmann (2010). A relationship may exist between mode of instruction and memorization ability. Also, Glenn may have achieved different results because she assessed students’ sight-reading at the end of the
study rather than their ability to memorize musical material. This suggests memorization might be a better determinant of how students learn music rather than sight-reading; however, further research is needed to validate this hypothesis.

Rhythmic errors were not affected by modality. Results indicated that beginning-level string students do not encode and recall rhythmic stimuli from visual and aural contexts at significantly different rates; therefore, this support previous research by Glenn (1999). These findings also support Sloboda and Parker (1985, p. 159) and Lehmann (1997) who suggest that rhythm is the most preserved element in memorized music because it provides a structural framework for melodic recall.

Findings from the present study and those of Woody and Lehmann (2010) suggest that visual and aural pitch-based recall do not develop at equal rates when visual instruction is emphasized in a heterogeneous string class. Visual memorization skills developed at a faster rate. Because multi-model memorization strategies appear to increase learning efficiency (Dickey, 1991; Lim & Lippman, 1997; McPherson, 1995, 1996; Woody & Lehmann, 2010), this researcher does not recommend placing more emphasis on visual over aural memorization. Rather, teachers may consider developing curricula that emphasizes instruction in both visual and aural modalities. Curricula could include daily aural warm-ups (Hamann & Gillespie, 2009) and aural modeling (Dickey, 1991; Frewen, 2010; Sang, 1987). Teachers could also consider teaching a portion of their concert programs by rote or requiring students to perform a work by memory.

These findings should be interpreted with caution. Prior research indicates that using multi-modal strategies to practice musical material produced significantly better
results than uni-modal strategies (Coffman, 1990; Lim & Lippman, 1991; Ross, 1985; Theiler & Lippman, 1995). Visual memorization incorporates both visual and aural musical stimuli during the encoding process. Aural memorization does not require individuals to encode visual musical stimuli. It is possible that beginning-level string students in the visual treatment group performed fewer mean errors because they encoded the melody using both aural and visual modalities (i.e., aural and visual stimuli).

In addition, the experimental design did not control for tempo uniformly between groups. The tempo of the aural model was set at 103 to 104 beats per minute using Audacity 1.3.13-Beta Audio Editor. The visual group was given no suggested performance tempo or a metronome to control their own performance tempo. If subjects in the visual group performed the melody at a slower tempo than the aural group, they would have had more time to cognitively process the musical stimuli. This would potentially give the visual group an advantage over the aural group in terms of performing with better pitch and rhythmic accuracy. To test this hypothesis, a post-hoc descriptive statistical analysis on subjects’ performance tempi was performed. The researcher listened to each subject’s 15-minute assessment recordings and labeled subjects’ performed tempo using a Boss Dr. Beat metronome, Model DB-88 (see Table 5.2).

Data do not support the hypothesis that tempo affected the results of the present study. Subjects in the visual group actually performed the melody at a faster mean tempo and with more variability \((M = 104.83, SD = 10.01)\) than the aural group \((M = 96.62, SD = 4.65)\). It is interesting to note that the majority of subjects in the aural group performed
the melody at a slower tempo than the aural model (i.e., 103-104 bpm). Also, the visual group performed the melody more accurately than the aural group despite playing it at a faster tempo during the 15-minute assessment period. Future research may want to investigate further the relationship between tempo and modality-specific memorization strategies.

