Examining the Effect of Practicing with Different Modeling Conditions on the Memorization of Young Piano Students

Mémoire

Nisreen Jardaneh

Maîtrise en musique - avec mémoire

Maître en musique (M. Mus.)

Québec, Canada

Résumé

La modélisation est une technique d'enseignement étudiée dans les domaines de l'apprentissage moteur, des neurosciences, de l'enseignement et de la musique. Cependant, on ignore si cette technique peut être efficace pour mémoriser la notation musicale pour piano, en particulier pour les jeunes élèves. Cette étude a donc examiné l'effet de la pratique instrumentale utilisant différentes conditions de modélisation sur la mémorisation d'une pièce de piano. Ces conditions de modélisation étaient les suivantes: modélisation auditive et modélisation vidéo avec indices. L'étude comportait une quasi-expérience avec 24 jeunes élèves de piano de 3e année du Conservatoire royal de musique (CRM) au Canada ou l'équivalent. Les participants ont pratiqué avec une condition de modélisation afin de déterminer quelle condition produirait les meilleurs résultats de rétention mnémonique. Les résultats ont montré que la modélisation vidéo avec indices était l'outil de pratique le plus efficace en termes d'erreurs de notes et de rythmes, lorsqu'elle est comparée à la modélisation audio et aux groupes de pratique libre. Ces résultats appuient les recherches en neurosciences selon lesquelles l'utilisation de techniques visuelles, auditives et motrices produisent la meilleure rétention. Cela offre un grand potentiel pour l'utilisation de la modélisation vidéo avec repères comme outil de pratique pour les élèves en piano afin d'améliorer la mémorisation.

Abstract

Modeling is a teaching technique that is studied in the fields of motor learning, neuroscience, teaching, and music. Yet it is unknown whether this technique can be effective in memorizing piano music especially for young students. Therefore, this study examined the effect of practicing with different modeling conditions on memorizing a piano piece. These modeling conditions were: aural modeling, and video modeling with cues. The study conducted a quasi-experiment with 24 young piano students at Grade 3 level of the Royal Conservatory of Music (RCM) in Canada or equivalent. Participants practiced with one modeling condition in order to measure which condition would produce best retention results. Results showed that video modeling with cues seemed to be the most effective practice tool in terms of low note mistakes and rhythm mistakes compared to audio modeling and free practice groups. This finding supports neuroscience research that states that the use of visual, aural and motor techniques produce the best memory recall. This provides great potential for using video modeling with cues as a practice tool for piano students for better memorization.

Keywords: Memorization, modeling, aural modeling, mirror neurons, educational neuroscience, motor learning, video modeling with cues, practicing

Table of Contents

Table of Tables

Table of Figures

Acknowledgements

This project wouldn't have been possible without the help of many people. I would like to start by expressing deep gratitude to the piano students who took part in this study. Their support along with that of their parents made this project happen. Special thanks goes to the Director of Opus Academy Marie-Claude Bourque who hosted the pilot study at her academy and helped in recruiting students. Special thanks goes to the Centre of Musical Arts and the Music Hub for their support to this study. I would like to thank my friend Liz who helped me in recording the introduction video for the experiment. My gratitude goes to my talented sister Ayah who spent many hours creating and editing all videos used for the experiment.

I would also like to thank professor Francis Dubé for his patient guidance, enthusiastic encouragement and useful critiques of this research work. Thanks to professor Louise Mathieu and Simone Grondin for their guidance and supervision during data collection and analysis.

I wish to thank the Canadian composer Christine Donkin who wrote the composition and showed great interest in this research project.

Finally, I wish to thank my parents, siblings and friends for their support and encouragement throughout my study. My deepest gratitude also goes to my husband Nawriz and children, Hamza and Yasmeen who supported me all the way through and travelled with me when I was collecting my data.

Introduction

The goal of this study was to test the effectiveness of using different modeling conditions on the memorization of piano music. This has been done by asking 24 piano students studying at the grade 3 piano level of Royal Conservatory of Music (RCM) and equivalent system like Associated Board of Royal Schools of Music (ABRSM) and Vincent D'Indy to memorize a given piece in two sessions using one of the following modeling conditions: aural modeling, or video modeling combined with cues, while the control group did free practice. From the researcher's point of view, cues represent the general practice guidelines that teachers provide their students to be done during home practice. This study didn't include video modeling with corrective feedback because it does not represent the natural practice setting for piano students. In real life, students practice their assigned pieces without receiving external feedback during their practice sessions. Therefore, we did not deem this condition to be pertinent to this study.

Playing securely from memory is an essential facet of Western classical piano performance; it has been a standard practice in competitive, professional and educational settings, for many decades (Bastien, 1995; Nellons, 1974). It is also a required element in many examination systems (e.g.: The Associated Board of Royal Schools of Music (ABRSM) in the United Kingdom), and a rewarded aspect in other examination systems (e.g.: The Royal Conservatory of Music (RCM) Canada). The Kiwanis Music Festival, responsible for preparing and presenting a competitive Music Festival annually in Canada since 1945, has a specific section on memorization stating that preference will be given to the participant who performs from memory, and that all solo classes at the Provincial and National level of competition must be performed from memory (Mortin, 2013). Playing without music notation is therefore an important aspect of music learning (Shockley, 2001). However, although this requirement is part of tradition, knowledge in this area is underdeveloped, especially with regard to the memorization process used by young pianists to play without the aid of a score.

The importance of performing from memory seems to have many benefits for the musician. It can help the performer to acquire detailed knowledge of the music notation played (Hughes, 1915) and allows him/her to reflect better musicality and expressivity ensuring a more rewarding experience with the audience (Williamon, 1999). Some of the benefits of playing from memory is that the musician will have the advantage of focusing on physical aspects of the performance such as monitoring the finger movements, paying attention to ensemble members instead of worrying about turning the page or securing a page turner. Most importantly, playing from memory improves musical communication and musicality (Ginsborg, 2007). The complex phenomenon of memorization has been extensively explored and therefore been conceptualized from different angles (Ginsborg, 2004), including music psychology, cognitive psychology, neuroscience, and piano pedagogy.

In music psychology, studies focused primarily on describing the process of memorization, while other studies tested the effectiveness of specific tools or techniques on musical memory. However, despite the growing amount of research in music psychology that tries to understand the complex process of music memorization, memorizing music is still not greatly understood (Mishra, 1999). Many studies in music psychology lack common terminology to discuss the process of memorization, leaving it unclear (Mishra, 2005). Also, almost all previous studies in music psychology have concentrated on expert (advanced and professional) musicians, whether by examining how they memorized music or by testing the effectiveness of a certain memorization strategy on their performance (Chaffin & Imreh, 1997; Dubé, 2006; Shockley, 1980; Wheatley, 1991). This has contributed little understanding of how young piano students can memorize music effectively.

In cognitive psychology, memorization is seen as a mental progression that entails three main stages: encoding, storage, and retrieval (Baddeley, 2000). Encoding is the first stage in processing the material to be learned or the information coming from the environment. It involves transferring sensory input to mental representations and includes many aspects involved in perception. Storage is the second stage; it deals with maintaining and storing the information that has passed through the encoding stage. Retrieval deals with accessing and retaining the stored information from the memory system (Eyesnck & Keane, 2010). It is important to note that cognitive psychology research indicates that the nature of encoding the information and storing it in the long term memory directly affects how efficiently we can retrieve it through “recall” and reproduce the information on demand (Wilding & Valentine, 1997). This has implications for the memorization of music, in that to ensure effective recall during the performance of a piece, the player must first have encoded and stored the musical information in an appropriate way.

In neuroscience, playing the piano may be considered a serial motor skill because the discrete movement of striking the piano keys must be done in a definite sequential order (Hays, 2006; Schmidt & Lee, 2005). For example, when playing a scale, a pianist is carrying out a series of discrete actions – striking each key – in a specific order, where each key must be played at the appropriate time in the sequence and the pianist’s fingers must land in the correct position in relation to the key played immediately beforehand. However, neuroscientific literature also describes piano playing as a sensorimotor skill because it involves motor actions that must be carried out in a specific pattern and are generated by sensory perceptions - i.e. what one sees, feels and hears (Shusterman, 2012). Several neuroimaging studies have described the tight and automatic coupling between auditory, visual, and motor networks in the brains of musicians (Haslinger et al., 2005), a coupling evident even in the brains of beginners who had had just 20 minutes of piano training (Bangert & Altenmüller, 2003). Given that piano playing is regarded a sensorimotor skill, this indicates that, where piano playing is concerned, not just the motor networks of the brain but also the visual and auditory networks are engaged - the pianist places his or her fingers on the keys in response to auditory, visual and proprioceptive stimuli and memory.

Successfully encoding information into memory is essential, according to cognitive psychology, for later recall, and neuroscientific literature suggests that playing the piano requires input from the motor, visual and auditory systems of the brain. So, for a pianist, having a reliable memory of visual, auditory and motor information in relation to playing a particular piece is essential to being able to perform that piece without music in front of them as a prompt.

Moreover, research in neuroscience has shown that the brain regions responsible for the planning of movement and for movement itself are activated when observing actions, a function of the so-called ‘mirror’ neurons. This mirror system seems to become particularly active in subjects who are observing an action they will later have to imitate – that is, to do the action based on a memory of having observed it being carried out. They enable the subject better to encode memory traces of the skill so that he/she can recall those traces later on when attempting the skill himself or herself. (Buccino et al., 2004).

Applied to piano playing, this suggests that, for piano students attempting to memorize a piece, observing another person playing it may help them to encode the visual, auditory and motor information they need to be able to recall later in order to play the piece without reference to the music on the page. Indeed, research suggests that the ability to learn precise and difficult motions through observation is an effective method for learning; it seems that musicians learn much from watching someone else perform a piece that they are working on (Schlosser, 2011). It would seem pertinent, then, to investigate whether teaching methods involving learning through observation have a positive effect on piano students' ability to memorize music. That's why we chose to use a modeling-based teaching approach in this research.

In piano pedagogy, the focus of the literature has mainly been around the elements involved in the memorization process, the four main principles that make up what Eaton (1978) calls the "four-component theory." Researchers and piano pedagogues have used varied but similar terms for these principles: aural or auditory memory relates to what the music sounds like, visual memory to what the music notation looks like and the movements of someone who is observed playing the music, kinaesthetic (also known as touch, tactile, finger or motor, memory) to the player's proprioceptive sense when they are playing, and analytical, intellectual or conceptual memory to the conscious knowledge the player builds around the form and structure of the piece (Ahrens & Atkinson, 1955; Bernstein, 1981; Broughton, 1956; Cark, 1992; Dubé, 2006; Eaton, 1978; Gieseking & Leimer, 1932/1972; Haydon, 1996; Hughes, 1915; Lawrence, 1976; Matthay, 1970; Newman, 1984; Rickey, 2004; Shockley, 2001; Whiteside, 1997). Looking back to the theory of memory suggested by the cognitive psychology literature, we can view these four components as four different elements of the music that the player might 'encode' and commit to memory, to be recalled at will later on when the piece is to be performed. It is important to note that while the first three types of sensory memory – aural, visual and kinesthetic memory – are built through repeated exposure, the last – analytical memory – is acquired through focused and deliberate thought.

Turning once more to the problem of memorization of music for performance by young piano students, we find there is little in the literature – that of music pedagogy, psychology, or otherwise - about what methods are most effective. However, based on what neuroscience tells us about the effects of observation on learning and memory, we can form a basis for further research on how memorization of pieces of music can be better achieved. The emphasis cognitive psychology, music pedagogy and neuroscience all place on the inter-reliance of auditory, visual and motor networks brings to the forefront the importance of using a teaching method that doesn't rely solely on verbal instruction when learning a new task for strong memory retention. This brings us to the concept of modeling, which is the corner stone of this study. Modeling, defined as the presentation, live or recorded, of anything that may be later imitated by an observer (Madsen, Greer & Madsen, 1975), is a method based on the use of observation as a learning tool, and hence has the potential to encourage memorization by piano students. Research literature identifies modeling as an essential instructional technique for learning and retrieving information about how to perform a skill (e.g. Frewen, 2010). Some studies in modeling show that combining modeling with cues and corrective feedback may enhance learning and hence retrieval of specific skills (Bandura, Jeffrey, & Bachicha, 1973; Keele, 1977). The efficacy of modeling is also evident in several studies with specific reference to motor learning and sports (Gould & Weiss, 1981; McCullagh & Caird, 1990; George, Feltz, & Chase, 1992).

The work of cognitive psychologist Albert Bandura (1977, 1986, 1997) has become the predominant reference and theoretical foundation for most research concerning the acquisition and demonstration of specific skills through modeling (Edwards, 2010). Bandura (1977) describes learning a skill via modeling through four main stages: paying attention to the modeled skill, retaining a memory of the modeled skill, reproducing the action through practice, and feeling self-efficient when producing the learned action. Clearly, a piano student seeking to memorize a piece of music is focused on the last two stages: reproducing the skill (playing the piece) accurately, and feeling a sense of self-efficacy as they do so. According to Bandura's theory, to achieve this, the student would need to pay attention to a skill being performed and retain it in their memory as they do so. Based on this framework, then, modeling would appear to be a suitable method to take for a student seeking to memorize a piece in order to be able to play it back confidently and accurately without reference to notation. This is another reason why we chose to use modeling to study the memorization of young pianists.

However, very little has been written about the use of modeling for memorization in music teaching textbooks, and there is less literature on the use of visual modeling than on the use of aural modeling, which suggests a gap in the literature specifically around the use of visual modeling to improve memorization. It is also the case that the studies in music focused mostly on advanced and undergraduate students, and that piano-specific literature on the topic is scarce. Hence this study aims to evaluate the effect on young piano students of practicing using different types of modeling to memorize pieces.

In order to test whether it is indeed the case that students' memorization of piano music can be improved through modeling, this study will examine the effect of visual modeling, with cues, on students' memorization of a piece. This form of modeling involves the observation of a model's movements when playing a piece, as well as visual and auditory cues that provide information about the piece. While many studies have focused on testing the effect of solely aural modeling on performance accuracy levels, research on video modeling in music – which combines aural, visual and motor aspects of learning - has received less attention. To examine the effect of removing the visual element from the modeling, this study will also test the use of audio-only modeling, where the participant will only hear the piece being playing, not see it, and cues will be provided aurally, and not visually. Both types of modeling will be compared with free practice of the piece without modeling.

Chapter 1. Review of Literature

Hidden behind the cognitive tasks that seem easy and natural is the most complex and mysterious puzzle of human intelligence: that is, memory (Medin, Ross, Markmnan, 2005). This remarkably complex process involving numerous parts of the brain plays a vital role in every aspect of our lives (Cherry, 2014). It is involved in every mental task from the simplest to the most complex. Therefore, we must first explore the definition of memory and understand what it exactly means.

1.1 Definition of memory

The objective of this section is to define the concept of memory from three main sources: dictionaries (general), pedagogy texts, and research texts. Webster's (2013) dictionary defines the verb memorize as the ability 'to learn (something) so well that you are able to remember it perfectly'. In turn, Oxford dictionaries online (2013) defines the verb memorize as the action to "commit to memory; learn by heart".

Neither the music psychology research nor the pedagogy literature offer a large number of definitions for the term music memorization. Perhaps this concept is not addressed extensively because it is assumed that everyone knows what it means. Few piano pedagogy authorities have much to say about the definition of memorization. However, Broughton (1956) defines memorization as "the translation of notation into a mental picture on the keyboard" (p. 43), and Agay (1981) defines memorization as "the process and discipline by which we may obtain this faculty. In other words, memory is the result, the end product of memorization" (p. 219).

Most researchers in music psychology seem to agree that music memorization is a complex cognitive process that involves playing music that was previously learned and stored in the long-term memory without referring to notation. Mishra (1999) defines memorization in music as "learning a piece of music for performance without notational reference" (p. 1). Nellons (1974) defines it as "the faculty to acquire and retain musical impressions gained from experience with a music score as demonstrated by an ability to identify and reproduce the music contained therein without overt visual reference" (pp. 4-5) which ties well with Eaton (1978) who describes memorization as “the ability to reproduce a musical composition at the keyboard without the aid of the notation after prior study” (p. 8).

Ginsborg (2004) states that the memory of a piece of music, whether it results from repeated hearing or conscious memorization, is a “mental representation stored in long-term memory, on which the musician can draw when performing” (p. 128). However, Rickey (2004) considers memorizing piano music as both a process and a result. The process involves a structuring of musical symbols that is retained in the mind. The result is the extent to which these music symbols are reproduced fluently and accurately on the keyboard upon demand.

In piano pedagogy, the focus of the literature has mainly been on discussing and exploring the ways or methods by which music is memorized. Most of this discussion revolves around the elements involved in the memorization process, the four main principles that make up what Eaton (1978) calls the “four-component theory.” Researchers and piano pedagogues have used varied but similar terms for these principles: aural or auditory memory, visual memory, kinaesthetic (also known as touch, tactile, finger or motor, memory) and analytical, intellectual or conceptual memory (Ahrens & Atkinson, 1955; Bernstein, 1981; Broughton, 1956; Cark, 1992; Dubé, 2006; Eaton, 1978; Gieseking & Leimer, 1932/1972; Haydon, 1996; Hughes, 1915; Lawrence, 1976; Matthay, 1970; Newman, 1984; Rickey, 2004; Shockley, 2001; Whiteside, 1997).

Aural memory is related to remembering what the music sounds like, and thus involves the mental hearing of the melody, dynamics, rhythm, etc. This type of memory plays a dominant role in a pianist's memorization, since music is basically an assortment of sounds. Auditory memory allows pianists to recognize if they are playing the right notes, and based on that, to predict the next notes to be played. Visual memory is related to what has been seen. It involves the ability to form a mental image of the way the notes look on the music score and piano, and of how someone’s hands are moving when they are playing it. Kinesthetic memory has to do with the sense of position, and direction of movement or effort. It deals with muscle memory—that is, what it feels like to play a piece. Since playing piano involves physical movements, this kind of memory is useful for managing movement and finding the way around the keyboard. Analytical memory refers to the conscious knowledge built around the form and structure of the piece. This includes the analysis of harmony, tonality, nuances, phrasing, counting, and other elements. (Ahrens & Atkinson, 1955; Dubé, 2003; Haydon, 1996; Newman, 1984; Rubinstein, 1950; Shockley, 2001; Whiteside, 1997).