Table 5.2

*Tempi Performed by Subjects During the 15-Minute Assessment Recording*

<table>
<thead>
<tr>
<th>Subject</th>
<th>Tempo (bpm)</th>
<th>Mean Errors</th>
<th>Subject</th>
<th>Tempo (bpm)</th>
<th>Mean Errors</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>98</td>
<td>29.17</td>
<td>1*</td>
<td>96</td>
<td>5.00</td>
</tr>
<tr>
<td>4*</td>
<td>96</td>
<td>5.50</td>
<td>5</td>
<td>96</td>
<td>8.00</td>
</tr>
<tr>
<td>6</td>
<td>93</td>
<td>27.67</td>
<td>7*</td>
<td>100</td>
<td>7.00</td>
</tr>
<tr>
<td>8</td>
<td>93</td>
<td>8.67</td>
<td>9</td>
<td>120</td>
<td>12.83</td>
</tr>
<tr>
<td>10*</td>
<td>93</td>
<td>7.00</td>
<td>12</td>
<td>98</td>
<td>9.67</td>
</tr>
<tr>
<td>13*</td>
<td>98</td>
<td>4.33</td>
<td>14*</td>
<td>96</td>
<td>3.83</td>
</tr>
<tr>
<td>15</td>
<td>96</td>
<td>15.17</td>
<td>16*</td>
<td>103</td>
<td>1.83</td>
</tr>
<tr>
<td>17</td>
<td>96</td>
<td>27.50</td>
<td>18</td>
<td>114</td>
<td>7.33</td>
</tr>
<tr>
<td>19</td>
<td>96</td>
<td>29.17</td>
<td>20</td>
<td>125</td>
<td>7.17</td>
</tr>
<tr>
<td>21</td>
<td>91</td>
<td>9.50</td>
<td>22*</td>
<td>110</td>
<td>3.00</td>
</tr>
<tr>
<td>23*</td>
<td>98</td>
<td>4.83</td>
<td>26*</td>
<td>100</td>
<td>6.67</td>
</tr>
<tr>
<td>27</td>
<td>98</td>
<td>15.67</td>
<td>28*</td>
<td>100</td>
<td>1.83</td>
</tr>
<tr>
<td>29*</td>
<td>110</td>
<td>6.00</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Mean Tempo: 96.62 (4.65)  Mean Tempo: 104.83 (10.01)

*Note.* * denotes subjects who successfully completed the memorization task.
Lastly, findings from the present study do not suggest that beginning-level students have more accurate intonation when musical information is presented in a visual format. Rather, pitch was measured in terms of pitch recall (i.e., how many pitches were performed correctly overall). A pitch was considered accurate if performed within a half step of the assigned pitch.

**Implementation: Using Memorization Strategies**

Researchers have investigated at length the strategies used by collegiate musicians (Flowers, 1987; Hallam, 1997; Lehmann, 1997; Lim & Lippman, 1991; Mishra, 2002a; Nuki, 1984; Williamon, 1999; Woody & Lehmann, 2010; Williamon & Valentine, 2002) and expert musicians (Chaffin & Imreh, 1997; Hallam, 1997; Jakobson, et al., 2008; Miklaszewski, 1989; Sloboda, Hermelin, & O’Connor, 1985). Only a few researchers have examined types of strategies used by beginning-level instrumental musicians (Frewen, 2010; McPherson, 2005). Neither of them has examined similarities and differences between visual and aural strategies used by beginning-level string students and addressed resulting trends.

Mishra (2002a) found that subjects use holistic, additive, segmental, and serial strategies to memorize musical material. McPherson (2005) found that novice musicians tend to analyze melodic contours, chant note names and rhythms, sing a melody, and finger through a melody. Rohwer and Polk (2006) found that students tend to use repetition. Results from the present study supported these findings. Beginning-level string students use repetition, self-evaluation, segmental practice, holistic practice, alternation
between pizzicato and arco, and singing. Other strategies included chanting pitch names in rhythm, vocalizing notated rests, and adjusting practice tempi.

Seddon and Biasutti (2010) found that musicians memorize aural stimuli in five stages: instruction, copying, practice, playing, and evaluation (see also Campbell, 1995; Green, 2002; Lilliestam, 1996). Results from the present study support these findings. Subjects in the aural treatment group memorized musical material using repetition, copying (i.e., practicing with CD), evaluation (i.e., practicing without CD), and instruction (i.e., only listening to CD). They also used segmental practice, holistic practice, and alternated between pizzicato and arco. No studies have been found that examine segmental and holistic practice strategies in an aural memorization context.

Findings from the present study indicated that at least 67% of practice strategies used by the aural and visual groups were similar. These strategies, in order of frequency, included self-evaluation, repetition, segmental practice, holistic, alternation between pizzicato and arco, and singing. The remaining strategies were specific to treatment groups. The aural group used copying (i.e., practicing with the CD) and instruction (i.e., listening to the CD) (Seddon & Biasutti, 2010). The visual group chanted pitch names in rhythm and vocalized rests (McPherson, 2005).

While only 48% of students successfully memorized the melody, it is worth noting that students knew how to use the above strategies when memorizing the melody. Music teachers should continue to reinforce the use of these strategies in student practice behaviors and develop students’ awareness of these strategies by helping them identify and label them.
Number of Strategies

Rohwer & Polk (2006) found that eighth-grade students are able to describe using an average of only three strategies after practicing a music excerpt. These strategies included, in order of frequency, repetition, pinpointing difficult sections, practicing slow to fast, and analyzing key and meter. In some cases, repetition was the only strategy subjects could describe (ibid., 2006, p. 357). The researchers made no mention of self-evaluation.