It is important to note that while the first three types of memory – aural, visual and kinesthetic memory – are built through repeated exposure, the last – analytical memory – is acquired through focused and deliberate thought. In the context of piano playing, this means that aural, visual and kinesthetic memory of a piece is gained through repeatedly hearing it, seeing it played and physically playing it oneself, while analytical memory of the piece would be achieved by a much more theoretical application of the conscious mind to the inherent properties of the piece. Many piano pedagogues advocate the use of all types of skills—aural, visual, kinesthetic, and analytical—for optimum memorization results (Mishra, 1999). However, most of the pedagogical references are based on descriptive personal teaching experiences and "common sense" (Mishra, 1999, p. 4) rather than rigorous scientific research. In addition, the effectiveness of what teachers recommend on how to memorize is not scientifically tested (Mishra, 2007).

Recent views on how human memory works come from cognitive psychology and neuroscience. In cognitive psychology, the description of structure and function of memory are based on observing the behavior of individuals in memory situations. As for neuroscience, the structure of memory is examined in terms of what is happening in the nervous system during behavioral changes in relation to memory (Magill & Anderson, 2013).

In cognitive psychology, it is important to note that discussions of memory concepts are still described as underdeveloped (Dudai, Roediger, & Tulving, 2007). There is little in the literature, and systematic work on the concept of memory is scarce (Tulving, 2000). Using one term that can refer to different concepts at the same time is a common source of confusion. Endel Tulving, the influential experimental psychologist and cognitive neuroscientist, devoted an entire chapter to concepts of memory in his well-known reference, the *Oxford Handbook of Memory*. Tulving noted that the term memory seems to have at least six common meanings. Among them are the neurocognitive capacity to encode, store and retrieve information; the storage in which information is held; the information in that store; some property of that information; the componential process of retrieval of that information; and finally the individual's awareness of remembering something (Tulving, 2000, p. 36).

Some cognitive psychology researchers define memory as the process of maintaining information over time (Matlin, 2005). Others perceive memory as "the means by which we draw on our past experiences in order to use this information in the present" (Sternberg, 2008, p. 177). However, most authors refer to memory as the mechanism of creating, storing and retrieving information (Crowder, 1976; Eysenck & Keane, 2010; Mailenow, 2007; Medin, Ross, Markmnan, 2005; Mohs, 2014; Myers, 2013; Sternberg, 2008). The American Psychological Association (2014) states on their website that memory refers to "The mental capacity to encode, store, and retrieve information'.

Cognitive psychologists have identified three main phases of memory: encoding, storage, and retrieval (Baddeley, 2000; Brown & Craik, 2000). Encoding is the first stage of processing material to be learned or the information coming from the environment. It involves transferring sensory input to mental representations and includes many aspects involved in perception. Storage is the second stage; it deals with maintaining and storing the information that has passed through the encoding stage. Retrieval deals with accessing and retaining the stored information from the memory system (Eyesnck & Keane, 2010; Sternberg, 2008).

In neuroscience, neuroscientists focus on the physical structure of the memory that is housed in the brain through networks of neurons which communicate through synaptic connections that form different kinds of memories (Edwards, 2010). The motor learning and motor control fields concentrate on the acquisition and retention of motor skills (Schmidt & Lee, 2014).

1.2 Memory in piano pedagogy

The pedagogy literature provides us with teachers' perspectives on memorization; their experience with students, their many years of preparing for performances and, most importantly, their teaching knowledge, all make teachers' viewpoints essential. Based on content analysis that was conducted by Mishra (2010) which covers articles written by musicians and teachers from

1872 to 2006 on memorization, major topics surfaced from this literature: memory methods (aural, visual, kinesthetic, analytical), organization of memorization practice, and memory cues.

1.2.1 Memory methods

Views on the importance of each memory varied. In general, at least two of the memorization methods were usually mentioned in the pedagogy literature, but more commonly all four methods were discussed (Mishra, 2010). Some pedagogues praised some types of memory more than others. For example, few pedagogues discourage pianists from relying on kinesthetic memory alone because it is the first kind of memory that goes (Broughton, 1956; Matthay, 1970; Whiteside, 1997). Others, like Whiteside (1997) and Rubinstein (1950), rate aural memory above all other memory types. For example, Rubinstein notes that the ear memory controls the work of other types of memory, so a piece of music cannot be committed securely to memory unless the ear functions properly. Whiteside also believes that since we recognize music by its sound and no other way, aural learners are the only ones who have secure musical memory.

Nonetheless, many piano pedagogues agree on the notion that deep understanding of the music is the key process that shapes the reliability of memorization. To be more precise, analytical memory is acquired by deliberate and conscious effort while other types are involuntary and do not result in reliable retention of the musical text. Most importantly, the process of analyzing each piece that the student plays should start very early on in the learning process, beginning with the most simple and obvious analytical premises to the most complex ones. For example, Matthay (1970) focuses on the importance of progression of thoughts. He believes that in order to memorize anything, the only possible way is by forming a logical progression or sequence of thoughts. In other words, the student must build onto existing knowledge by linking existing information with new information to create a mental progression of onwardness. Haydon, 1996 explains that memorization is done using theoretical analysis on two levels. The macro level includes identifying the music form, and the repetitions, while the micro level consists of identifying key areas, themes, sequences, intervallic unity, and harmonic relationships. In addition, Cooke (1970) explains that general and detailed analytical memorizing moves the musician to the highest level of memorizing, which is the intellectual level. At this level, students will not know a piece because they remember it, rather they will remember the piece because they know it. Agay (1981) explains that since music by its nature requires tonal organization of various kinds like harmony, form, and rhythm, it becomes very natural to memorize the music through exploring and understanding the specific characteristics and interrelationships of the musical elements within the piece.

Consequently, a planned and conscious analysis allows the pianist to collect, link, and store important elements that make it easier and more dependable to retain information, rather than cluttering the mind with indistinct pieces of information. Schokley (2001) asserts that the benefit of memorizing in such an intellectual way goes beyond just mastering a specific piece; it leads to a broader development of the students' musical skills.

Several pedagogues advocate cognitive work like imagery and visualization for secure and long-term memorization (Ahrens & Atkinson, 1955; Bastien, 1995; Matthay, 1970; Newman, 1984; Shockley, 2001). Matthay (1970) believes that the only way to prevent finger memory mistakes is through practicing without touching the keyboard at all—through silent practicing. This way, by imagining every note memorized, it is impossible to allow the attention to flag. Leimer and Gieseking (1932/1972) introduced the term visualization as an important part of solid memorization. This term implies intense concentration and studying the piece away from the keyboard until the ability to write the piece down from memory is reached. Using this approach, students are asked to visualize each piece through silent reading. Students then discover how to approach each piece not as individual notes, but as a coherent musical structure. In order to be able to visualize, students should be trained in systematic logical thinking. Such systematic memory training not only allows the student to thoroughly understand the structure of compositions, handle more difficult musical tasks and find different ways to facilitate the memorizing of pieces, it also gradually develops the ability to hear with the "inner ear." In the end, this process results in transforming the piece from being purely technical to mainly mental.

Haydon (1996) also advocates the use of visualization for better memorization. This process entails that the student place the piece somewhere away from the piano and study a small portion of the music—one or two measures. The student then verbalizes what he or she is trying to memorize, and then immediately tries to play. This way, students can easily identify the missing points or "black holes" in their recollection, return to their music to answer questions, and then go back to the piano for another try. Shockley (2001) suggests mind mapping, an untraditional way to memorizing music. The main idea behind this approach is to study the score away from the piano, then draw a map using arrows, dots, dashes or any other symbol that helps create a meaningful diagram of the piece. This map serves as a visual representation of the main features, like harmony, melody, or other elements. When creating the map, Shockley advises the pianist to begin by locating patterns and determining the overall form of the piece. This should then be followed by spotting specific elements including melody, phrase structure, rhythm, harmony, repetition and contrast, and other patterns like finger numbers. Also, silent or mental practice, such as playing away from the piano or playing one hand and miming the other, is also an excellent way to solidify playing from memory (Ahrens & Aktinson, 1955; Haydon, 1996; Leimer & Gieseking, 1932/1972; Matthay, 1970; Newman, 1984; Shockley, 2001; Whiteside, 1997). Listening to recording of a piece to be memorized is also helpful (Agay, 1981; Bernstein 1981; Cooke, 1970; Newman, 1984).

Nonetheless, most piano pedagogues encourage the employment of all types of memory for optimum results (Ahrens and Atkinson, 1955; Clark, 1992; Haydon, 1996; Matthay, 1970; Newman, 1984). Ahrens, Atkinson, and Matthay all affirm that memorization is a complex phenomenon; the best memory work is that which includes all types of memory, so pianists should be trained to use all the available ones. For instance, Clark (1992) explains that memorizing a piece of music means recalling it in four different ways: aurally, visually, kinesthetically, and analytically. If each of these types is well-emphasized, students will feel more confident when memorizing music. Similarly, Haydon (1996) clarifies that relying on a single way to memorize music will not ensure solid music retention and will prove to be unreliable under pressure. Rather, if students memorize their music using all memory types, they will learn it several ways, and if one of these fails then the student will still have the other types as backup.

1.2.2 Organization of memorization practice

As a starting point, some pedagogues believe that the process of memorization should start as soon as the habits of fingering, counting, and analysis are correctly learned and not delay them till the end of the learning process, since asking students to memorize the pieces after being learned is like asking them to start all over again (Broughton, 1956; Clark, 1992; Leimer & Gieseking, 1932/1972; Newman, 1984). Clark (1992) explains that memorization is a continuous process that should start very early on in the learning process. If this process is begun early, students will not only perceive the memorization process as simple and natural, but will get into the habit of analysis before playing any piece. Clark also explains that to experience real memory, the memorization process should start by learning the piece analytically and visually before playing it. Accordingly, students should start by looking at the title, time signature, dynamics, and phrasing. Then they should address the rhythm by pointing and counting, or tapping and counting or any other means. Once this is done, students should then explore the notes and identify any existing relationship, such as any similarities between measures or repetitions. Then they can start playing slowly. Making this process the starting point lays the groundwork for the aural and kinesthetic aspects of memorizing, which continues until the piece is memorized.

In addition, Newman (1984) suggests that when playing from memory for the first time and a memory lapse occurs, students should stop and then start a few bars ahead and not from the beginning. On the next day of memorizing the same piece, students should start with a new section; the old material will seem easier when they get back to it later on. Newman also encourages counting from memory as it keeps track of bar lines, with all they entail harmonically and rhythmically.

Some pedagogues provide tips to be used once the piece is memorized. For example, a good way to check on a memorized piece is by asking students to begin playing from different places in the score. Once the pieces are memorized, students are also advised to continue reviewing them to avoid any inaccuracies (Cooke, 1970; Broughton 1956; Haydon, 1996; Leimer & Gieseking, 1932/1972). Some pedagogues encourage students to skip sections deliberately while playing, in order to solidify the memorization process (Ahrens & Atkinson, 1955; Bastien, 1995; Clark, 1992;

Newman, 1984). Finally, some pedagogues advise students to play the piece several times taking frequent breaks. This process should be short, not exceeding half an hour, and for better results students should pause afterwards to relax the brain (Agay, 1981; Leimer & Gieseking, 1932/1972).

Bernstein (1981) believes that students should acquire essential skills that enhance the memorization process. Students should be equipped with aspects that enhance the memorization process. They should first start with good practicing habits, which include playing with no mistakes from the beginning, and slow playing in order to pay attention to all details of the piece so all musical elements, such as notes, rhythm, and correct fingering, are learned correctly (Agay, 1981; Ahrens & Atkinson, 1955; Bastien, 1995; Bernstein, 1981; Cooke, 1970; Leimer & Gieseking, 1932/1972). Students should also develop functional skills for easier memorization, which include sight reading, improvisation, technique, playing by ear, transposition, and finally harmonization (Bernstein, 1981; Haydon, 1996; Shockley, 2001; Whiteside, 1997). For example, harmonic analysis through writing a chordal outline of the piece is an essential technique. In addition, although it is time-consuming, transposition leads to a much deeper understanding of the piece. The process of changing keys will raise a lot of questions about theoretical information like intervallic distance or harmonic relationships that would not be discovered otherwise (Haydon, 1996).

Bernstein (1981) makes the point that some of these memorization techniques are general while others are considered specific. For example general techniques include reading through the entire composition and analyzing its general structure, marking the ending of each melodic invention, memorizing the dynamics, observing entrances of new voices and memorizing the simple vertical relationships. Specific techniques include studying the first melodic invention and humming or singing its accompaniment while playing the melody; finding repetitions in the piece; observing all imitative sessions such as canons and fugatos; memorizing the entire pieces hands separately while paying attention to intervals, common tones, rest and long notes; and going through any detail that was temporarily skipped.

1.2.3 Memory cues

Some pedagogues encourage students to conduct a closer analysis by studying the piece section by section noting down any element that might serve as a memory aid, and they should focus on few parts only of the phrase until it is mastered (Agay, 1981; Bernstein 1981; Cooke, 1970; Newman, 1984). Students should be trained to find repetitive phrases and sequence patterns in the piece being learned, using the concept of chunking or "grouping elements into meaningful units for learning" (Shockley, 2001, p. 5). The ability to organize groups of notes, melodies, chords and scales is essential not only to smooth sight reading, but also for effective memorization.

What is equally important is to analyze the form of a piece, whether it is a minuet, sonata or sonatina, and try to explore the various themes within the exposition. For example, most Baroque pieces are written in binary form, while pieces from the Romantic period are in ternary form (Bastien, 1995). Consequently, Haydon strongly advocates the need to internalize the information in the piece, meaning to incorporate it into oneself as a set of guiding principles, which allows the development of an understanding of the piece on an intellectual level.

Even though it is important to highlight what piano pedagogues recommend for enhancing memorization, several points of caution should be addressed. Most of the pedagogical references reviewed are based on descriptive personal teaching experiences and "common sense" (Mishra, 1999, p. 4). Therefore, the effectiveness of the recommended memorization techniques is not scientifically tested so there is lack of information regarding the application of the four types of memories (Mishra, 2007). Moreover, there is a lack of clarity regarding linking the type of strategy to the related memory. For example, would marking the music be considered as visual or analytical or could it fall under the two types of memory? There was no attempt to link large number of strategies with each type of memory, the only exception being Mishra (2010) who indicated that the grouping of practice strategies into memorization methods of aural, visual, kinesthetic, and analytical reflects her understanding and categorization of these practices.

Moreover, the pedagogy literature focuses mainly on methods of memory throughout the years which is surprising for two reasons. First, many students and performers still perceive memorization as challenging and anxiety provoking which may indicate that focusing only on memory methods is insufficient. Second, the pedagogy literature seems conventional and reserved when compared with the drastic changes in the psychological understanding of human memory in the twentieth century. Over the years, psychology has progressed from introspection, through behavioural psychology into cognitive psychology and has now entered the era of neuropsychology. Consequently, the understanding of human memory has changed drastically, where the influence of the sensory memories (aural, visual, and kinesthetic) has been replaced by a more concept-driven understanding of human memory (Mishra, 2010). Yet, we still see an attachment to the old-fashioned description of methods of memorization. Therefore, it would be essential and beneficial to consider the psychological understanding of human memory in musical memorization.

1.3 Memory in music psychology

A review of studies in music psychology shows that some studies focused primarily on describing the process of memorization, while other studies tested the effectiveness of specific tools or techniques on musical memory.

1.3.1 The process of memorization

Many researchers observed or interviewed advanced or expert musicians to better understand the complex process of memorization. Gonzalez (1996) interviewed seven pianists in order to identify the strategies that they follow to memorize music, make expressive decisions, in terms of the order in which the systems of representations (the five senses) are used. These interviews were videotaped, transcribed, and edited. The strategies were extracted from this information, and diagrammed in terms of the systems of representation. Findings of the interviews represent great differences regarding the number of steps used by each pianist to accomplish each task.

Rickey (2004) made video recordings of 17 university piano students' memorization processes to observe their learning approaches while memorizing piano music. In addition, each subject completed brief experience and task pretest, interview about what took place through the memorization process while observing the video, and a post-test questionnaire on learning approaches used. Students assessed their own memorization procedure by rating how much they used a particular approach. The study showed that visual or kinesthetic methods were most commonly used when memorizing. However, the post-test questionnaire indicated that students said they preferred aural and visual approaches to memory, not kinesthetic, although aural memory usage was not observed during practice. Perhaps the participants mentioned aural memory as frequently used because, music being an aural medium, its use might be expected. Sharpe (2004) explored the memorization process and offered useful strategies for students' and teachers' cognitive processes while memorizing music. Sharpe used samples of repertoire in the piano literature from different musical eras to demonstrate various strategies for memorization. For each example, a discussion of possible approaches one could use to memorize the music given, with reference to building visual, aural, kinesthetic, and conceptual memory. For example, Sharpe recommended outlining brief remarks about the musical work—history and style, for example—and urged defining the piece's main characteristics, including form and texture. These served as starting points to generate key items to be covered in the piece as well as the main ideas for memorization.

Mishra in 2005 created a model for music memorization that took into account the four most commonly discussed memorization forms—aural, visual, kinesthetic, and analytical. She explains that the process of memorization consists of three main stages: preview, practice, and over-learning. She then subdivides each stage: the preview stage which includes visual, aural and performance representations; the practice stage which consists of notational practice and conscious memorization; and the over-learning stage which involves re-learning, automatization, and maintenance rehearsal. The amount of time and effort spent in each stage depends on individual preferences, performance goals, task difficulty, training and ability. Previous experience and enculturation also play a significant role in shaping the memorization process. Furthermore, the stages and the subdivisions are flexible and not necessarily sequential, nor compulsory. It is important to note that the work of Sharpe is based on the researcher's point of view regarding memorization. As for Mishra's framework, which provides good insight into the memorization process, is based on a review of literature and has not been scientifically tested.

Dubé (2007) explored the process of memorizing piano music using microstructural references. The term microstructure analysis means "a learning activity where the pianist puts various observations extracted from the score in his own words" (p. 6). Ten pianists of varying levels, pre-university, university and professional, participated in the study. Each participant performed the same work from memory and the performance was followed by an in-depth interview. The complete data analysis created seven categories of references: theoretical, including note naming, rhythmic concepts, and harmony; quantitative, such as repetitions, notes, or concepts; physical, like movements of hands or fingers; score, which includes bars, beats, or sections; keyboard, meaning location and color of keys; repetitive, the reoccurrence of memorized information; and comparative, i.e., memorizing new information by comparing it with already memorized information. These references were further organized into broader categories according to a cognitive process. General findings of this study showed that the participants clearly favored theoretical references for memorizing the required repertoire. The study also stressed the importance of conceptual memory and suggested that the type of references described in this study can be of great benefit for developing and supporting the conceptual memory of less-advanced pianists.

Mishra (2010) examined whether music is affected by the serial position effect. She studied whether there is a predictable pattern to errors during a musical memorization task. The study was twofold: to examine the effect of serial positioning effect and structure of the piece on accuracy of performance. Experiment 1 dealt with serial position, where 20 pianists memorised a 36-bar exercise, with nine phrases, then recalled the music on an instrument after a retention interval of 23 minutes. Results supported the serial position effect since the first and last phrases were performed more accurately than the middle of the piece. In experiment 2, which tested the effect of structure of the piece, 23 musicians performed a piece they had learned but not deliberately memorised on the piano. Results indicated that more errors occurred on difficult bars and bars not considered structural. However, fewer errors occurred in difficult bars that occurred at structural boundaries and in bars that were not marked difficult whether or not they included structural boundaries. Findings of this study provided some evidence that serial position does have an effect on music memorization.

Aiello (2001) explored the difference in the ways expert pianists and intermediate piano students report memorizing the same piano pieces. Results showed that the expert pianists were more able to express how they memorized their repertoire in terms of the musical structure. They tended to conceptualize a composition into independent but linked sections at which they start and stop, creating a coherent musical structure. The expert pianists also frequently reported that they had memorized the music using some aspects of visual, auditory, and kinesthetic memory. On the other hand, the intermediate piano students found it very difficult to explain how they memorized the pieces, noting that they relied merely on rote memory. These students also were more likely to approach a piano piece either as an unstructured whole or as a series of independent notes. Hallam (1997) also reported on musicians' memorization strategies, interviewing 22 freelance professional orchestra musicians and 55 novice string players. Results of these interviews indicated that professional musicians used different strategies depending on the difficulty of the piece. For example, they tended to rely on automated processes or repetition if pieces were simple and short, but for longer and more complex works, these musicians would depend more on the analytical approach. None of the novice students mentioned using the analytical approach and they all seemed to rely on mere repetition and automatic processes to memorize their music.

1.3.2 Test the effect of memorization specific techniques on memorization

Some researchers examined the effect of using a specific technique memorization. Nellons (1974) investigated the effect of the blocking procedure as a tool to aid memorization. Blocking requires prestudy of the music score to look for memorization cues, identification of group notes according to hand positions, and analysis of patterns in the compositional devices used by composers. Nellons tested the effectiveness of this procedure using the number of repetitions, amount of practice time for the memorization, and retention accuracy of selected piano repertoire. Twenty-two graduate students in music education were divided into two groups. The experimental group memorized their music using the blocking procedure while the control group used their own strategies to memorize the music. The findings indicated that the group that used the blocking procedure used fewer average repetitions and required less practice time for memorization than the control group.

Lawrence (1976) studied the effect of visual memory training on memorizing harmonic piano music using a random selection of 30 piano students at Indiana University School of Music. Lawrence asked participants in the experimental group to use the technique of eyes-closed visualization, where students study the printed score and visualize portions of it, then attempt to play it on the keyboard. Results indicated that visual memory training has a positive influence on memorizing keyboard music because it induces students to focus and increases concentration.

Lo (1976) designed an experiment to examine whether study of the score followed by attempts to visualize the score with eyes closed would aid college students studying secondary piano in the memorization of four-part hymns similar to the patriotic songs they were required to memorize. The area of investigation was limited to short-term recall or immediate memory. The study did not attempt to explore visual memory as an asset to the memorization of advanced piano literature. Six second-semester piano classes at the Indiana University School of Music participated in the experiment. The number of students completing the experiment was 14 in the control group and 16 in the experimental group, each with an equal number of male and female students. The criteria used for judging the taped performances were total accuracy score or perfect score, rhythm score, melody score, and chord score. The experimental group, which received specific instruction to memorize musical examples visually, improved more than the control group, which did not receive this instruction, in every instance.

Shockley (1980) created an alternative approach to memorization, which she called mental mapping that involves preparing a visual abstract of the score away from the keyboard prior to playing in order to stimulate pattern awareness. Twenty-eight students enrolled in piano classes at the University of Colorado participated in her study. Students in the *experimental* group received practice sessions using this alternative *approach* to music learning. She gave a sight-reading test and a memorization task at the beginning and end of the three-week experiment. Each participant completed a questionnaire before and after the experiment as a subjective measure of achievement. The results suggest gains in memorization ability and improved reading habits resulting from using this method.

Jones (1990) tested the effect of pre-studying the music on quality of retention for piano students with different aural/kinaesthetic abilities. First subjects were tested through harmonization tests to measure their ability. Each subject then learned all four of the compositions, using a different pre-study method for each composition. Two of the methods involved studying the score before beginning practice at the piano. The other two methods were control methods, in which subjects began practicing immediately. The subjects relearned the compositions after a hiatus of three to four weeks. Results of the study indicated that pre-studying the score had no effect on retention. Also, subjects with high aural and kinesthetic abilities needed a lesser number of repetitions to memorize the music.

Wheatley (1991) examined if chunking in enhances the memorization process. Chunking, an automatic *memory* structuring system that involves grouping bits of information into chunks, can account for increases in *memory* and improved *performance* of *melodic patterns*. When applying the *chunking* process, musicians depend on previous auditory experience with *melodic* contour, rhythmic organization, and harmonic structure to make it possible to reorder a series of tones into one *memory* item. Wheatley studied 60 college music students to explore which type of musical context had the greatest effect on the chunking ability. The students were divided into four groups. Group one practiced *melodic patterns* accompanied by rhythmic and harmonic backgrounds. Group two practiced the same *patterns* accompanied by a rhythmic background. Group three practiced unaccompanied *patterns* and the fourth group, the controls, received no treatment. Even though there were no significant differences among the treatment groups, the trends that emerged indicate that musical background and experience are better predictors of *chunking* ability than the effect of a short-term treatment. Post-test interviews also suggest that participating in both school choral and instrumental ensembles has significant positive effects on *chunking* ability. It may be that *chunking* ability in music is best developed through exposure to holistic musical experiences.

Li (2007) believes that even if piano performers learn their music through four aspects of music memory, namely kinesthetic, aural, visual, and analytical memories, they may not be enough to prevent memory lapses. Therefore, the researcher outlines a memory technique that draws on the use of music mnemonics, labelled as MM. These mnemonics are believed to help retrieve learned information effectively and efficiently. Various mnemonics that the researcher herself uses are identified. In addition, the researcher extracted the memorisation techniques of five professional pianists while learning two contrasting pieces in order to highlight the extent to which mnemonics were used during the memorization period.

Martinovic-Trejgut (2010) studied the effect of movement instruction on the memorization and retention of songs among 92 first grade students. These students were tested in two experiments. In the first experiment, the students learned new songs across two time periods. A quantitative analysis measured the effects of movement versus non-movement instruction for the variables of text, pitch, rhythm, and melodic contour. The second experiment, using same whole-song approach, tested the same students again to determine the effects of locomotor and non-locomotor movement instructions on text, pitch, rhythm, and melodic contour. Findings of the experiments showed that that movement instruction significantly enhanced memorization of text, rhythm, and pitch.

Lim & Lippman (2010) examined the effect of mental practice on memorizing piano music. The researchers observed piano performance majors as they memorized short, unfamiliar selections from memory after practicing for 10 minutes. Participants either inspected the score visually or listened to a recorded performance while looking at the score. Independent experts rated performance of the participants based on four dimensions that were intended to reflect the musicality as well as the accuracy of the performances. Mental practice provided some benefit over visual inspection alone.

Mishra (2011) tested the effect of different ways of memorization; holistic, segmented, serial, and additive, on effectiveness of retrieval. The sample consisted of forty university wind players who memorized a 16-bar exercise using a randomly assigned strategy. Effectiveness was based on how quickly notated music could be encoded (efficiency) and on the number of errors committed made during a delayed performance (stability). The Holistic strategy was significantly more efficient than the other study strategies indicating the holistic strategy seems beneficial when memorizing short and simple pieces.

This review of the research literature on memorizing music has established two basic research orientations—studies designed to create models or frameworks for understanding the process, and others tested the effectiveness of specific tools or techniques such as blocking, chunking, mental mapping, and analysis in enhancing memorization. It should be noted that almost all of the studies reviewed revolve around advanced to expert musicians, and so we do not know how effective or applicable the findings will be on novice students.

1.3.3 Principles of memorization

The success of expert memorists is based on three main principles: meaningful encoding of new material, well-learned retrieval structure, and extended retrieval practice (Ericsson & Kintsch, 1995; Lehmann & Guber, 2006). Regarding the first principle, experts' knowledge in their field allows them to encode new information as ready-made chunks or schemas already stored in their memory (Brewer, 1987). In music, this means scales, arpeggios, chords, phrasing, harmonic progression, etc. Such knowledge that is learned as chunks and is built over years of experience plays an important role in every musician's training. Therefore, having this knowledge stored and ready in long term memory, provides several benefits to musicians such as recognizing new information as variations of existing ones (Ericsson & Kintsch, 1995), processing information in large chunks (Gobet & Simon, 1998), recalling, quickly, a large amount of information (Chase & Simon, 1973), and making quick decisions in complex situations (Gobet & Simon, 1996b).

As for the second principle, expert memory requires an organized hierarchy of a retrieval scheme that provides cues to retain the newly stored information. In music, this is apparent in the music structure which contains sections, subsections, and bars (Chaffin & Imreh, 2012).

Regarding the third principle of expert memory, retrieving information from conceptual long term memory is a slow process. Therefore, long hours of practice using a retrieval scheme increases the speed needed to access stored information (Gobet & Kintsch, 1995) hence providing pianists with a chance to rely on conceptual memory instead of external aids like score. This is especially important when the pieces get harder and more complex, and when motor and auditory memories become insufficient to rely on during performances. Therefore, the formal structure of the piece allows the pianist to keep track of where they are on the piece, reactivate the motor program and locate a suitable point for re-entry to get the performance on track should a memory lapse happen (Chaffin & Imreh, 2012).

Expert musicians memorize in the same way as expert memoirists do in other fields. Musicians memorize using three strategies that are employed by skilled memorisers those being: chunking, organization, and practice. Musicians seem to learn music in chunks by grouping familiar patterns like scales and arpeggios. They also use organization that is based on musical structure such as the retrieval scheme, and they put many hours of practice to retrieve information from long-term memory (Noice et al., 2008).

Work of some researchers in music psychology reinforces the importance of structure analysis in memorization. In a 1999 study on the methods employed by professional pianists to memorize piano pieces, Aiello reported that subjects emphasized that the most reliable tools for insuring secure memorization are the use of the analytical approach and having a clear knowledge of the structure of the piece under study.

Williamon and Valentine (2002) studied the use of structure in the encoding and retrieval of music and its relation to level of skill. The researchers asked twenty-two pianists, divided into four skill levels, to learn and memorize different compositions by J. S. Bach, which were assigned according to their level. At the end of the learning process, the pianists performed their assigned compositions in a recital setting. The pianists at higher levels of skill had the advantage of being able to divide their piece into meaningful sections and reported using these sections during practice as well as performance. Thus identification of meaningful structural units and the ability to make use of them while memorizing music seems to be a skill that advances with musical competence.

Chaffin and his colleagues have done extensive work with professional musicians to understand the complex process of memorization through longitudinal case studies. In these case studies, experienced soloists, including a classical pianist, singer and cellist, recorded their practice of a new work from the first time they played through the piece until it was memorized ready for a public performance (Chaffin, 2007; Chaffin and Imreh, 1997, 2001; Chaffin et al., 2002, 2003, 2007; Ginsborg et al., 2006; Imreh and Chaffin, 1996/1997).

The case studies indicate that most experienced performers memorize in much the same way, with only minor differences relating to the music itself, instrument, and learning style (Chaffin, 2007; Chaffin & Imreh, 2002; Ginsborg, Chaffin & Nicholson, 2006; Noice et al., 2008). They also indicate that in order to memorize a new piece, the performer goes through certain stages during the course of which specific strategies are used.

1.3.4 Use of retrieval cues

The several longitudinal case studies conducted by Chaffin and his colleagues, in which experienced soloists recorded their practice sessions as they learned new works for public performance, indicate the use of several features or aspects during the learning of the new piece to serve as retrieval cues for recalling these memorized pieces during a performance. These aspects are known as performance cues. These cues help musicians monitor and control their actions (Chaffin and Lisboa, 2008). These performance cues are thoroughly rehearsed during practice so that they come to mind automatically and effortlessly as the piece unfolds.

There are different types of performance cues. Structural cues relate to the form and structure of the piece such as sections, melodic patterns, or changes. Expressive cues represent musical feelings to be conveyed to the audience, such as excitement or surprise, etc. Interpretive cues relates to focusing attention on changes in tempo or dynamics. Basic cues represent the critical details of technique that must be executed exactly for the performance to unfold as intended, such as using specific fingering, or hand positioning (Chaffin & Lisboa, 2008). Most aspects of technique, interpretation, and structure become automatic through practice. By the time a piece is ready for public performance, the musician attends to only a few of the many features that initially required attention during practice (Chaffin, Demos, Crawford, 2009).

Table 1. Description of different kinds of cues

Dimension	Description
Basic: attention to playing the notes	Fingering, technical difficulties, familiar patterns (scale, chord, rhythm)
Interpretive: shape the musical character of the piece	Phrasing Dynamics Tempo Pedalling
Structure: critical places in the formal structure	harmonic and melodic boundaries
Expressive: turning points in the musical feeling	Sad/ happy/ excited
Performance: attention to features during a performance	Basic/ interpretive/ expressive

Ginsborg & Chaffin (2010) conducted a study to examine the consistency with which a performer used performance cues in different pieces. Ginsborg, an experienced soprano singer, was the subject of the case study. She reported the features that she attended to during practice and the performance cues used during a public performance, from memory, of two songs by Arnold Schoenberg. The singer learned the two songs constituting Schoenberg's Op. 14, allowing to assess the consistency of her identification of musical features and use of performance cues in two similar works. Results indicated that even though many of the features that the singer thought of at the performance were attended to at practice, some new features related to expressivity were thought of spontaneously during performance.

1.4 Memory in cognitive psychology: The three phases

Cognitive psychologists have identified three common operations of memory: encoding, storage, and retrieval (Baddeley, 2007; Eysenck & Keane, 2010; Malinow, 2007; Mohs, 2014; Medin, Ross, Markmnan, 2005). Psychologists have used different tools to study these three phases of memory: models, theories, and systems to illustrate how the human brain forms and retrieves memories. Some researchers focused on the aspect of encoding information (Craik and Lockhart, 1972; Craik and Tulving, 1975), while others explored the brain's capacity for and duration of information storage (Atkinson & Shiffren, 1968; Baddeley & Hitch, 1973). Other researchers explored how we retrieve information from long-term memory and what kind of retrieval cues seem to be effective (Cohen & Squire, 1980; Murdock, 1962; Tulving, 1972). This section will discuss each stage of the memorization process: its nature, how psychologists studied it, the type of forgetting that happens, and suggested strategies to ensure solid memorization.

1.4.1 Encoding stage

Encoding is the way in which information is processed in order to be stored in memory (Nevid, 2012). Topics of interest for researchers in the encoding process include the role of attention in this stage of memory, types of models, encoding failure, the interaction between encoding and the accuracy of retrieval, and tools needed for effective encoding.

To begin the encoding process, we have to attend to information (Mohs, 2014). Attention is defined as "the taking into possession of the mind, in clear and vivid form, of one out of what seem several simultaneously possible objects or trains of thought. Focalisation, concentration, of consciousness are of its essence" (James, 1890, pp.304–404). Therefore, the key to successful encoding is attention. Hence to learn new information we need to encode information effectively by paying attention and concentrating on accomplishing the given task (Brown & Craik, 2000).

Even though it seems difficult to identify in which stage memory failure happens, any adequate memory system must be capable of registering information, storing it, and retrieving it when required. Therefore, when forgetting occurs, it could be that the experience never registered in the brain, the memory trace faded away quickly, or the memory trace was saved but couldn't be accessed or retrieved properly (Baddeley, 2014).

To conclude, the encoding stage is a key determinant of the quality and accuracy of information retrieval (Baddeley, 2014). This reinforces the importance of using specific strategies that can assure effective encoding.

1.4.2 Storage stage

The second important stage in the memory process after encoding is the proper storing of the information. Memory storage deals with how the information is manipulated and retained in memory (Mastin, 2010). A basic and generally accepted classification of memory is based on the duration of memory retention. Some information we remember for less than a second, some for half a minute, and some for a lifetime.

Early work on memory research focused more on the storage of information than the encoding and retrieval phases (Brown & Craik, 2000). One of the main issues in memory research when studying storage is examining the duration, types, and purposes of memories involved.