Findings from the present study corresponded with prior research (Rohwer & Polk, 2006). Interview data indicated that subjects described using an average of three strategies to memorize the melody in both the aural and visual treatment groups. The most common strategies described by the aural treatment group, in order of frequency, were copying (i.e., practicing with CD), self-evaluation (i.e., practicing without CD), instruction (i.e., only listening to CD), segmental practice, and repetition. The most common strategies described by the visual treatment group, in order of frequency, were self-evaluation, repetition, holistic practice, and segmental practice. In both cases, subjects reported using self-evaluation more than repetition during the memorization.

Researchers hypothesized that subjects may not be able to describe verbally the majority of strategies they use during practice (Rohwer & Polk, 2006). Data from subjects’ practice session recordings indicate this hypothesis is true; however, the difference between described and implemented strategies is not substantial. Subjects in the present study used an average of five strategies ($M = 4.6, SD = 0.25$) to memorize the
melody. Subjects from Rohwer and Polk’s (2006) study could only describe using an average of three strategies.

**Self-Evaluation**

Of these three strategies, Rohwer and Polk (2006) found that middle school students described using repetition most often when asked to practice music material. Findings from the present study indicate that sixth- and seventh-grade subjects described using self-evaluation most frequently when memorizing an 8-bar melody. These findings support Seddon and Biasutti (2010) who found that collegiate musicians use self-evaluation as one of the key strategies when playing by ear.

The implications of this finding are profound when considering that self-evaluation is one of the four components of deliberate practice (for a review, see Ericsson, et al., 1993; Lehmann & Ericsson, 1997). It is the culminating behavior that allows students to assess their progress over time, which is a vital component in the learning process (Lehmann & Ericsson, 1997). Teachers are always looking for ways to encourage students to engage in more deliberate practice behaviors. These findings suggest that instructing young musicians to memorize musical material may encourage these self-evaluating behaviors more than asking students to practice. Future research should examine the effects of using different instructions (i.e., practicing and memorizing) on beginning-level string instrumentalists’ practice strategies.
Mental Practice

Beginning-level string students from the present study described in their interview using mental practice to memorize the melody; however, data from the audio recordings could not validate the use of these strategies. As a result, the design of this study does not support conclusions on the effectiveness of mental practice during memorization; however, is worth noting that the aural group reported using cognitive audiation, fingering along with the CD, and moving the bow through the air away from the instrument while listening to the CD. The visual group reported using cognitive audiation, formal analysis (Chaffin & Imreh, 1997), watching fingers and the bow while practicing, and counting.

Subjects from both treatment groups stated that they audiated the melody in their minds. More subjects from the aural group indicated using this strategy \( n = 4 \) than visual subjects \( n = 1 \). Only one of the four subjects memorized the melody successfully. It seems reasonable, then, to assume that middle school subjects recognize this as a possible memorization strategy. Additional research should be undertaken to investigate whether cognitive audiation is an effective memorization strategy for beginning-level string students.

Holistic and Segmental Practice

Holistic and segmental practices have been examined in novice (Hallam, 1997) and collegiate musicians (Mishra, 2002a; Nuki, 1984). These studies, however, have been restricted to visual memorization of musical material. No research has been found that discusses holistic and segmental practice in aural memorization contexts.
Researchers who have examined visually emphasized memorization suggest that holistic practice is more efficient than segmental practice when visually memorizing musical material (Mishra, 2002a; see also McPherson, 2005; Nuki, 1984). Results from the present study disagree; holistic and segmental strategies appear to vary in effectiveness according to modal contexts.

Results indicate that segmental and holistic practices are equally effective in a visual memorization context. Data indicated that four of the seven (57%) subjects from the visual group who successfully memorized the melody used a segmental strategy; three out of five subjects (60%) from the visual group who successfully memorized the melody used a holistic strategy. These percentages do not appear to be substantially different. It remains uncertain as to whether holistic or segmental practice strategies are more efficient in a visual memorization context. In comparing the present study Mishra (2002a) and Nuki (1984) the discrepancy in findings could be attributed to the difference in age among subjects. Further research is needed.

Results suggest that segmental practice is more effective than holistic practice in an aural memorization context. Data indicated that four of the seven (57%) subjects from the aural group successfully memorized the melody using a segmental strategy; one out of six (16%) subjects from the aural group successfully memorized the melody using a holistic strategy.