Among the most well-known models pertaining to the storing phase are the stage or modal model (Atkinson & Shiffrin, 1968) and working memory model (Baddeley & Hitch, 1974). The stage model also known as the modal model of memory is often used to explain the basic structure and function of memory. Initially proposed in 1968 by Atkinson and Shiffrin, this theory outlines three types of memory stores: sensory memory, short-term memory, and long-term memory. These memory stores differ in several ways: duration, and forgetting mechanisms (Eysenck & Keane, 2010). Through this model, information is assumed to flow from the environment through a series of very brief sensory memories, into a limited capacity short-term store where information is encoded through rehearsal. Then information moves to long-term memory for later retrieval.

1.4.2.1 Sensory memory

Information coming from the environment through our senses (aural, visual, touch, etc.), which is held for a very brief period of time, is known as sensory memory. This type of memory refers to the role of storage in processes involved in perceptions (Baddeley, 2014). It consists of two sub-forms: iconic refers to the visual sensory memory (Sperling, 1960), and echoic for auditory sensory memory (Cowan, 1988; Neisser, 1967).

Most studies of sensory memory have looked at iconic memory or echoic (auditory) memory regarding encoding of information and the level of awareness as it occurs; the duration and capacity of sensory memories, and what causes forgetting in this type of memory (Ricker, 2014).

Sensory memories are reproductions of the original perceptions that were processed in sensory areas of the brain. For example, an iconic memory is a detailed visual image of the original visual perception; and an echoic memory (derived from the word echo) is an auditory reproduction of the original auditory perception. Thus, even though the perceived information is rich and detailed, there is only superficial processing or encoding happening beyond the simple perceptions. The information at this stage is processing automatically at the preconscious level of awareness or what is also known as subliminal perception. Thus, it allows the brain to briefly hold information in order to determine if it is important enough to attend to (Ricker, 2014).

Sensory memory duration is very short, with no longer than a half-second for visual information and 2- 4 seconds for auditory information (Sperling, 1960; Guttman & Julesz, 1963; Treisman, 1964). The first scientific study of iconic memory was performed by George Sperling (1960). He flashed out a grid of letters for a very brief time for participants to recall. Results indicated that participants reported seeing the letters but were able to recall only few. However, when same experiment was conducted but with sounding low, medium and high tone for each projected pattern, participants reported better recall of letters. This result indicates that information is passed from the sensory memory into short-term memory via the process of attention, which effectively filters the stimuli to just those that are of interest (Mastin, 2010).

It is important to note that researchers found that auditory information stays longer in the sensory memory than visual information and so seem to be more durable than visual memory (Baddeley, 2014). Crowder and Morton (1969) discovered that a sequence of spoken digits is better recalled than digits presented visually. Participants made fewer errors and remembered more digits when they were presented aurally. However, the number of errors increased when the digits were presented visually one digit at a time.

As for the capacity of sensory memory, this involves the amount of information or number of memories that can be held at any one instant. There is some evidence suggesting that the iconic store can hold perhaps about 15-20 “icons” at once. The capacities of the other sensory-memory stores have not been well studied because of the difficulty of doing this; these memories last no more than a few seconds and they generally are at the preconscious level (Ricker, 2014). Nonetheless, Baddeley (2014) suggested that echoic memory is limited to one or two items.

Sensory memories consist of physiological changes in the brain that appear and disappear quickly causing sensory memories to be forgotten very rapidly. This explanation of the forgetting of sensory memories is referred to as decay theory because the neural traces of the memories are thought to 'decay' or disappear. The physiological or physical change underlying a memory is called an engram (Lashley, 1950; Thompson, 1976). Once the engram has disappeared, the memory no longer exists anywhere in the memory system. Therefore, unless a sensory memory is attended to, moving to short-term memory for further processing, it will decay almost immediately (Ricker, 2014).

The above-mentioned information provides important notes to consider when studying memorization. First, attention is an integral stage in the sensory memory that allows information to move to the next stage of memory for manipulation and storing. Therefore, in order to memorize new material effectively we must attend to the material under study. Second, auditory information is proven to be more durable and lasting than visual information, which stresses the importance of relying more on auditory than visual feedback for better recall and that is even more crucial in the case of memorizing music. So strategies such as listening to a recording of the piece and talking out loud about important features in a piece might be more beneficial than just reading music at the beginning of the memorization process. Finally, haptic or tactile memory is crucial in the memorization process of skills such as playing the piano but it hasn't been studied so far and so we do not know much about it.

1.4.2.2 Short-term memory

Also known as active memory, or primary memory (Medin, Ross, Markmnan, 2005), this memory holds the information we are currently aware of or thinking about. It has been referred to as the conscious mind (Cherry, 2013). Short- term memory plays an important role maintaining and manipulating attended information to make it available for further processing and/or permanent storage in long-term memory. It also serves as a crucial link that augments incomplete information coming from the world around us (Medin, Ross, Markmnan, 2005).

This type of memory has received a lot of research attention and caused considerable controversy in recent years whether it is unitary or a separate entity. One approach suggests that short-term memory is part of the same system as long-term memory but used under special conditions. The other approach view short-term memory and long-term memory as two separate systems. Another important argument revolves around whether short-term memory is regarded as one unit or consists of an interactive sub-system referred to as working memory (Baddeley, 2014). In addition, some research focused on the capacity and duration of short-term memory.

Even though there is a continuous debate around the actual capacity of short-term memory, many researchers agree that it is very limited in nature. For example, Miller, one of the leading figures in the cognitive revolution in the 1950s, suggested that most people store about seven independent or discrete items in short-term memory. These items may be numbers, letters or words, etc. He further noted that the capacity of the short term memory may be enlarged by grouping items together by associations/links they have with each other, referring to each of these items as chunks. However, later studies showed that the span of a chunk is short: larger chunks might consist of eight-word phrases, smaller chunks just one-syllable words (Simon, 1974). Moreover, some researchers argued that if rehearsal is eliminated, the capacity of short-term memory will be even shorter. Cowan et al. (2005) used a running memory task, where participants had to recall digits that were presented very rapidly to prevent rehearsal. Results showed that the recall mean was 3.87. Nevertheless, what would be important to remember from this is that chunking is a useful way to organize information especially if the processing capacity of short-term memory is limited.

Different studies have examined the duration of short-term memory. For example, Peterson & Peterson (1959) devised a technique that prevents information from being continually repeated in the short-term memory, referred to as maintenance rehearsal, in order to test how long information will be retained. The researchers suggested that the short-term memory can store information for approximately 15 to 30 seconds if maintenance rehearsal is prevented. They also suggested that information decays (fades away) rapidly in short-term memory unless rehearsal of that information occurs. On the other hand, Reitman (1974) suggested that this short duration is due to displacement; as new information is coming into the short-term memory, it is moving aside the previous knowledge due to limited capacity. The researchers therefore suggested attending to the information and holding it; the longer an item resides in this store, the greater the probability of its transfer to long-term memory.

1.4.2.3 Long-term memory

To an experimental psychologist, long-term memory refers to “information that is stored durably to be accessible over a period of anything more than a few seconds” (Baddeley, 2014, p.16). Unlike sensory and short-term memory that store information as a by-product of other cognitive processing, long-term memory is primarily concerned with storing information. This memory is capable of storing huge amount of information that can last up to a lifetime.

There has been controversy as to whether long-term memory is unitary (Eysenck & Keane, 2010; Baddeley, 2014). Over the years, researchers have identified several major long-term memory systems (Eysenck & Keane, 2010). However, the most common distinction in long-term memory is that between declarative (explicit memory) and non-declarative memory (priming and procedural memory). The distinction between declarative and non-declarative memories emerged from evidence that comes from studying amnesic patients, as they seem to have difficulties in forming declarative memories but have normal non-declarative memory. Evidence coming from functional imaging also indicates the separate brain activation areas for both types of memories (Schott, et al., 2005).

The Canadian psychologist Endel Tulving is one of the pioneering researchers who examined long-term memory from the 1970s onwards. He pointed out that declarative memory involves conscious recollection of semantic and episodic memories (1972). Semantic memory deals with knowledge about words and concepts while episodic relates to recollection of past experiences and events.

Non-declarative memory involves a change of behaviour and enhanced performance over time in the absence of conscious recollection or thought, such as riding a bike or learning to play piano as well as other motor skills (Keane & Eysenck, 2010; Baddeley, 2014). This type of memory is also known as implicit memory or procedural memory, involving “knowing how” to do things with little or no awareness of the skills involved (Cohen and Squire, 1980).

There are three types of learning related to implicit memory: priming, procedural learning and classical conditioning. Priming, which relates to the unconscious process of identification or enhancing performance through previously learned information, is the most studied. During priming, cues such as words or images can prime a person's ability to generate the correct response to stimulus unconsciously (Dehn, 2010). Procedural learning refers to learning skills and habits. It involves cognitive, motor, perceptual and other types of learning. This learning requires attention at the beginning stage and is accumulated slowly through repetition and practice. Over the long run, however, performing the task does not require conscious retrieval. Finally, in classical conditioning, the individual learns the predictive effect of an environmental stimulus with a result. This type of learning is based on the classic example of Pavlov's experiment, in which a sound reliably predicted delivery of food. In a learning context, retrieval of information and resulting behaviour are elicited through cues that are similar to the ones used during the encoding stage. The retrieval via associative relationship of the cues is usually quick and unconscious, so it is categorized as implicit learning. All of these types of learning reinforce the importance of using cues.

What is important to note is that some psychologists believe that perceptual-motor tasks such as playing the piano or typing requires little consciousness or attention. Moreover, they believe that thinking too much about it will lower the performance of the skill. Memories for such skills also do not seem to decline over long intervals of retention in the way declarative memory does (Weiten, 2013). This suggests an interesting dichotomy; the process of playing the piano might be considered implicit learning since recollection of the learning experience is absent, but memorizing a piano piece requires conscious effort and selective attention. Thus merely relying on procedural or tactile memory may not lead to the best memory performance results!

One of the most controversial topics in memory research is the relationship between short-term memory and long-term memory. It is important to acknowledge that the modal model is notable for the significant influence it had in generating subsequent memory research based on the conceptual distinction of three kinds of memory. Many theories of human memory have built on the foundations of this model (Keane & Eysenck, 2010). However, the modal model suffered from some limitations. First of these concerned the learning assumption; the model proposed that holding information in short-term memory is sufficient to transfer it to long-term memory. Therefore the longer the information stays in short-term memory, the greater the chance it will transfer to long-term memory. However, evidence from later experiments (Craik and Watkins, 1973; Tzeng, 1973; Bjork and Whitten, 1974), suggested that merely holding an item in short-term memory through rehearsal did not guarantee secure memory. Rather, the nature of processing used on the material being learned plays a much more important role than the length of time information is kept. This was especially emphasized in the levels-of-processing framework proposed by Craik & Lockhart (1972). The model also assumed that only information processed consciously in the short-term memory can be stored in the long term. However, a lot of learning happens automatically without awareness in what we know as implicit memory.

The second problem in the modal model relates to the sequence of processing flow. The model suggested that short-term memory provides a crucial stage in the process of long-term learning, so if one is deficient in the short-term memory system then it should affect the performance of long-term memory. However, some studies proved otherwise. Patients who had deficient short-term memory could do other cognitive tasks normally (Shallice and Warrington, 1970). Also, information processed in short-term memory already had made contact with long-term memory or might transfer directly for permanent storage (Myers, 2013; Logie, 1999).

1.4.2.4 Working memory

The major issue with the multi-store model is the assumption that short-term and long-term memory stores are both unitary, meaning each store operates in a single, uniform way (Keane & Eysenck, 2010). However, it became more evident that Atkinson and Shiffren's theory was too simplistic (Baddeley, 2006, 2007). Something more complex than a simple storage system is needed to form an effective interference between perception and memory, attention and action (Baddeley, 2007). Therefore, the work of Baddeley & Hitch dating back to 1974 proposed that the concept of a simple unitary short-term memory be replaced by a multimodal system, which they termed *working memory,* to emphasize its functional importance in the cognitive processing in which temporary manipulation and storage is carried out, which underpins complex human thought. Therefore, short-term memory is used to describe tasks in which immediate recall of small amounts of information is required while working memory referred to a broader system typically involving attentional control and allowing the manipulation of information held in short-term storage (Baddeley, 2007).

According to Baddeley and Hitch (1974), working memory consists of the following components: the central executive, the phonological loop and the visuospatial sketchpad. All three systems are limited in capacity. The central executive, an attentional controller, is the most complex and least understood component of working memory (Baddeley, 2014). It acts as a supervisory system that controls cognitive processes. Important tasks of central executive include coordinating the work of subsystems and activation of long-term memory; switching between retrieval plans, and controlling selective attention (Baddeley, 1996).

Furthermore, the central executive is aided by two slave systems: the phonological loop and the visuospatial sketchpad. The phonological loop comprises two parts: a *phonological store* holds acoustic or speech–based information for about 2 seconds, and an *articulatory control process*, which is the inner speech that allows humans to subvocally rehearse information in order to help keep information available by refreshing the phonological store. Baddely et al. (1998) suggested that the main function of the phonological loop is for acquiring new language, specifically learning new words. The visuospatial sketchpad (or scratchpad) is assumed to allow the temporary storage and manipulation of visual and spatial information (Repovs & Baddeley, 2006). More recently, a fourth component of working memory has been proposed that is accessible through conscious awareness: the episodic buffer (Baddeley, 2000). This system forms an interface or a workspace that allows the integration of information coming from subsystems (visual, verbal, perceptual) and long-term memory (episodic and semantic), for learning and retrieval (Baddeley, 2007).

The theory behind this model suggests it is possible to perform two tasks that require different components of the model but not within the same component. Experimental evidence supported this theory. For example, Baddeley and Hitch (1976) conducted an experiment in which participants were asked to perform two tasks at the same time (dual-task technique)—a digit-span task required them to repeat a list of numbers, and a verbal reasoning task included true or false questions. Results indicated that as the number of digits increased in the digit-span tasks, participants took a little bit longer to answer the reasoning questions, but only fractions of a second. Also, participants didn't make any more errors in the verbal reasoning tasks as the number of digits increased. This result indicated that verbal reasoning task utilized central executive and the digit span task was processed by the phonological loop.

Working memory can also help understand how brain damage affects cognitive skills (Cicerone & others, 2006; Wood & Rutterford, 2006). For example, some types of amnesiacs (individuals with memory loss) perform well on working-memory tasks but not on long-term memory tasks. Another group of patients have normal long-term memory abilities yet do very poorly on working-memory tasks. Baddeley (1992) reported a case of a patient who had good long-term memory despite having a memory span of only two digits. He couldn't maintain verbal codes in the phonological loop and so the memory span suffered. Finally, working memory deficits are involved in Alzheimer disease since patients have great difficulty coordinating different mental activities, which is one of the central executive's functions (Baddeley, 2006, 2007).

Nevertheless, the working memory theory has some limitation. For example, little research exists on how the central executive works, its function, and capacity (Baddeley, 2014; Mcleod, 2008). More research is needed to further understand the relationship between the episodic buffer, subsystems, and long-term memory (Eysenck & Keane, 2005).

What is important to extract from the evolving studies on working memory is its link with learning and memorization. Working memory is an important cognitive skill that is linked to academic success according to Tracy Packiam Alloway (2013), a well-known researcher on working memory who has developed the world's first standardized working memory tests for educators. Alloway & Copello (2013) have recommended strategies for working memory that include spotting memory failure such as not completing tasks, followed by breaking down information into smaller elements, and building long-term knowledge that will help reduce overload of working memory.

1.4.3 Retrieval stage

After the information is encoded and stored comes the crucial stage of retrieval. Retrieval involves the mental processes that determine and control how memories are extracted and brought into performance (Naime, 2013). Therefore, it is important to highlight important concepts related to retrieval, such as methods of retrieval, causes of retrieval failure, and recommended strategies to enhance the retrieval mechanism.

It is important to note that there are principle ways of accessing memory and retrieving information (Mustin, 2010) through recall, recognition, and relearning (Myers, 2013). Recall involves reproducing the stimulus items. Probably the simplest recall measure is free recall, in which a sequence of items, typically words, is presented, and the subject is required to recall as many as possible in any order he/she wishes. Recognition requires the subject to say whether a given item was presented or not in a Yes/No type of response or to choose the previously presented item from a set of two or more alternatives (forced choice recognition). Finally, relearning is when we go through the material previously learned. It is assessed by measuring the amount of time saved when learning the material again. It is important to add that even though much of the retrieval from long-term memory may be effortless and automatic, in some cases we consciously search for information, through an active process known as recollection (Baddeley, 2014). This type of retrieval involves problem solving skills such as logical structures or clues (Cherry, 2014).

1.4.4 Forgetting

Several theories of forgetting have emerged from the literature for each phase of the memorization process. When at the encoding stage, information does not enter memory, either because we didn’t pay attention to it from the first place, or because information was entered inaccurately. This is known as encoding failure. This failure could be due to dividing attention between learning and other activities, which increases the chance of failing to store sufficient information to create a useful memory (Coon & Mitterer, 2013; Naveh-Benjamin, Guez, & Sorek, 2007). Therefore, a great deal of attention should be paid to prevent such failure through the use of effective encoding strategies.

When at the storage stage, main theories of forgetting in cognitive psychology involve trace decay and displacement in the short-term memory and interference in the long-term memory (Hill, 2001; Mcleod, 2008; Myers, 2013)

The theory of trace decay explains how forgetting occurs with time. Learning creates a physical trace or an engram in the brain, which consists of a chemical change in the nervous system (Hebb, 1949). With time, however, and if the information is not used, the traces get weaker and fade away (Manglan, 2013). Hence, forgetting is the result of the automatic decay or fading of the memory trace. Decay can be attributed to fading sensory memories and affects short-term memory as well, through a quick brain activity that quickly dies out (Coon, 2005). Research carried out by Brown (1958) in the United Kingdom, and Peterson and Peterson (1959) in the United States supports the decay theory in short-term memory, which states the information is held in the short-term memory from 15 to 30 seconds if it is not rehearsed, then it fades away. Consequently, drill, practice, rehearsal of learning is recommended to overcome forgetting through trace decay (Manglan, 2013).

Another explanation for how information is forgotten in short-term memory is through displacement. Since encoding new information is an almost continuous process, and short-term memory has only a fixed number of slots, new items of incoming information replace the old ones. The old information which is displaced is forgotten. In his serial position experiment, Murdock (1962) supports the idea of forgetting due to displacement from short- term memory. Serial position effect refers to the tendency to better recall items at the beginning and end of a list but not the middle. Good recall of items at the beginning of the list is called the primacy effect. On the other hand, recency effect refers to better recall of items at the end of the list. In his study, Murdock asked participants to learn a list of words that varied in length from 10 to 30 words and free recall them. Each word was presented for one to two seconds. Results indicated that words presented either early or at the end of the list were more often recalled, but the ones in the middle were more often forgotten. Justification for remembering items at the beginning is the effect of rehearsal or elaborative processing and absence of competing information during the learning (Atkinson & Shiffren, 1968; Craik & Tulving, 1975). As for the recency effect, items are better remembered either because they are still processing in the working memory or they are recent in their position of the recall serial. The middle of the list is most likely forgotten because it has been there too long to be kept in the working memory and so is lost through displacement, but not long enough to be stored in the long-term memory (Mcleod, 2008). The serial probe study by Waugh & Norman (1965) showed the effect of displacement in short-term memory. Researchers provided participants with a series of numbers to learn. Participants were then given one of the numbers and asked which number followed it. The researchers found that when the probe digit is nearer the end of the list, the better the recall.

Such information brings to mind research questions that relate to memorizing a piece of music: would memorizing a piece of music have similar serial position effect as word memorization? Accordingly, one would wonder if the effect of serial positioning justifies why some students who encounter a memory slip have to start over? Therefore, it would be important to determine the different kinds of techniques that could be used to help students from falling under the serial position effect while learning new pieces.

As for interference theory, it suggests that forgetting happens due to memories interfering with each other in long-term memory (Nevid, 2012). There are two ways in which existing learning can interact to cause forgetting: proactive and retroactive interference. Proactive interference happens when old memories disrupt the formation of new memories, while retroactive interference occurs when we forget previously learnt material due to learning new material or tasks. What is important to add is that both types of interference are thought more likely to occur when the memories are similar in nature. For example, a study by Chandler (1989) showed that students who study similar subjects at the same time often experience interference.

Research has provided some recommendations on how to prevent interference. For example, proactive interference can be prevented by changing the type of material to be memorized or by switching subjects, i.e. animals to cars (Nevid, 2012; Wickens, 1970). Another way is through inserting time intervals between serial of recall trials (Loess & Waugh, 1967). Such recommendations can be applied to memorizing music: for instance, a student could switch to another music activity such as sight reading or playing scales, then go back to reviewing the memorized piece. Also, taking breaks will help prevent forgetting. Other recommendations include overlearning the material by continuous repetition, either aloud or silently, until it is repeated without any errors (Nevid, 2012).

Retrieval usually happens smoothly and automatically, yet sometimes it does fail or becomes imperfect, a process known as retrieval failure (Reisberg, 2013). Retrieval failure is where the information is stored and available in the long-term memory, but cannot be accessed. Some researchers believe that information in long-term memory never disappears or gets lost, but may become less accessible with time. It cannot be accessed because of a lack of appropriate retrieval cues, known as cue-dependent forgetting, as opposed to decay of a memory trace over time or interference from other memories (Tulving, 1974).

An important phenomenon that relates to failure of retrieving information specifically while performing a learned skill, is choking. It means performing worse than expected when under pressure. Choking under pressure has largely been explained by two different classes of theories. Distraction theories propose that choking occurs because attention needed to perform the task at hand is coopted by task-irrelevant thoughts and worries. Explicit monitoring theories claim that pressure prompts individuals to attend closely to skill processes in a manner that disrupts execution. Beilok and Carr (2001) argued that the cause of choking in stressful situations results when performers pay too much attention to the external environment.

Beilock (2010) explains that when stressed, we try to control what we are doing. Therefore, if we are practicing a skill that is normally learned outside conscious awareness, such as an easy golf swing for example, once we try to think about and control the actions, everything falls apart. All the training that has improved motor skills becomes useless because the conscious attention controls motor memory (Beilock, 2010). Therefore, choking appears to be the result of trying to let declarative memories control the execution of skills that have been encoded and stored into procedural form.

Accordingly, in music performance, the explanation of memory lapses attributed to relying too much on kinesthetic memory are likely a breakdown in the automated muscle movements necessary during performance. Further, a processing breakdown might happen when the musician tries deliberately to control automated movements because cognitive thought functions slower than automated movements. Therefore, the problem is not the automated movement but rather in the conscious attempt to control them. However, the feeling of moving muscles without receiving input or feedback from the brain can be unsettling (Mishra, 2010). So what would be important is to train oneself in thinking about what you are doing without choking (Chaffin & Lisboa, 2008).

Even though these forgetting theories provide a good insight into reasons for memory failures, they do have some limitations that should be taken into consideration. For example, in the decay theory, some research has demonstrated that some memories that have not been rehearsed are remarkably stable in long-term memory (Cherry, 2014; Manglan, 2013). Also, decay and displacement theories are hard to test and their distinction seems to be unclear (Hill, 2001). For example, in practice it is hard to prevent any intervention from happening between the introduction of material and the recall of that material when measuring decay, and if another task is introduced to prevent rehearsal, that could cause interference. Interference theory does not provide detailed information about the cognitive processes involved in forgetting. Also, the majority of research into the role of interference has been carried out in a laboratory setting, focusing mainly on using lists of words as testing material, and so it suffers from low ecological validity (McLeod, 2008).

To conclude, theories of forgetting provide a good insight into why we might forget information in short and long term memory. Even though they do suffer from some limitations such as the difficulty of testing, and vagueness in the distinction between the concepts, they still suggest important aspects that can be taken into consideration when memorization is taking place such as the use of active rehearsal, overlearning, taking breaks, and switching between tasks.

1.5 Memory in neuroscience

Technological advances have helped in getting closer to understanding how the brain encodes information and what actually happens in the brain when retrieving a memory. The scientific study of the brain and nervous system is called neuroscience or neurobiology (Freudenich and Boyd, 2014). Latest advances in the field have led to techniques that study the way the brain operates without causing any harm to the organism. Information can be obtained about the location of the brain activity (spatial resolution), or the time the activity occurs (temporal resolution).

1.5.1 Mirror neuron system

Another contribution of advances in research is one of the most extraordinary discoveries of contemporary neuroscience; mirror neurons (Rizzato, 2014). Giaccamo Rizzollati (2002, 2006) found a system of brain cells, now referred to as mirror neurons, in his experiments on monkeys. These neurons are known frontal lobe neurons that are believed to fire when performing certain actions or while observing others doing so (Myers, 2013). Mirror neurons may provide the basis for imitation and observational learning. Researchers use fMRI scans to monitor brain activity associated with performing and observing actions. For example, Calvo-Merino et al. (2004) used fMRI scanning to monitor brain activity of ballet and capoeira dancers while watching other dancers. The results showed that the brain activity of the ballet dancers was higher when observing other ballet dancers than capoeira. The same for capoeira dancers who showed more brain activity while observing other capoeira dancers than ballet. Such findings do confirm the existence of mirror neurons in the human brain and its relation to learning.

Another study by Stefan at al. (2005) used Transcranial Magnetic Stimulation (TMS) to show that observation of another individual performing simple repetitive thumb movements gives rise to a specific memory trace of the observed motions. Results of their experiment support the role the mirror neuron system plays in memory formation and possibly human motor learning. It has been proposed that the mirror neuron system is instrumental in motor learning (Stefan et al., 2005). The human primary motor cortex displays mirror activity in response to movement observation, is able to form motor memory, and is involved in motor learning. There is strong evidence from studies that observation of movements lead to performance gains (Vogt, 1995; Black and Wright, 2000; Brass et al., 2001; Heyes and Foster, 2002; Horn et al., 2002; Vinter and Perruchet, 2002; Edwards et al., 2003; Petrosini et al., 2003; Mattar and Gribble, 2005). However, the issue of whether the human capacity to stimulate another's action or share in another's experience is down to mirror neurons or rather to distributed brain networks is still debatable (Gallese et al. 2011; Mukamel et al., 2010). Also, it is still unknown whether observing actions alone can lead to performance improvement (Stefan et al., 2005).

In the music field, interest in mirror neurons has started to emerge. For example, MacKie (2013) conducted a preliminary test on the effect of mirror neurons in relation to musical performance. In this test, a pianist, a music analyst, a choreographer, and two dancers from the Royal Ballet, Covent Garden, collaborated to assist the pianists in controlling the pace and flow of the piece “Claire de lune” by Debussy through imitation and emulation of the dancers’ movements. The length of the study was three hours which began when analyst who provided the musical template for discussions with the pianist and the choreographer. At the end of the final performance, seven delegates who attended the workshop at the London International Piano Symposium assessed whether they had noticed an improvement in the performance of the piece. Four of the delegates agreed they had. Overall, the test has proved inconclusive and yet its promising results can serve as the basis for future research in the field.

With regard to music education, the very important discovery about the function of the mirror neuron system lies in the realization that demonstration and imitation are far more effective for learning complex motor skills than providing verbal instructions. It is noted that verbal instructions can actually inhibit the performance of a complex sequence of motions involved in the playing of any musical instrument. This in itself poses a challenge as it is common practice at university-level music schools, to see analytic and verbal methods of music education used as mainstream teaching methods. Therefore, recent research is advising the avoidance of linguistic descriptions of technique and musicianship in favour for a demonstration-based pedagogy (Kudirka, 2014).

Though, it seems, the music psychology, cognitive psychology and neuroscientific literature has much to say on how memory works and how memory of music can be built, a gap remains in the scientific literature relating to how musicians can systematically memorize a piece of music for performance. With reference to memorization of music specifically by young piano students, there exists little in the literature of piano pedagogy but anecdotal accounts of from pedagogues of what has and hasn’t worked for them or their students – for example, methods such as intellectual and theoretical engagement with the music (Haydon, 1996; Cooke, 1970; Agay, 1981; Schokley, 2001), visualization and silent practice (Ahrens & Atkinson, 1955; Bastien, 1995; Haydon, 1996; Leimer & Gieseking, 1932/1972; Matthay, 1970; Newman, 1984; Shockley, 2001;

Whiteside, 1997), and listening to recording of the piece to be memorized (Agay, 1981; Bernstein 1981; Cooke, 1970; Newman, 1984). This literature, while of some practical use for other teachers and students, is insufficiently scientific and rigorous to formulate a coherent and reliable theory of the effectiveness of any particular approach. It also fails to take into account developments in the understanding of how memory is formed in the fields of cognitive psychology and neuroscience.

Therefore, in an attempt to fill this gap in the literature, this study will examine the effectiveness of one particular learning method – modeling – in helping young piano students to memorize a piece of music successfully. Modeling, defined as the presentation, live or recorded, of anything that may be later imitated by an observer (Madsen, Greer & Madsen, 1975), is a method based on the use of observation as a learning tool. This method in particular has been chosen for examination because neuroscientific and cognitive psychology research has highlighted the potential of observation as a learning aid, helping subjects more effectively to store and recall information needed to perform a skill. The study will compare video modeling with cues, which provides the visual, audio and motor/kinesthetic information that cognitive psychology and music pedagogy literature suggests is required for the learning of music, with audio-only modeling and free practice as methods to aid music memorization by piano students. It is hoped this will go some way to filling the gap in the literature around this topic.

1.6 Modeling in the Teaching Literature

It is important to explore the different fields that have studied modeling, so this section outlines modeling in teaching which includes general education, music education, and piano teaching .

1.6.1 Modeling in education

Several educators reinforced the importance of modeling in education. For example, Wilson (2012), author of *Interactive Modeling: A Powerful Technique for Teaching Children*, provides a seven-step format that entails showing children exactly what to do, helping them notice key elements, and giving them instruction while the teacher coaches. The seven steps are: 1- explain what is to be modeled and why, 2- model the behavior, 3- ask the students what they have observed, 4- ask another student to model, 5- ask other students what they noticed, 6- practice, 7- provide students with feedback. Through this approach, children have an active role, which helps them stay engaged and better able to remember what they learned. In their book '*Teaching in Today's Inclusive Classrooms: A Universal Design for Learning Approach*', 2012, Garguilo and Metcalf (2012) stress the important role that modeling plays in teaching students. The authors recommend the use of modeling before asking the students to practice a certain behavior. They also recommend the use of direct instructions along with modeling when teaching a new skill. Taylor and MacKenney (2008) believe that teachers often overlook the important role that modeling plays in teaching. The authors advocate that modeling is a valuable teaching technique that should be incorporated in classroom teaching in a specific time and setting.

1.6.2 Modeling in music education

In music lessons or rehearsals, modeling typically consists of alternating between teacher demonstrations and student imitations, with teachers using their instrument, voice, or electronic media and students responding with their instrument or voice (Dickey, 1992). The use of modeling is evident as one of the teaching techniques in instrumental music instruction. For example, Weaver (1981) carried on a descriptive study to observe and document behaviors in instrumental music lessons in two schools in the USA. Weaver used the *Individual Instructor Teaching Skills Workbook* developed by Froseth and Delzell (1981). Accordingly the categories identified were: description, identification, imitation, discrimination, association, analysis, generalization, and synthesis. Weaver found that 22.65% of behaviors involved instrumental, kinesthetic, or oral forms of imitation. Instrumental imitation was the most commonly used, followed by kinesthetic and oral respectively. Weaver concluded that imitation along with association should be a central component of music teaching. Dickey (1992) pointed in his article that caution should be taken in generalizing from Weaver's results since the researcher did not describe the characteristics of classes or schools being observed. Also, the sample did not represent a typical beginner's instrumental class.

Another study by Mcleod (2010) compared different instructional strategies used by experienced band and orchestra teachers when teaching a first-year class a new music piece. Through observation, the researcher identified 12 strategies being used: echoing technique, question and answer, verbal instruction, co-verbal instruction, modeling with an instrument, modeling with instrument during student performance, modeling without an instrument, conducting, student performance, pedagogical touch, and classroom management. In general, band teachers used verbal instructions, conducting, question and answer, and student performance more than orchestra teachers. On the other hand, orchestra teachers used echoing technique, co-verbal instruction, modeling, and modeling with an instrument during student performance.

1.6.3 Modeling in piano pedagogy

Modeling is also used in private music lessons. Duke (1999) found that in Suzuki string lessons, the teacher's modeling takes up 27% of lesson time, and teacher approximations (forms of modeling such as clapping, singing, counting, conducting) accounted for 9% of lesson time. This does not seem to be the case for private piano teaching. For example, Speer (1994) and Kostka (1984) both found that more time in piano lessons was spent on teacher verbalization than on teacher modeling. In addition, modeling does not seem to be a topic that is covered in piano pedagogy textbooks. Most of the piano pedagogy textbooks reviewed cover topics like principles of learning and learning styles; setting up a piano studio, as well as choice of methods and materials for teaching (Baker-Jordan, 2004; Bastian, 1995; Bruser, 1997; Jacobson, 2006). When discussing the use of technology in piano teaching, authors talk about the use of digital pianos, computer assisted software and the use of MIDI files (Baker-Jordan, 2004; Uzsler, 1999). Of the few pedagogues who talked about modeling, Camp (1992), author of *Teaching Piano*, believed that child prodigies, jazz players, skilled dancers and conductors serve as model learners. These model learners have a natural sense of rhythm, pulse, and natural way to unite the body and mind processes and they move quickly through the learning stages. Camp also explained that in modeling, observers pay attention to the aural and visual demonstrations because they are intertwined. Therefore, audiences experience the sound of the performance as well as the visual display of the physical response to the music. Mary Craig Powell (1988) explained in her book, *Focus on Suzuki Piano*, that modeling is one of the points that she discusses with parents when starting piano lessons for their children. She notes that parents are meant to sit in the lesson in order to learn so he/she can model after the teacher during home practice.

Many findings exist that show modeling as an effective music teaching technique because it decreases the overall amount of teacher talk (Dickey, 1991, 1992; Duke, 1999; Rosenthal, 1984; Siebnaler, 1997). Siebnaler (1997) found that shorter teaching episodes, less teacher talk, and faster pacing with frequent directives, specific feedback, and modeling were associated with more effective teaching in private piano lessons. The need for musical models is perhaps most acute during the beginning stages of instrumental study, when playing habits are formed (Linklater, 1994). An essential way to improve music performance is by providing a student with a music model that the student can watch, listen to, or copy (Greer, 1980).

Literature on the use of modeling in piano pedagogy is therefore limited to more anecdotal accounts of its usefulness. Its more extensive use in specific pedagogies, such as the Suzuki method, suggests that audio and visual modeling warrants further examination as a method of helping students, especially beginners, to memorise the visual, aural and motor data they need to recall the specific motor actions required to play the piano.

1.7 Modeling in the Research Literature

To understand how a piano student is able to carry out a motor action – playing a certain piece, whether from memory or not – it is essential to understand how the student has been able to encode and store the information that has enabled them to recall it in order to carry out that motor action. The process of encoding and storing this information, resulting in correct motor action, is broadly referred to as 'motor learning'. Modeling is a method that is often used to enable motor learning in many fields. This section will therefore cover research on the use of modeling for motor learning in a range of fields, as well as research on the use of modeling specifically in the field of music.

1.7.1 Modeling in motor learning

In general, research has shown the effectiveness of modeling in motor learning (Shea, Wright, Wulf, & Whitacre, 2000; Shea, Wulf, Park, & Gaunt, 2001). Modeling is effective because it allows learners to have an accurate representation of their target goal and use that representation to guide their practice, identify errors, and self-correct (Frewen, 2010). Research topics in modeling of motor skills revolved around the skill level of the model, combining modeling with cues, and corrective feedback.