Based on these findings, music teachers may consider implementing a segmental practice strategy when teaching young instrumentalists using aural models. In a visual
context, both holistic and segmental strategies may be equally effective, although more research is needed to validate this conclusion.

The present study should be replicated because the above conclusions are based on such a small subsample of the study’s overall sample population. Future research should also include video recordings of student practice behaviors to verify the use of specific strategies, which cannot be verified through audio recordings.

**Motivation: Attitudes Toward Memorization**

Researchers suggest that children participate in musical activities because they enjoy the experience (Duke, Flowers, & Wolfe, 1997; Rife, et al., 2001). Researchers also suggest such enjoyment positively correlates with musical achievement (Rife, et al., 2001; see also Hallam, 2009, citing Gellrich, et al., 1986); therefore, it seems imperative that music students enjoy participating in various musical activities so that they are motivated to develop both technically and musically.

When asked which aspects of playing they like most, the majority of students cite learning music that was assigned to them, popular music notated on sheet music, their own compositions, and improvisation. Less than 6% of students selected playing by ear; no students cited memorization (Duke, Flowers, & Wolfe, 1997). The present study investigated whether beginning-level string students enjoyed memorizing music.

Results from the present study indicate that the majority of beginning-level string students (61%) enjoyed memorizing the melody. Only 26% disliked the experience and 13% were indifferent. The present study also revealed that subjects’ initial attitude
towards memorization does not always reflect their attitude after completing the memorization task. Eight (8) out of 23 subjects ($n_A = 6$, $n_V = 2$) indicated a change in attitude as the experiment progressed.

Interview data indicated that beginning-level students enjoyed memorizing the melody because they felt a sense of accomplishment and increased confidence. They also felt that memorization was challenging and interesting (Rife, et al., 2001). Students who did not enjoy memorizing the melody claimed they learned more efficiently using another modality, they had a bad memory, or did not like the melody. They also felt uncomfortable memorizing on their own, felt nervous, or felt pressured by the time constraints.

These findings suggest that string teachers should choose melodies that students enjoy when instructing elementary or middle school string students to memorize musical material. If students feel nervous or uncomfortable, teachers should instruct beginning-level string students using a variety of modalities (Coffman, 1990; Lim & Lippman, 1991; Ross, 1985; Theiler & Lippman, 1995; Williamon & Valentine, 2002), thereby demonstrating to students their aptitude toward memorizing musical material. Teachers may also have students memorize as a group activity until they feel more comfortable memorizing musical material on their own. Finally, for students who feel constrained by time limits, the teacher should allow them to memorize musical material at their own pace.

Since the present study is one of the first investigations to examine beginning-level string students’ attitudes on memorization, researchers should try to replicate these
findings. The conclusions from the present study should be loosely interpreted with caution until validated through future research.

**Other Implications**

*Length of Melody and Temporal Constraints*

String pedagogues suggest that the memorization of simple melodies is an intermediate-level aural skill, which develops by the third year of string instruction (Hamman & Gillespie, 2009). Researchers suggest that musicians of all ages and skill levels memorize music at different rates (Lehmann, 1997; Lim & Lippman, 1991; Mishra, 2002a; Nuki, 1984; Rubin-Rabson, 1940b, 1941c). However, no studies have been found that examine how much time or how many measures a beginning instrumental student can memorize. While ancillary to the primary research questions, the present study investigated whether beginning-level string students with no more than 20 months of public school string instruction could memorize a simple 8-bar melody in 15 minutes.

Findings from the present study correspond with prior research and pedagogical literature. In this experiment, subjects were asked to memorize a simple 8-bar melody in 15 minutes. Results indicate that 15 minutes of deliberate memorization practice is not sufficient time for the majority of beginning-level string students to memorize a simple 8-bar melody. Only 12 (48%) out of 25 subjects were able to successfully memorize the 8-bar melody. No subjects performed the melody free of errors. Data, however, indicated that 15 minutes is sufficient time for beginning-level string students to significantly decrease the number of pitch and rhythmic errors within a simple 8-bar melody.
Based on these findings, it is reasonable to assume that the memorization of simple melodies is an intermediate-level skill for beginning-level string students with only 20 months of public school string instruction and no teacher supervision. Furthermore, beginning-level string students do memorize at different rates. The results, however, suggest that string teachers should encourage beginning-level string students to memorize musical material for at least 15 minutes each day. While one 15-minute session may not be a sufficient length of time to learn an entire melody by memory, several sessions may yield substantial results over the course of a week. It remains unclear at this point how much time beginning-level string students need to memorize a simple 8-bar melody. Further research should examine the length of time that beginning-level string students need to visually and aurally memorize an 8-bar melody. Researchers should also investigate how many measures beginning-level string students can memorize in a 15-minute practice period.