1.7.1.1 Skill level of model

According to social cognitive theory, expertly modeled skills that are correct and almost perfect are more beneficial to the encoding of visual information and thus result in greater learning. However, Jack Adams (1986), an influential motor learning theorist, suggested that observing a learning model might be as effective, if not better, than watching an expert model. Therefore, two distinctive terms emerged: the expert model, which refers to a skilled model who performs the skill correctly, and the learning model, which demonstrates correct and incorrect features of a performance while learning a task.

Several studies show that observing a learning model can lead to better retention than observing an expert model. For example, a study by McCullagh and Caird (1990) found that groups performing in a timed task who first watched a learning model performed better at the acquisition and retention tests than the group who first observed an expert model. In another study, Gould and Weiss (1981) asked untrained female college students to perform an endurance task after watching one of two models. One group watched a similar ability model (i.e., the models were untrained) while the other group watched an athletic higher ability model. Results of the study indicated that the group who observed a closely matched model (untrained in this case) scored better on acquisition and retention tests and had a higher self-efficacy level than the group who watched the highly skilled model. In a more recent study by George, Feltz, and Chase (1992), the Gould and Weiss study was replicated to examine whether the sex of the model being a male or female had any effect on the participants' attainment levels. Results of the study showed that participants' performance and self-efficacy were influenced by the similarity of the models' skill levels (in this case being trained or not), regardless of the model's sex. Therefore, the use of learning models can be just as effective as or even more than expert models because they encourage learners to detect and correct errors in the learning process. Observing a model that is similar to the learner in ability and stage of learning is favored among learners. This is because observing a learning model who is similar to the observer (peer) enhances an observer's feeling of self-efficacy and motivates him/her to attend to the demonstration. There is, however, one study done by Pollock and Lee (1992) that showed no difference in attainment levels between a group who watched a learning model and another that watched an expert model when learning a computer tracking game.

Darden (1997) suggested different ways that a learning model can present great learning opportunities compared to an expert model for the novice observers. The model should have a similar peer status, it should be just above the student's current ability level, it should provide verbal cues and instructional feedback with demonstrations, it should show correct and incorrect performances, and it should display an encouragement of problem solving and thinking.

Several researchers recommend that modeling take place before practice trials, and preferably spaced out during the practice for greater benefit. This is especially important for beginners when learning a certain skill. As learners progress through stages of learning, they benefit from different types of information by observing models, and therefore in each stage it is essential to involve the use of demonstrations as part of that process (Carroll & Bandura, 1990; Hand & Sideway, 1993; Weeks & Anderson, 2000).

The use of learning models can be just as effective as or even more so than expert models because it encourages learners to detect and correct errors in the learning process. Also, observing similar models that closely resemble an observer's skill, age and level is more effective since the observer will feel it is within his/her ability to perform that specific skill with a larger degree of confidence than when solely observing an expert model. The research outlined in this paper will therefore examine the learning model, rather than the expert model, as the preferred method of modeling.

1.7.1.2 Modeling with cues

According to Bandura, simply exposing the observer to watching a model does not guarantee that the observer will be able to recognize and attend to the important features of the modeled behaviour. Therefore, there is a need to use memory codes, also known as symbolic codes, that are added to the actions being modelled to enhance learning and memory (Bandura, Jeffrey, &

Bachicha, 1974). In this way, the observer will learn through constructive observation than mere copying.

This is specifically important to consider when teaching a skill to young children as they can't initially verbalize their observation of a modeled behaviour. A study by Coates and Hartup (1969) examined differences between 4 and 5 year olds with 7 and 8 year olds in using verbal comments to explain the modeled behaviour after watching a short film. This is known as a verbal mediator, using verbal coding of modeled behaviour that the observer stores in memory. Findings of the study showed that older students were able to verbalize what they had seen and were then able to reproduce the modeled behaviour in a better way than the younger students. This study implies that young children may not benefit from learning by modeling without providing verbal mediators that will help them understand and re-produce the modeled behaviour. Bandura (1997) suggested the use of cognitive modeling, which means having models verbalize their thought processes and strategies aloud as they produce actions or engage in problem solving activities. This is especially important for complex skills where verbalized thinking skills that guide actions are generally more informative than modeling actions alone.

Adding cues is important especially when observing a model through video because the video can provide too much information and the viewer might not know exactly which details to look for. Therefore, guiding the learners by providing cues and instructions while observing seem to help in learning motor skills. Rothstein and Arnold (1967) pointed out that using cues to direct viewers to observe specific aspects of the video showed overall more positive effects. This was confirmed by successive studies. For example, a study by Zetou et al. (2002) showed that video modeling with cues that were provided simultaneously while observing video helped elementary school children in the acquisition and retention of set and serve volleyball skills. Another study by Nahed, Zahra and Elham (2013) examined the effects of video modeling with instructions on skill acquisition in learning handball shoot. Sixty students aged between 16 and 34 participated in this study. Each participant was randomly assigned to one of two groups: 1) the traditional (control) group learned the skill via teacher instructions, 2) the experimental group viewed a film demonstration for 20 minutes and received teacher instruction. Participants practiced under these conditions for 5 weeks. Results of the study showed that the experimental group was significantly better than the traditional group in shoot carefulness and the angle test. Researchers concluded that video modeling with instructions significantly improved the accuracy of handball shoot.

The research outlined in this paper will therefore examine the effectiveness of modeling with cues, rather than without.

1.7.1.3 Modeling with corrective feedback

Another factor that is important in modeling is to add external corrective feedback from a teacher or coach. Errors in performance might result from an inappropriate reference, a motor difficulty while performing, or a difficulty in perceiving errors, thus hindering appropriate comparisons with the model. Therefore, one way to minimize those errors is to provide some form of additional feedback that provides the performer with more information about their performance than they are able to gather by themselves. In motor learning contexts, investigators sometimes supplement the information that is normally available from performing the movement (e.g., through proprioception and vision) by using mirrors or video recordings to provide information about the sensory consequences of the action (Hodges, Chua, & Frank, 2003). Such feedback will allow observers to engage in an active problem solving mechanism and to try different techniques to correct actions.

Corrective feedback is also useful in video modeling. Video feedback, whether analog or digital, is a powerful tool to display knowledge of performance (KP). In motor learning, a video will contain a record of the entire performance, allowing the performer to detect errors and attempt to correct them in the next trial. Keele (1977) proposed that video feedback needs to be combined with the simultaneous provision of a model (template) to make it possible for the learner to accurately check his movements against those of the model.

A few studies showed that adding corrective feedback to modeling has a positive effect on motor learning. For example, Hebert and Landin (1994) divided their sample of undergraduate female beginner students learning tennis volley shot into three groups. The first group watched a learning model with no feedback, while the second group watched a learning model accompanied by corrective feedback. The third group received feedback from an instructor on their practice trials but did not watch a model. Findings of this study showed that two groups observing a learning model outperformed the group who did not observe any model. Of the two groups who observed the model, the group who observed the learning model with corrective feedback and received direct feedback from the instructor had the best scores on acquisition and retention tests.

Reynolds (2013) examined the use of video modeling in addition to video feedback to improve boxing skills with a case study on two participants. The two participants in the study had little or no previous boxing instruction. During intervention, the participants watched a video of a professional boxer performing specific skills. The participants recorded their performance in order to compare it with that of the professional model. The results of the case study showed that both participants' skill levels increased. Boyer et al. (2009) examined the effectiveness of a video treatment package including modeling and video feedback on the acquisition of three gymnastic skills. The participants included competitive gymnasts, with ages ranging from 7 to 10 years old. In baseline and intervention, the coach continued with his usual coaching procedure that included verbal feedback after the athlete dismounted from the apparatus. In the video modeling by experts with video feedback phase, upon completion of the task, the athlete walked to the computer and received verbal feedback from the computer technician. The athlete viewed the computer on the left that showed an expert performing the skill followed by her own clip on the computer on the right hand side. The athlete then viewed both clips at the same time while the technician paused the routines at several points throughout in order to compare the two processes. The gymnast then watched the expert model alone and her own clip alone one more time before attempting the routine again. The results of this study showed that this procedure improved skill performance more rapidly than the normal method of coaching. There was a clear increase in skill set acquisition with the introduction of the video treatment package.

On the other hand, one study showed no effect of combining modeling with feedback on learning a motor skill. For example, Emmen, et al. (1985) tested the effect of video mediated instruction on the learning of the tennis service by novices. The research setting took place in an indoor tennis hall under normal training conditions. The study consisted of three experimental groups:

a video-model (VMT), a video-feedback (VFT) and a group with a combination of video modeling and video feedback (VMFT). There were two control groups using two different training periods. One group practiced for 45 minutes and the other group practiced for only 30 minutes. All subjects took part in five successive training sessions. The results of the study showed no clear advantages of using video mediated instruction methods in teaching novices the tennis service.

Though the research literature suggests that corrective feedback improves the effectiveness of modeling, this study didn't include it in the video modeling used. Corrective feedback does not represent the natural practice setting for piano students because, in real life, students practice their assigned pieces without receiving feedback during their practice sessions. Therefore, we did not deem this condition to be pertinent to this study.

1.7.2 Modeling in music research

Modeling has been found to be an essential component of effective music teaching in numerous studies (Colprit, 2000; Dickey, 1992; Duke, 1999; Hewitt, 2001; Rosenthal, 1984; Sang, 1987; Siebnaler, 1997). Modeling has been shown to be effective with students of all ages: elementary schoolchildren (Baker, 1980), middle school students (Dickey, 1991; Ebie, 2004; Hewitt, 2001), high school students (Henley, 2001), and college students (Rosenthal, 1984; Rosenthal, Wilson, Evans, & Greenwalt, 1988). It has been shown to affect children's preferences for appropriate and inappropriate renditions of a musical performance (Baker, 1980). Modeling also contributes to young instrumentalists' reduction of pitch error mistakes in weekly lesson assignments, as well as improved pitch matching skills (Zurcher, 1972).

1.7.2.1 Aural modeling

Aural modeling entails listening to an audio recording of the pieces to be learnt. Several studies have shown that aural modeling is an effective music learning tool. A study by Rosenthal et al. (1988) tested relative effects of five practice conditions on instrumentalists' performance of a musical composition. Sixty college music students practiced under five practice conditions to perform a composition after a short practice session. Practice conditions were aural modeling, singing, silent analysis, free practice, and control. In the modeling condition, participants used their practice time to listen to a recording of the composition, with the written music available. Singing subjects used their practice time to sing the composition. Participants in the silent analysis group, studied the music quietly. Free-practice subjects practiced the piece continuously. Control subjects practiced an unrelated musical composition and then performed the experimental composition. The evaluation was based on correct notes, rhythms, phrasing or dynamics, articulation, and tempo. Results of the study indicated that aural modeling and practice were most effective in facilitating mastery of the selection. Singing and silent analysis were, in general, no more effective than sight-reading.

A study by Ebie (2004) examined whether there were significant differences in middle-school students' ability to appropriately convey the emotions of happiness, sadness, anger, and fear while singing musical passages within the context of four treatment situations using four different learning conditions: traditional instruction, aural modeling, kinesthetic exploration, and audio-visual learning. In the traditional instruction condition, participants learned what they should do with their voices and their performances in traditional musical terms and descriptive analogies. In the aural modeling condition, participants listened to pre-recorded models singing a melody. Each model performed a musical example and attempted to convey during separate trials happiness, sadness, anger, and fear in his or her interpretations. Participants were instructed to listen closely to how the model manipulated his or her voice in order to convey the various emotions, with the goal being able to manipulate similar qualities within their own voices. In the kinesthetic exploration, each participant used physical and active ways to experience an emotion. Participants were asked to portray a specific emotion. There were many possibilities available, including acting out, drawing a picture, etc. As for the audio-visual presentation condition, participants viewed 20 individual pictures representative of a specific emotion while listening to a piece of music which was representative of the emotion being viewed. Results of the study showed modeling and audio-visual learning to be significantly better than traditional instruction.

Frewen (2010) examined the effects of familiarity with the sound of a melody on children's memory and performance of the melody. Ninety-seven students from kindergarten through fourth grade, with no previous formal instrumental instruction, were taught to play a four-measure melody on a keyboard during an individual instruction session. Before learning to play the melody, half of the children listened to a model of the melody repeatedly in music class to become familiar with the music. Children's memory of the melody was assessed through a melodic error identification test administered immediately before and after instruction. Results of the study showed that students who had some memory of the melody played significantly more correct notes than did children who had no memory of the melody, and that performance accuracy increased with grade level.

Hewitt (2001) tested the effects of modeling, self-evaluation, and self-listening on junior high school instrumentalists' music performance and attitude to practice. Eighty-two woodwind, brass, and percussion students in the seventh, eighth, and ninth grade participated in this study. Results indicated that participants who listened to a model during self-evaluation improved more than those not listening to a model in the areas of tone, melodic accuracy, rhythmic accuracy, interpretation, and overall performance, but not in the areas of intonation, technique/articulation, or tempo.

In a recent study, Cash et al. (2014) investigated the extent to which the presentation of an auditory model prior to learning a novel melody affects performance during active practice. Thirty-two musicians practiced a 13-note keyboard melody with their left (non-dominant) hand in twelve 30-s practice intervals separated by 30-s rest intervals. Half the participants, prior to the first practice interval, listened to 10 repetitions of the target melody played. All participants were then tested on the target melody the following morning, approximately 12 hours after training, in three 30-s blocks separated by 30-s rest intervals. Performance was measured in terms of the mean number of correct key presses per 30-s block. Results of the study indicated that participants who listened to the model made significantly larger gains in performance during training and between the end of training and test than did those who did not hear the model.

A few studies combined aural modeling with verbal codes. For instance, Puopolo (1970) compared the musical achievement of a control group with a group who practiced using programmed self-instructional materials. The self-instructional materials included recorded aural models of the pieces to be practiced. Participants were fifth-grade trumpet and cornet players who had played for about six months. Each participant had a weekly lesson during which they received a cassette tape containing programmed instruction and recorded models for that week's lesson. All students practiced in a monitored school setting in order to make sure that all participants practiced for the same duration. Student performance achievement was measured using the Watkins-Farnum Performance Scale. Results of the study showed better results for students who used aural modeling as part of their practice. Rosenthal (1984) examined the effect of four modeling conditions on the music performance of forty-four college music education students. These participants were randomly assigned to practice under the following conditions: (a) a combined verbal and aural example of a complex musical selection (verbal guide recording was prepared); (b) an aural model only; (c), a model only; and (d) a practice only. Dependent variables were instrumentalists' correct notes, rhythm, dynamics, tempo, and phrasing/ articulation. Subjects in the model only group attained significantly superior scores compared with all other groups, and subjects in the combined verbal and aural group scored significantly higher than subjects in the guide only and practice only groups. Henley (2001) examined the effect of modeling conditions and tempo patterns on the performance of high school instruments. Conditions of the study were: model versus no model, practicing with steady tempo, practicing slowly then speeding up tempo, and alternating tempos between fast and slow. Sixty high school wind instrumentalists participated in the study. The participant sight read an etude and practiced it six times using one of the six practice conditions. A professional musician recorded the performance of the etude. Spoken instructions were recorded digitally on professional quality equipment. Each set of instructions was transferred to compact discs. Pre and post-tests of correct pitches and rhythms were compared. Results of the study showed that the group with model conditions obtained best results for percentage gain in rhythm and tempo than the group that practiced with various tempo conditions.

While most music studies showed the positive effect aural modeling has on music learning, a few studies showed opposite results. For example, Morrison, Montemayor, and Wiltshire (2004) examined effectiveness of recorded models in the context of ensemble rehearsals. Three middle/junior high and two high school bands systematically included professional recordings as part of their preparation of selected pieces for a period of five weeks. Students completed weekly self-evaluation reports about their individual progress and their ensembles' progress on model and no-model pieces. Evaluation was based on ensemble achievement on notes/rhythms, articulation/dynamics, tuning, and balance. Student evaluations showed more modest achievement gains for model pieces. High school students demonstrated more positive self-evaluations for their own versus their ensembles' performance and greater overall differentiation in their evaluations across time. Middle school/junior high students were significantly more positive toward the model pieces. However, expert evaluations revealed no difference in achievement between model and no-model pieces.

Woody (2006) compared the effectiveness of three approaches used to elicit expressivity in music students’ performances: (a) aural modeling, (b) verbal instruction addressing concrete musical properties, and (c) verbal instruction using imagery and metaphor. Thirty-six college pianists worked with three melodies, one in each instructional condition. With each, subjects first gave a baseline performance, then received instruction for performing more expressively and then gave a final performance. Subjects also verbally reported their thoughts during the process. Results of the study show that participants can accommodate all three types of instruction used in the study and that each has strengths and weaknesses related to the characteristics of the music being performed and the musicians themselves. In addition, the analysis or verbal report indicate that participants use cognitive processes where they translate imagery into more explicit plans to reflect music performance like tempo, and dynamics.

The research literature covers the use of aural modeling to improve music learning and performance, but does not explicitly cover its use for complete memorization of a piece. However, cognitive psychology stresses the role that memory plays in improvement and learning, and so it seems reasonable to hypothesize that if aural modeling has been shown to improve learning and performance then it may have a similar effect on ability to learn and perform a piece by heart. To examine this hypothesis further, this study will compare the efficacy of aural modeling with that of both free practice and visual modeling with cues.

1.7.2.2 Video modeling

A few studies in music looked into the effect of video modeling on music performance. A recent study by Schlosser (2011) examined the use of video tapes where undergraduate pianists regularly watched videos of their practice and performance. The practice sessions were recorded through an “Online Music Practicing Log.” The log allows for extensive journaling. It records a variety of elements related to practicing including date/time/length of practice, the particular type of practice (a particular piece, technique, etc.), and a self-rating for each practice session. The log is able to track and provide instant statistics regarding the amount of hours practiced by week, month, and year. Using a journal, participants were asked to record their reflections and analyses of videos filmed at their individual lessons. The experiment consisted of two parts. Part one tracked the effects of watching self-referent videos of both practicing and performing, while part two examined students’ responses to the use of the Recital Review Protocol (RRP). This protocol uses Cognitive Intervention (CI) adapted from Davis et al. (2008) where participants were expected not only to name and articulate feelings related to failure, but also to consider and plan changes to improve performance. Such a protocol seems to help in reversing blood flow patterns in areas of the brain responsible for negative mood induction. Findings of the study indicated that use of regular video watching of participants’ performances produced significant degrees of objectivity with regard to playing, as well as objectivity about participants’ reactions to performances. Viewing of video recordings along with the use of calming effects of cognitive intervention and meditation, provides pianists with realistic reflections of their performances and suggests opportunities for change. The findings from the second part of the study indicated that more attention needs to be paid to students by instructors immediately after performances in order to overcome negative perceptions.