*Maturation and Experience*

Researchers suggest that achieving expertise in a domain requires individuals to practice deliberately specific-related activities for approximately 10 years or 10,000 hours (Ericsson, Krampe, & Tesch-Romer, 1993; see also Ericson & Kintsch, 1995; Lehmann, 1997). Previous research, however, has not investigated if 1 year of chronological maturation between sixth- and seventh- grade subjects has an effect on beginning-level string students’ ability to perform correct pitches and rhythms when students have similar levels of experience.
Findings from the present study support prior research. Older beginning-level string students do not memorize music material with more accuracy than younger students with the same amount of instruction. Sixth-grade subjects performed significantly better than the seventh-grade subjects, but only in the aural treatment group. There was no significant difference between grade levels in the visual treatment group. Also, sixth-grade subjects’ committed an equivalent number of errors between groups. Seventh-grade subjects in the aural groups committed nearly twice as many errors than seventh-grade subjects in the visual group on all levels of time. The maturation that occurs between sixth grade and seventh grade did not seem to positively influence beginning-level string students’ ability to memorize musical material.

One can only speculate at this point why the aural group of seventh-grade students performed significantly more errors than in the visual group. Consistency of music instruction may have been an influential factor. The majority of subjects in the present study described participating in elementary level general music activities. One could hypothesis that the yearlong gap between fifth-grade general music and seventh-grade orchestra class placed the seventh-grade subjects at a disadvantage when performing the memorization task. Also, beginning-level string instructors use a lot of modeling during the initial years of string instruction. The seventh-grade orchestra classes in the present study included both first-year and second-year beginning-level string students. As a result of this heterogeneity, it is possible that the seventh-grade subjects received less aural training (i.e., modeling or rote training) than a normal sixth-grade beginning-level orchestra class. Overall, however, these finding should be interpreted with caution. Grade level was analyzed as a post-hoc blocking factor. The
sample population was small and included nearly twice as many sixth-grade subjects as seventh-grade subjects ($n_6 = 16; n_7 = 9$). Further research is needed before any conclusions can be drawn from this finding.

To analyze this question of experience versus maturation further, a case study was performed on the five subjects who were disqualified from the analysis because of prior musical experience. Four of the five subjects successfully completed the memory task, two of whom performed the melody without errors. Of the eligible subjects, only 12 (48%) out of 25 were successful. No eligible subjects performed the melody void of errors. This evidence suggests that prior experience is a primary factor in determining beginning-level string students’ ability to memorize musical material (Ericcson & Kintsch, 1995), more so, perhaps, than students who are one year older.

Together, these findings suggest that experience may be a stronger predictor of memorization ability than chronological maturation. The mental representations that lead to expertise within a musical domain must be developed experientially through mental and deliberate practice.

**Conclusions**

Each time beginning-level string students participate in musical performance activities they are surrounded with an array of both visual and aural stimuli. Findings from the present study suggest that the cognitive mechanisms responsible for encoding and recalling these stimuli do not develop at equal rates when presented at the same time. Modal development, therefore, may be highly dependent on teachers’ primary mode of
instruction. To develop each mode equally, it is vital that teachers balance their curriculum with visual and aural instruction by addressing each skill independently.

The present study has identified several trends related to modality-specific strategies that beginning-level string students use to memorize musical material. These students typically use five of these strategies, but can only recall three of them. Teachers should instruct beginning-level string students on how to use a segmental approach when memorizing aural stimuli and either a segmental or holistic approach when memorizing visual stimuli to increase efficiency during memorization. Memorization encourages beginning-level string students to self-evaluate. Since self-evaluation is a primary component of deliberate practice, students may develop technical facility at a more efficient rate while memorizing. Rather than instruct students to practice assigned material, teachers may consider instructing students to memorize assigned material. Memorizing music for 15 minutes daily should be a sufficient length of time to allow significant progress.

Findings from the present study indicate that beginning-level string students enjoy memorizing either at the onset or following the memorization task. Memorization encourages self-evaluation; students enjoy participating in memorization tasks. It is reasonable to assume then that using memorization strategies will make the learning process more efficient and encourage deliberate practice behaviors.

To achieve these goals, teachers should make the memory activity challenging, choose music with fun and interesting melodies and harmonies, give students sufficient time to memorize the material, and allow students to memorize with their peers.
Teachers, however, should be careful not to overwhelm students with too much material. Students can only memorize less than eight measures during 15 minutes of consistent deliberate practice.

Memorization is quintessential to all forms of learning and occurs in various forms and degrees. While it has been acknowledged that memorization occurs naturally (i.e., incidental memorization) (Chaffin, et al., 2009), students should be encouraged to practice and develop the ability to memorize. Classroom music educators, therefore, should consider including memorization as an important component of their music curriculum (McPherson, 1997, 2005).

This exploratory examination on modality-specific memorization has produced new data on memorization and supports previous research findings; however, more research is needed to investigate memorization on beginning-level instrumental musicians. These investigations should: 1) explore the effects of integrating memorization activities in the public school curriculum, 2) examine strategies that will increase aural development in heterogeneous public school music classes, and 3) investigate the relationship between memorization and students’ understanding of self-evaluation.
Bibliography


Major, M. L. (2010). *How they decide: A case study examining the decision making process for keeping or cutting music in a K-12 public school district.* Unpublished doctoral dissertation, The Ohio State University, Columbus, OH.


Unpublished doctoral dissertation, University of Michigan, Ann Arbor.


Update - Applications of Research in Music Education, 8(1), 9-14.


Appendix A: General Music Teacher Melody Assessment Form

How many years have you taught general music in public school systems? ____ years

What grade levels do you teach on a weekly basis?

____ Kindergarten       ____ 3rd grade
____ 1st grade          ____ 4th grade
____ 2nd grade          ____ 5th grade

You are a nationally recognized teacher. Please list the top honors and awards you have received as of April 19, 2011.

________________________________________________________________________
________________________________________________________________________
________________________________________________________________________

Instructions: Attached to this form are three melodies. Please look over each melody carefully and answer the questions below to the best of your ability.

Excluding pitch range, would you consider these melodies singable by third-grade students in a public school general music program?

Melody 1      ____ Yes      ____ No      If no, why? ____________________________

Melody 2      ____ Yes      ____ No      If no, why? ____________________________

Melody 3      ____ Yes      ____ No      If no, why? ____________________________

Excluding pitch range, would you consider these melodies singable by fourth-grade students in a public school general music program?

Melody 1      ____ Yes      ____ No      If no, why? ____________________________

Melody 2      ____ Yes      ____ No      If no, why? ____________________________

Melody 3      ____ Yes      ____ No      If no, why? ____________________________
Excluding pitch range, would you consider these melodies singable by fifth-grade students in a public school general music program?

<table>
<thead>
<tr>
<th>Melody 1</th>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>Melody 2</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Melody 3</td>
<td>Yes</td>
<td>No</td>
</tr>
</tbody>
</table>

If no, why? ______________________
Appendix B: String Teachers’ Mode Of Instruction Survey

Instructions: Please answer the following questions. This survey consists of two pages.

1) How often do you teach your sixth- and seventh-grade string students every two weeks?

6th grade: __________ times bi-weekly; __________ minutes per class.

7th grade: __________ times bi-weekly; __________ minutes per class.

2) Approximately how much class time do you have students read musical notation from a book or sheet music?

6th grade: 1 2 3 4 5 6 7

No time Half Time Whole

7th grade: 1 2 3 4 5 6 7

No time Half Time Whole

3) Approximately how much class time over the course of two weeks do you have students read musical notation from a book or sheet music?

6th grade: 1 2 3 4 5 6 7

No time Half Time Whole

7th grade: 1 2 3 4 5 6 7

No time Half Time Whole
4) Approximately how much class time do you have students play musical excerpts or melodies by ear without the aid of written notation?

6\textsuperscript{th} grade: 1 2 3 4 5 6 7
No time Half Time Whole

7\textsuperscript{th} grade: 1 2 3 4 5 6 7
No time Half Time Whole

5) Approximately how much class time over the course of two weeks do you have students play musical excerpts or melodies by ear without the aid of written notation?

6\textsuperscript{th} grade: 1 2 3 4 5 6 7
No time Half Time Whole

7\textsuperscript{th} grade: 1 2 3 4 5 6 7
No time Half Time Whole

6) How often do you model musical material and have students imitate you each class period?

6\textsuperscript{th} grade: 1 2 3 4 5 6 7
No time Half Time Whole

7\textsuperscript{th} grade: 1 2 3 4 5 6 7
No time Half Time Whole

Thank you for your responses.
Appendix C1: External Evaluator Instructions

Judge No. ______

Instructions: Please answer the questions below by filling in the blanks with the requested information.