There was one music study that compared the different effect between video modeling and aural modeling on musical development. Linklater (1994) investigated the comparative usefulness of audio and video cassette tape models in facilitating beginning clarinet students' musical development. Participants practiced through three different sorts of cassette tapes: (1) video cassette tapes presenting both aural and visual clarinet modeling plus instrumental accompaniments, referred to as video modeling tapes; (2) audio cassette tapes presenting aural clarinet modeling plus instrumental accompaniments, labeled as audio modeling tapes; and (3) audio cassette tapes presenting instrumental accompaniments only, without clarinet modeling, named as non-modeling audio tapes. Students kept a daily log of the total amount of time they practiced as well as the amount of time they used their assigned tape and the amount of parental help they received during practice sessions. There was also space on the logs for parent comments. The experiment lasted for eight weeks after which students underwent a performance test. Students were brought back every two months after the experiment ended to measure retention. Results of the study showed that students in the modeling video tape group were found to have the best results. That is, video students exhibited more precise and properly developed embouchure, posture, hand position and instrument position than did non-modeling students. The researchers noted though that audio and video tapes seemed effective in increasing home practice time, and using them as a regular supplement to class can enhance music development.

On the other hand, video modeling didn't seem to be effective in teaching the bowing pattern on the double bass. A study by Ellsworth and Kantorski (1991) examined the effect of instructional video as a way to teach undergraduate non-music majors to play a four-stroke bowing pattern on the double bass. Students were assigned to one of four groups: three experimental and one control. The three experimental groups viewed a videotaped modeling of the bowing pattern one, three, and six times respectively. The control group received live verbal instruction on how to perform the bowing pattern. Performances were rated by two judges using two five-point scales, one for visual criteria and one for aural criteria. The results showed no significant differences between any of the groups on either visual or aural criteria. Due to this lack of performance difference between video instruction and live instruction, Ellsworth and Kantorski concluded that videotape can be as effective as live verbal instruction for selected psychomotor skills.

Because music teaching's main emphasis is on sound, many studies have focused on testing the effect of aural modeling on performance accuracy levels. As such, research on video modeling in music has received less attention; it would be interesting to examine whether combining aural, visual, and motor aspects through video modeling, as suggested by neuroimaging studies, would have – if any - a positive effect on learning music.

This study, then, will examine the effectiveness of the method of modeling that research suggests is most effective – visual modeling with cues and using a learning model – in helping students memorize a piece through solo practice. Corrective feedback will not be included in the modeling as this is not thought to be representative of real-life practice sessions. Aural modeling will also be included as a comparison to the visual modeling with cues and free practice, in order to further explore its potential for enhancing memorization of a piece of music.

Because music teaching's main emphasis is on sound, many studies have focused on testing the effect of aural modeling on performance accuracy levels. As such, research on video modeling in music has received less attention; it would be interesting to examine whether combining aural, visual, and motor aspects through video modeling, as suggested by neuroimaging studies, would have – if any - a positive effect on learning music.

2. Conceptual Framework

The main theory behind this study comes from Albert Bandura's work on modeling. This section highlights the definition of modeling, the social cognitive theory that explains the stages of observational learning, and the renewed look of research on learning by modeling.

2.1 Definition of modeling

Modeling is the presentation, live or recorded, of anything that may be later imitated by an observer (Madsen, Greer & Madsen, 1975). Video modeling is used as a visual instructional method that demonstrates a task done by a person (or model) (Acevedo, 2009). This study will use basic video modeling, which involves recording someone besides the learner engaging in the target behavior or skill. The video is then viewed by the learner at a later time. Other types of video modeling include video self-modeling, point-of-view video modeling, and video prompting. Video self-modeling is used to record the learner displaying the target skill or behavior which is reviewed later. Point-of-view video modeling is when the target behavior or skill is recorded exactly as the learner would see it so the camera is positioned at the eye level of the learner (Murray, 2012). Video prompting involves breaking the behavior skill into steps and recording each step with incorporated pauses during which the learner may attempt the step before viewing subsequent steps. Video prompting may be done with either the learner or someone else acting as a model (Franzone & Collet-Klingenberg, 2008).

There are different terms that are used to describe matching behaviours such as imitation, modeling, observational learning, copying, internalization, introjection, and role-taking. Modeling has distinctive effects depending on the different processes involved. Observational learning is when observers learn new patterns by watching others perform, then try to reproduce them accurately at a later time (Bandura, 2007).

2.2 Social cognitive theory

Cognitive psychologist Albert Bandura (1977, 1986, 1997) proposed a theory of how people learn through observation known as the social cognitive theory. Bandura believed that learning by observing others is much more complex than merely imitating or copying behaviour. Accordingly, Bandura used the term ‘observational learning’ to describe the complex set of behaviours acquired through observation. As he noted “learning would be exceedingly laborious, not to mention hazardous, if people had to rely solely on the effects of their own action to inform them what to do. Fortunately, most human behaviour is learned observationally through modeling: from observing others, one forms an idea of how new behaviours are performed and on later occasions this coded information serves as a guide for action.” (Bandura, 1977, p. 22).

According to Bandura’s theory of observational learning (1977), the learner goes through four stages in the learning of skills, with each stage influenced by the quality of visual demonstration and modeling of skills. The four stages are: attention, retention, reproduction, and motivation.

In the attention phase, the learner should observe and pay attention to a person (the model) who is performing the skill to be learned. The learner’s attention is influenced by many factors such as interest, motivation, previous knowledge, nature of skill, and model characteristics. Demonstrations in this phase should be accurate so they can be easily imitated. Also, the demonstration should focus the attention of the observer on the most important features of the skill.

At the retention stage, the learner should remember what the model has done. For learning to occur, the learner should transform the observed movement pattern into a representational form and store it in memory. Bandura believed that this process was the function of imaginal and verbal sub-processes. Imaginal refers to extracting patterns from visual information. According to Bandura’s theory not all skill elements should be retained; rather, only relevant features of the skill are encoded and stored in memory. Also, verbal instructions and visual demonstrations are essential for the formation of memories.

The third stage is reproduction which is the active rehearsal of an observed skill. Once information is retained, the learner must have the ability to reproduce a copy of the action that was demonstrated by the model. Bandura emphasized the importance of rehearsal in order to strengthen an acquired response.

The fourth stage is motivation. Bandura (1997) proposed the concept of self-efficacy, which is the belief in one's ability to acquire and master a skill or task. The higher the level of self-efficacy, the more information the learner will pay attention to and retain from observing a model. Therefore, demonstration plays an essential role in enhancing the learner's level of self-efficacy especially when the model has similar abilities to that of the learner's. Below is a figure that highlights the four stages with the important elements for each stage.

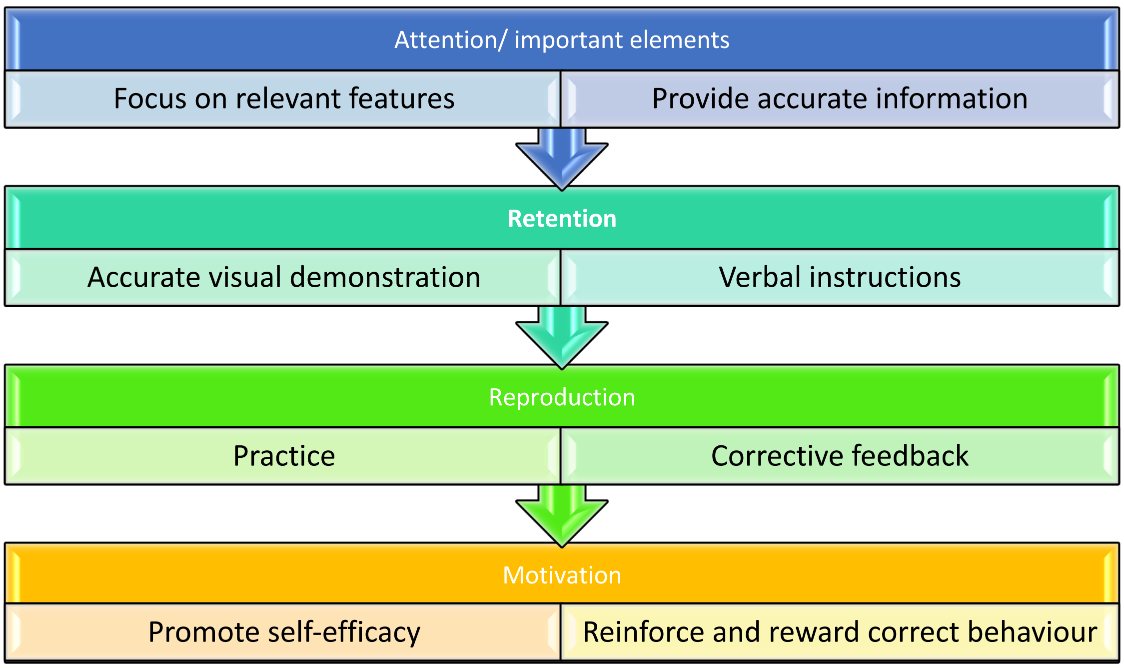

Figure 1. Summary of the Four Stages of Observational Learning

The learning and memorization method under examination in this study, video modeling with cues, reflects each stage in Bandura's theory. The attention phase, during which the learner should observe and pay attention to a person (the model) who is performing the skill to be learned, corresponds in the video modeling experiment in this study to the point where participants watch a video of the model playing the piece. The retention phase, during which the subject converts the patterns they observe into a representational form and stores it in memory, corresponds in video modeling to the subject's use of the visual information – finger numbers – as a prompt to guide their finger movement. The reproduction phase, where the subject rehearses the skill they've observed, corresponds in video modeling to the point when the participant practises the piece after watching the model. The motivation phase, at which the subject practises self-efficacy, corresponds in video modeling to the participant's observation of a learning model with similar abilities. Bandura conceptualizes self-efficacy as the belief in one's ability to acquire and master a skill or task. Modeling plays an essential role in enhancing the learner's level of self-efficacy, especially when the model has similar abilities to that of the learner.

Bandura's theory of observational learning is therefore used in this study to underpin the use of video modeling with cues as a method for aiding memorization and as a framework for understanding its success as a method.

2.3 Mirror neurons

Also of relevance to the use of video modeling in this study is what the field of neuroscience has uncovered about how the brain learns from observation. Renewed research on observational learning has received an unexpected boost due to one of the most extraordinary discoveries of contemporary neuroscience, that of so-called 'mirror' neurons (Rizzolatti, 2005). Investigations have shown how brain regions responsible for the planning of movement and movement itself are activated when observing actions, a function of the mirror neurons. Giaccamo Rizzollati (2005) found a system of brain cells, now referred to as mirror neurons, in his experiments on monkeys. These neurons located in the frontal lobe are believed to fire when performing certain actions or while observing others doing so. Mirror neurons may provide basis for imitation and observational learning. Researchers use fMRI scans to monitor brain activity associated with performing and observing actions. For example, Calvo-Merino et al. (2004) used fMRI scanning to monitor brain activity of ballet and capoeira dancers while watching other dancers. The results showed that the brain activity of the ballet dancers was higher when observing other ballet dancers than capoeira. The same pattern was observed in capoeira dancers who showed more brain activity while observing other capoeira dancers than ballet. Such findings do confirm the existence of mirror neurons in the human brain and its relation to learning. Another study by Stefan at al. (2005) used transcranial magnetic stimulation (TMS) to show that observation of another individual performing simple repetitive thumb movements gives rise to a specific memory trace of the observed motions. Results of their experiment support the role for the mirror neuron system in memory formation and possibly human motor learning.

For music education, the very important discovery about the function of the mirror neuron system is that demonstration and imitation are far more effective for learning complex motor skills than providing verbal instructions. It is noted that verbal instructions can actually inhibit the performance of complex sequence of motions involved in the playing of any musical instrument. This poses a challenge as it is common at university-level music schools, to see analytic and verbal method of music education used as the main teaching techniques. Therefore, recent research is advising to avoid linguistic descriptions of technique and musicianship in favour a demonstration-based pedagogy (Kudirka, 2012).

The discovery of the role of mirror neurons in in human memory formation therefore provides a neuroscientific basis for the use of video modeling in this study. It enables the effectiveness of video modeling in helping students to learn a skill, as observed in the literature of cognitive psychology, to be explained in terms of specific brain function. The fact that mirror neurons not only enable a subject to mimic an action but actually to form memories of performing that action provides a further basis for the hypothesis that video modeling will support piano students in forming the memory traces required to enable them to memorize a piece of music.

3. Methodology

In order to test the effect of practicing with different modeling conditions on young students' memorization of piano music, this study adopted a quasi-experimental design. Main hypotheses of this study are:

- Subjects in aural modeling and video modeling with cues conditions would have better memorization scores than the comparison group (free practice).
- Among the modeling conditions, video modeling with cues would produce the best memorization results (fewest errors in notes, and rhythm).

A quasi-experiment is "a form of experimental research in which individuals are not assigned randomly to groups" (Creswell, 2013, p. 247) but have volunteered to be part of the intervention. The experimental group, which goes through intervention (in this case two different modeling conditions), is matched with the comparison group. This means that both experimental and comparison groups have to be as similar as possible in demographics to eliminate any possible factors that might affect the outcome of the study. Therefore, background information such as piano level which reflects music abilities was used as criteria for recruiting the participants in this study.

3.1 Sample

All participants in this study, aged between 9-13 years old, passed their grade 2 piano level, and were at grade 3 piano level. They were doing the Royal Conservatory of Music Canada (RCM) program or equivalent (Associated Board of the Royal Schools of Music (ABRSM) and Vincent D'Indy School of Music). At grade 3, the program of studies and the exam requirements of these schools, regarding piano repertoire and technique, are equivalent (Lau, 2016) (Appendix A). The reason behind choosing students in grade 3 piano is that around that level students should have gained enough musical independence that they are able to learn and memorize a piece of music on their own (Donkin, 2013).

An invitation letter was sent to different music schools in Ottawa region, and to the Ontario Registered Music Teachers' Association (ORMTA) (Appendix C). Invitation Letters were also sent to different music schools in Otttawa, Abu Dhabi and Dubai regions (Appendix D). Interested students were contacted to schedule the date of the experiment (for parent and piano student consent forms, see appendices, E & F). All students signed video release form (Appendix H). The researcher selected participants that have the same characteristics in terms of music and technical abilities, by making sure they were at the level of grade 3. This was done by checking with their piano teachers at the recruitment stage that they can play comfortably at grade 3 level regarding sight reading, playing scales and pieces. Also, the student model who participated in the study was in grade 3 music and within age range (for video release form for student model and parent, see Appendix G).

Of the twenty four students (*N*=24) who participated in the study, 58% are females (n=14) and 42% are males (n=10). Three groups of eight students each were formed. Each student was assigned to one of the following conditions: Aural modeling group; video modeling with cues; and free practice group.

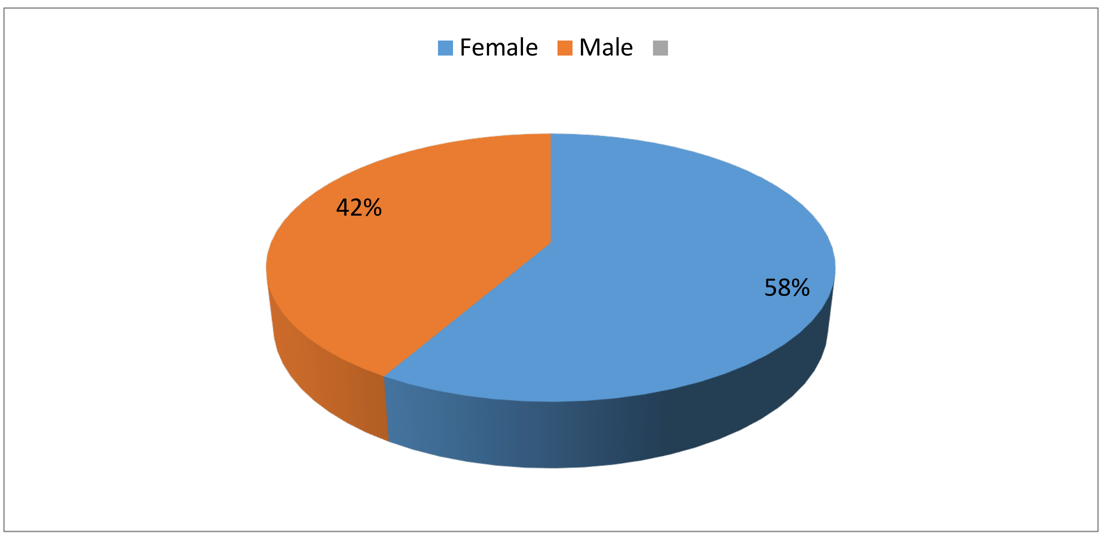

Figure 2. Demographics

3.2 Material and setting

In order to make sure that the experiment was done in a controlled environment to focus only on the variables that needs to be studied, a couple of steps were taken. To ensure that the participants have not heard or played the musical piece used in the experiment before, an original composition specifically written for this study by Christine Donkin was used. Christine Donkin is a Canadian composer, who is active in the field of music education as a teacher, adjudicator, clinician, and arranger (Donkin, 2015). The piece is 16 measure long written in c minor (3 flats), and is considered a grade 2 level by the composer (Appendix B for the piece).