• What is your primary string instrument? __________________
• Approximately how many years have you played a string instrument? ________ years
• Approximately how many years have you taught strings in the public school system? ________ years

Instructions: Please read the directions below very carefully.

Included in your packet should be:

• 1 CD of the test melody.
• 1 CD containing 89 subject recordings.
• 16 assessment forms. There should be six copies of the melody on each page (front and back).
• 1 score sheet (front and back).
• Yellow and orange highlighters.

1) Listen to the test melody repeatedly until you can sing it with ease.

2) Download the three Practice X.wav files and the 89 subject recording X.wav files onto your I-tunes (working from the CD player in your computer puts undue stress on the hardware).

3) Read the following instructions carefully and then complete the three Practice X.wav recordings.

• Mark the recording number in the space provided at the top of the melody.
• Listen to each recording twice. On the first hearing, mark all PITCH errors using the YELLOW highlighter. On the second hearing, mark all RHYTHMIC (duration) errors using the ORANGE highlighter. If a note head contains both a pitch and rhythmic error, be sure each colored mark can be recognized.
• Rules: After you have listened to each recording at least twice and made the appropriate marks on the melody form, count the number of red circles and write that number in the space labeled ‘Pitch.’ For example, if you counted 10 red circles, you would write:

Pitch: 10/58

Then count the number of blue circles and write that number in the space labeled ‘Rhythm.’ For example, if you counted 15 blue circles, you would write:

Rhythm: 15/60

If a note head is circled twice, it counts as one pitch error AND one rhythmic error.

Practice 1: _____ # of Pitch errors
             _____ # of Rhythmic errors

Practice 2: _____ # of Pitch errors
             _____ # of Rhythmic errors

Practice 3: _____ # of Pitch errors
             _____ # of Rhythmic errors

4) Compare your results to the templates provided below. You may go back and re-assess the practice recordings again if needed.

Practice 1

Practice 2

Practice 3
5) When you are ready, begin listening to the subject recordings. Be sure to listen to each recording carefully and make your best judgment.

6) Please complete all 89 recordings with one week (7 days) from receiving the forms. This assessment should take no longer than 4 to 5 hours. A check of $100.00 has been included to compensate you for your time.

Since completion time is an issue, please send the results back to me using 2-Day Express Mail. I have added an extra $8.00 to compensate you for the mailing cost. In the package, please include:

- Both CDs
- All the completed assessment forms
- Any incomplete assessment forms
- Score sheet (Make sure there are no blank spaces)

Send the results back to:

Jacob Dakon  
557 Stinchcomb Dr. #5  
Columbus, OH 43202

If you have any questions, please contact me at 803-524-5594 or jmdakon@gmail.com.

Thank you for your help.

Sincerely,

Jacob Dakon
Appendix C2: Assessment Form
Assessment Form

1: Pitch: ____/30  
   Rhythm: ____/35

2: Pitch: ____/30  
   Rhythm: ____/35

3: Pitch: ____/30  
   Rhythm: ____/35

4: Pitch: ____/30  
   Rhythm: ____/35

5: Pitch: ____/30  
   Rhythm: ____/35

6: Pitch: ____/30  
   Rhythm: ____/35

7: Pitch: ____/30  
   Rhythm: ____/35

8: Pitch: ____/30  
   Rhythm: ____/35

9: Pitch: ____/30  
   Rhythm: ____/35

10: Pitch: ____/30  
    Rhythm: ____/35

11: Pitch: ____/30  
    Rhythm: ____/35

12: Pitch: ____/30  
    Rhythm: ____/35

13: Pitch: ____/30  
    Rhythm: ____/35

14: Pitch: ____/30  
    Rhythm: ____/35

15: Pitch: ____/30  
    Rhythm: ____/35

16: Pitch: ____/30  
    Rhythm: ____/35

17: Pitch: ____/30  
    Rhythm: ____/35

18: Pitch: ____/30  
    Rhythm: ____/35

19: Pitch: ____/30  
    Rhythm: ____/35

20: Pitch: ____/30  
    Rhythm: ____/35

21: Pitch: ____/30  
    Rhythm: ____/35

22: Pitch: ____/30  
    Rhythm: ____/35

23: Pitch: ____/30  
    Rhythm: ____/35

24: Pitch: ____/30  
    Rhythm: ____/35

25: Pitch: ____/30  
    Rhythm: ____/35

26: Pitch: ____/30  
    Rhythm: ____/35

27: Pitch: ____/30  
    Rhythm: ____/35

28: Pitch: ____/30  
    Rhythm: ____/35

29: Pitch: ____/30  
    Rhythm: ____/35

30: Pitch: ____/30  
    Rhythm: ____/35

31: Pitch: ____/30  
    Rhythm: ____/35

32: Pitch: ____/30  
    Rhythm: ____/35

33: Pitch: ____/30  
    Rhythm: ____/35

34: Pitch: ____/30  
    Rhythm: ____/35

35: Pitch: ____/30  
    Rhythm: ____/35

36: Pitch: ____/30  
    Rhythm: ____/35

37: Pitch: ____/30  
    Rhythm: ____/35

38: Pitch: ____/30  
    Rhythm: ____/35

39: Pitch: ____/30  
    Rhythm: ____/35

40: Pitch: ____/30  
    Rhythm: ____/35

41: Pitch: ____/30  
    Rhythm: ____/35

42: Pitch: ____/30  
    Rhythm: ____/35

43: Pitch: ____/30  
    Rhythm: ____/35

44: Pitch: ____/30  
    Rhythm: ____/35

45: Pitch: ____/30  
    Rhythm: ____/35

46: Pitch: ____/30  
    Rhythm: ____/35

47: Pitch: ____/30  
    Rhythm: ____/35

48: Pitch: ____/30  
    Rhythm: ____/35
Appendix C3: Score Sheet
Score Sheet

Code: _________________

Violin

Code: _________________

Violin

Code: _________________

Violin
Table: Appendix D: Subjects’ Pitch And Rhythmic Error Scores

<table>
<thead>
<tr>
<th>Modality</th>
<th>Subject</th>
<th>Grade Level</th>
<th>Pitch</th>
<th>Rhythm</th>
</tr>
</thead>
<tbody>
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<td></td>
<td></td>
<td></td>
<td>5</td>
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</tr>
<tr>
<td>Aural</td>
<td>2</td>
<td>7</td>
<td>27.33</td>
<td>28.00</td>
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<td>Aural</td>
<td>4</td>
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<td>Aural</td>
<td>6</td>
<td>7</td>
<td>28.67</td>
<td>27.67</td>
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Appendix E: Internal Review Board Approval
May 3, 2011

Protocol Number: 2011B0098
Protocol Title: THE EFFECT OF AURAL AND VISUAL MEMORIZATION PROCESSES ON BEGINNING STRING STUDENTS’ PITCH AND RHYTHMIC ACCURACY, Robert Gillespie, Jacob Dako, School of Music

Type of Review: Initial Review—Expedited
IRB Staff Contact: Jacob R. Stoddard
Phone: 614-292-0526
Email: stoddard.13@osu.edu

Dear Dr. Gillespie,

The Behavioral and Social Sciences IRB APPROVED BY EXPEDITED REVIEW the above referenced research. The Board was able to provide expedited approval under 45 CFR 46.110(b)(1) because the research meets the applicability criteria and one or more categories of research eligible for expedited review, as indicated below.

Date of IRB Approval: May 3, 2011
Date of IRB Approval Expiration: April 18, 2012
Expedited Review Category: 7

In addition; the protocol has been approved for the inclusion of children (permission of one parent sufficient).

If applicable, informed consent (and HIPAA research authorization) must be obtained from subjects or their legally authorized representatives and documented prior to research involvement. The IRB-approved consent form and process must be used. Changes in the research (e.g., recruitment procedures, advertisements, enrollment numbers, etc.) or informed consent process must be approved by the IRB before they are implemented (except where necessary to eliminate apparent immediate hazards to subjects).

This approval is valid for one year from the date of IRB review when approval is granted or modifications are required. The approval will no longer be in effect on the date listed above as the IRB expiration date. A Continuing Review application must be approved within this interval to avoid expiration of IRB approval and cessation of all research activities. A final report must be provided to the IRB and all records relating to the research (including signed consent forms) must be retained and available for audit for at least 3 years after the research has ended.

It is the responsibility of all investigators and research staff to promptly report to the IRB any serious, unexpected and related adverse events and potential unanticipated problems involving risks to subjects or others.

This approval is issued under The Ohio State University’s OHRP Federalwide Assurance #00006378.

All forms and procedures can be found on the ORRP website – www.orrp.osu.edu. Please feel free to contact the IRB staff contact listed above with any questions or concerns.

Shari R. Speer, PhD, Chair
Behavioral and Social Sciences Institutional Review Board

ha-017-06 Exp Approval New CR
Version 01/13/09