The experiment took place at the premises of OPUS Academy in Orleans, Ontario, and different music schools in Abu Dhabi (Music Hub, the International Music Institute) and Dubai (Center for Musical Arts) (Appendix I). All practice sessions were conducted in a typical practice room to control the testing and practice duration. The practice sessions were video recorded to guarantee that participants followed the protocol of the study. The researcher was present in all sessions, and made sure to remind participants when to use their assigned modeling condition, if needed. The practice room was equipped with a piano, a laptop, and a camera. The laptop was used to display the video-guides that were used for the experiment.

Three video-guides were produced for the experiment: (a) one for the aural modeling group; (b) one for the video modeling with cues; and (c) one for the free practice group. The three video-guides follow the same structure. First, a detailed introduction about the piece is presented. This introduction is similar to what the student experiences when introduced to a new piece by his teacher during a piano lesson: to begin with, the teacher (for this experiment, the researcher played the role of the teacher) plays the whole piece; then, she points out important factors about the piece (a c minor piece, important fingering, hand positions shifts, etc.); afterwards, she tells the participant to follow the instructions given by means of the video-guide during the practice session (the script of the Introduction is presented in Appendix J).

The instructions in the video-guides are provided in two modes: audio and graphic (the participant can hear the instructions and can see them written on the screen). These video-guides guarantee that all participants follow the exact same practice routine and time, keeping the only variable as the modeling condition. See the outline of each video-guide and the instructions given to each group below in Table 2 and Table 3.

The specific characteristics of each video-guide are the following:

1. Video-guide for video modeling with cues group (VMC): participants in this group watch and listen to the performance of a student model playing the piece (only the hands are seen on the screen), and follow practice instructions. Camera overhead was used for clear display of hands and fingers on the keyboard. Finger numbers were added to the video (at the right place on the keyboard) in order to direct the attention of the student to specific fingering of the performance.
2. Video-guide for audio modeling group (AM): participants in this group listen to the audio recording of the piece, and follow practice instructions.
3. Video-guide for free practice group (FP): participants in this group practice the piece freely without any audio or video model, and follow instructions

3.3 Procedure

After the students were welcomed and thanked for their participation in the study, the researcher presented them the video-guide that will lead their practice sessions (Appendix K). Then, participants practiced with assigned modeling conditions in two separate sessions. Total time for the two practice sessions plus performing from memory was one hour long. The reason for choosing two sessions is that students normally memorize their pieces through several practice sessions, not just one. The following tables outline the various steps of the experiment with the participant.

As seen below (Table 2), after the first practice session, participants took a break by doing unrelated task like walking around. The second practice session (Table 3) started after the break and participants went through the same procedure by practicing their piece following the assigned condition, but without the introduction to the piece. At the end of the second session, the piano score was removed and the participants performed the piece from memory (that is, without the piano score). Then, after a 10-minute break, participants performed the piece from memory a second time. During the 10-minute break, participants would walk around in the room and would chat with the researcher. After the second session, each participant was thanked and was given a thank you card with 15 Canadian dollars. Parents were asked to make sure that students do not practice their piece or play piano during the rest of the day in their home.

On the following day, participants performed their piece from memory for the third time. This makes the total of playing from memory three times. This procedure tested the reliability of memory at each different time period: (a) first, right after the end of the two practice sessions; (b) second, ten minutes after the break following the second practice session; and (c) third, the following day. The performances were recorded via video camera for evaluation purposes, showing only the hands of the participants. The following two tables outline the sequence of events of this experiment.

Table 2. Practice session 1 and recordings

Aural Modeling Group	Video Modeling with cues	Free Practice
Introduction to the piece	Introduction to the piece	Introduction to the piece
Listen to the audio recording of the 1st line of the piece, performed two times	Watch and listen to the video (with cues) of the 1st line of the piece, performed two times	Practice the 1st line
Practice the 1st line	Practice the 1st line	Practice the 1st line
Listen to the audio recording of the 2nd line of the piece, performed two times	Watch and listen to the video (with cues) of the 2nd line of the piece, performed two times	Practice the 2nd line
Practice the 2nd line	Practice the 2nd line	Practice the 2nd line
Listen to the audio recording of the 1st & 2nd lines, performed two times	Watch and listen to the video (with cues) of the 1st & 2nd lines, performed two times	Practice 1st & 2nd lines
Practice 1st & 2nd lines	Practice 1st & 2nd lines	Practice 1st & 2nd lines
Listen to the audio recording of the 3rd line of the piece, performed two times	Watch and listen to the video (with cues) of the 3rd line of the piece, performed two	Practice the 3rd line
Practice the 3rd line	Practice the 3rd line	Practice the 3rd line
Listen to the audio recording of the 4th line of the piece, performed two times	Watch and listen to the video (with cues) of the 4th line of the piece, performed two	Practice the 4th line
Practice the 4th line	Practice the 4th line	Practice the 4th line
Listen to the audio recording of the 3rd & 4th	Watch and listen to the video (with cues) of the 3rd & 4th lines of the piece, performed two	Practice the 3rd & 4th lines

lines of the piece, performed two times		
Practice the 3rd & 4th lines	Practice the 3rd & 4th lines	Practice the 3rd & 4th lines
Listen to the audio recording of the whole piece, performed two times	Watch and listen to the video (with cues) of the whole piece, performed two times	Practice the whole piece
Practice the whole piece	Practice the whole piece	Practice the whole piece
End of practice- 5 minute break		

Table 3. Practice session 2 and recordings

Aural Modeling Group	**Video Modeling with cues**	**Free Practice**
Listen to the audio recording of the 1st line of the piece, performed two times	Watch and listen to the video (with cues) of the 1st line of the piece, performed two times	Practice the 1st line
Practice the 1st line	Practice the 1st line	Practice the 1st line
Listen to the audio recording of the 2nd line of the piece, performed two times	Watch and listen to the video (with cues) of the 2nd line of the piece, performed two times	Practice the 2nd line
Practice the 2nd line	Practice the 2nd line	Practice the 2nd line
Listen to the audio recording of the 1st & 2nd lines, performed two times	Watch and listen to the video (with cues) of the 1st & 2nd lines , performed two times	Practice 1st & 2nd lines
Practice 1st & 2nd lines	Practice 1st & 2nd lines	Practice 1st & 2nd lines
Listen to the audio recording of the 3rd line of the piece, performed two times	Watch and listen to the video (with cues) of the 3rd line of the piece, performed two	Practice the 3rd line
Practice the 3rd line	Practice the 3rd line	Practice the 3rd line
Listen to the audio recording of the 4th line of the piece, performed two times	Watch and listen to the video (with cues) of the 4th line of the piece, performed two	Practice the 4th line
Practice the 4th line	Practice the 4th line	Practice the 4th line
Listen to the audio recording of the 3rd & 4th line of the piece, performed two times	Watch and listen to the video (with cues) of the 3rd & 4th line of the piece, performed two	Practice the 3rd & 4th lines

<table>
<tr><td>Practice the 3rd & 4th lines</td><td>Practice the 3rd & 4th lines</td><td colspan="2">Practice the 3rd & 4th lines</td></tr>
<tr><td>Listen to the audio recording of the whole piece, performed two times</td><td>Watch and listen to the video (with cues) of the whole piece, performed two times</td><td colspan="2">Practice the whole piece</td></tr>
<tr><td>Practice the whole piece</td><td>Practice the whole piece</td><td colspan="2">Practice the whole piece</td></tr>
<tr><td colspan="4">First recording</td></tr>
<tr><td>Perform the piece from memory and record the performance</td><td>Perform the piece from memory and record the performance</td><td>Perform the piece from memory and record the performance</td><td>Perform the piece from memory and record the performance</td></tr>
<tr><td colspan="4">10 minute break</td></tr>
<tr><td colspan="4">Second recording</td></tr>
<tr><td>Perform the piece from memory and record the performance</td><td>Perform the piece from memory and record the performance</td><td>Perform the piece from memory and record the performance</td><td>Perform the piece from memory and record the performance</td></tr>
<tr><td colspan="4">NEXT DAY
Third recording</td></tr>
<tr><td>Perform the piece from memory and record the performance</td><td>Perform the piece from memory and record the performance</td><td colspan="2">Perform the piece from memory and record the performance</td></tr>
</table>

3.4 Data analysis

There are three dependent variables of interest in the present study: the number of note errors, the number of rhythm errors, and the duration of performances. For analyzing the statistical significance of the results, we used a 3 (modeling) x 3 (recording) ANOVA on each of these three dependent variables. The level of significance is expressed as a probability value p. In this study, a p of .05 level has been established.

3.5 Data coding and entry

The researcher evaluated the recordings following specific criteria for evaluation of the performances: number of wrong notes, number of wrong rhythm, and duration of performance. If a note mistake was observed, it was counted as one point. If a rhythm mistake was observed it was counted as one point. Total duration of performance was counted in seconds. Beginning of timing starts from the time the participant plays the first note to the moment the participant stops playing. The duration of performance reflects the hesitations or repetitions made while performing the piece. The longer duration of performance reflects more hesitations, repetitions, and pausing made while performing the piece. Participants were free to play the piece at the speed they wanted. Each participant was assigned a number to ensure anonymity and confidentiality of data collection. After the evaluation was done, another judge evaluated 20% of the recordings without prior knowledge of which group the participants belonged to and results were compared to ensure inter-judge agreement. Pearson correlation was 0.981, and it is significant ($p < .05$). It is an almost perfect correlation, which means that when you detect a high number of errors, so does the evaluator and when you detect a low number of errors, so does the evaluator.

After the data collection was completed, a coding scheme was created to organize the data (Appendix L).

3.6 Pilot testing

Pilot testing is a key element of good experimental design (Webster & Sell, 2007). This means trying out the experiment on few participants who are representative of the sample that will take part in the actual experiment (Peter, 2008). This step is essential because participants act as informants, they let the researcher know what worked and what didn't with regard to tasks and data collection (Webster & Sell, 2007). It detects problems or flaws that may have been overlooked when creating the design, which helps in improving the design before using it with a big sample. Moreover, pilot testing provides the opportunity to detect the potential of facing any floor or ceiling effect in the design. For example, knowing if the experiment is too difficult that only few participants can do it (floor effect) or too easy that everyone can do it (Ceiling effect) (Peter, 2008).

The pilot test of this study took place at OPUS Academy, Orleans. The objective of this pilot was to examine the research design and pinpoint any needed changes or adjustments. The elements evaluated included the appropriate level of difficulty of the piece, the clarity of procedure and instructions, how the participants dealt with each practice condition, the length of the practice sessions, the time allocated to practicing each line and the whole piece, and any other insights that help in better planning for the experiment, such as the positioning of camera in the video-modeling conditions (from top or from an angle). The pilot test was conducted in November 2015, and six participants took part in the pilot test. All participants commented that the procedure was easy to follow and instructions were clear. The time allocated to practice seemed sufficient (with no pressure), and all participants noted that it was satisfactory.

Since this study involved young students, the researcher applied for ethics approval prior to conducting pilot testing. Documents such as consent forms for parents, students, teachers, and invitation letter for the research as well as the research design were submitted for approval. The study got the approval from the Ethic Committee no. 2015-143/ 16-07-2015.

4. Results

This section presents the results for each dependent variable, note errors and rhythm errors. Because a close inspection of the results indicates that there seems to be important differences between the execution at the first section and the second section of the piece, the statistical analyses will take into account this factor. Section 1 includes measure 1-8 and section 2 includes 8-16. Moreover, because the total number of notes in Section 1 was 47 and total number of notes in Section 2 was 52, ratios were calculated by dividing number of note (or rhythm) errors on total number of notes (or rhythms) per section. The ratio data are analyzed with an Analysis of Variance (ANOVA) according to a 2 (section: halves of the piece) x 3 (recording conditions) x 3 (modeling conditions) design, with repeated measures on the first two factors.

4.1 Note errors

Figure 3 provides a summary of the overall (both sections together) mean number of note errors. In general, it shows that the main differences between the modeling conditions occur during the third recording. In this condition, the mean note errors were 11.13, 32.13 and 13.88 for video modeling with cues, audio modeling, and free practice respectively.

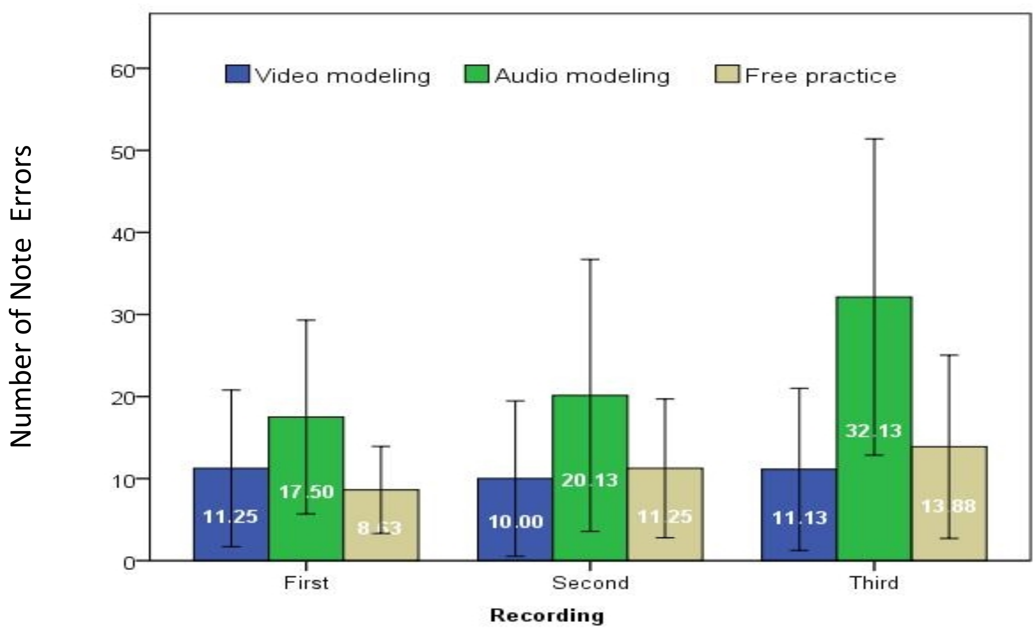

Figure 3. Mean note errors (and 95% CI) in each experimental condition

The overall mean ratios (both sections together) for note errors across the three recordings for video modeling, audio modeling, and free practice conditions are reported in Figure 4. As can be seen, it is in the audio modeling group that the highest ratio of note errors was obtained, and this ratio kept increasing across the three recordings, from 17.19 on first recording, 19.65 on second recording and reaching to 31.42 on the third recording. In other conditions, it remained between 9.8 and 13.9. There were very different ranges of errors in each case, which is why each graph has its own scale on the Y axis.

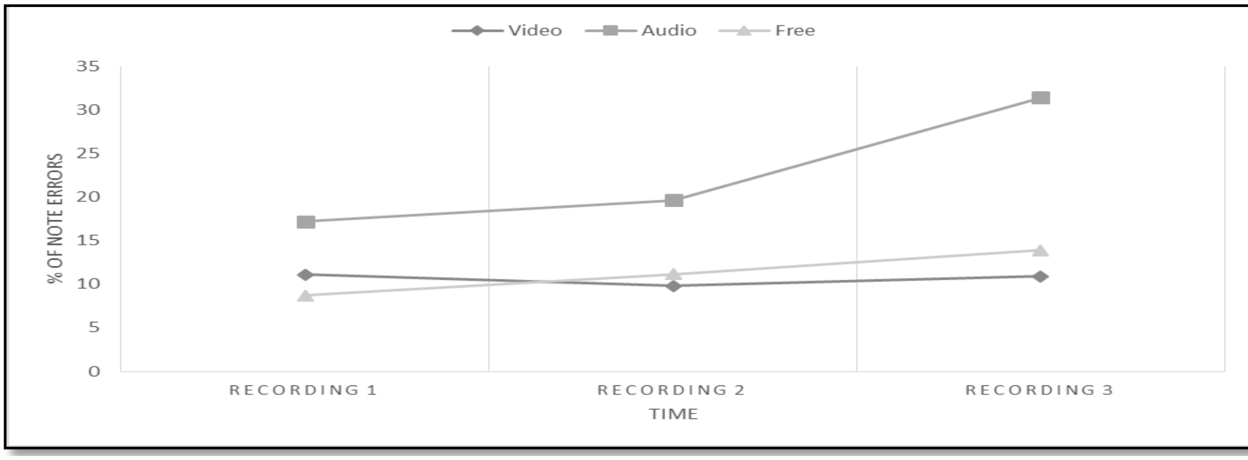

Figure 4. Mean note error ratios in each modeling condition across recording

The results of the mixed factorial ANOVA on ratios (2 x 3 x 3) revealed that there was a significant section effect, $F(1, 21) = 12.78$, $p = .002$, $\eta^2_p = .38$ and a significant recording time effect, $F(1.45, 30.47) = 5.71$, $p = .014$. The mean note error ratio was higher in the second section ($M = 22.22$) than in the first section ($M = 7.53$). Contrast analyses showed that there is significant difference ($p = .023$) between recordings 1 ($M = 12.34$) and 3 ($M = 18.75$). There was a significant interaction effect between section and recording, $F(1.79, 37.53) = 4.25$, $p = .025$. There was no significant difference between mean note error ratios across recordings (7.70, 5.67 and 9.21) within Section 1, $F(1.34, 30.72) = 3.41$, $p = .063$, $\eta^2_p = .13$, while within Section 2 there was a significant difference between mean note error ratios across recordings (16.98, 21.39 and 28.28), $F(1.56, 37.80) = 4.76$, $p =.022$, $\eta^2_p = .17$.

No significant effect was found with modeling conditions, $F(2, 21) = 2.278$, $p = .127$, $\eta^2 = .18$ but the interaction between section and modeling conditions was marginally significant, $F(2, 21) = 3.153$, $p = .063$, $\eta^2 = .23$ and the interaction effect between recording and modeling conditions was also marginally significant, $F(2.90, 30.47) = 2.48$, $p = .082$, $\eta^2 = .19$. No significant interaction effect was found between section, recording and modeling conditions, $F(3.57, 37.53) = 1.96$, $p = .127$, $\eta^2 = .16$.

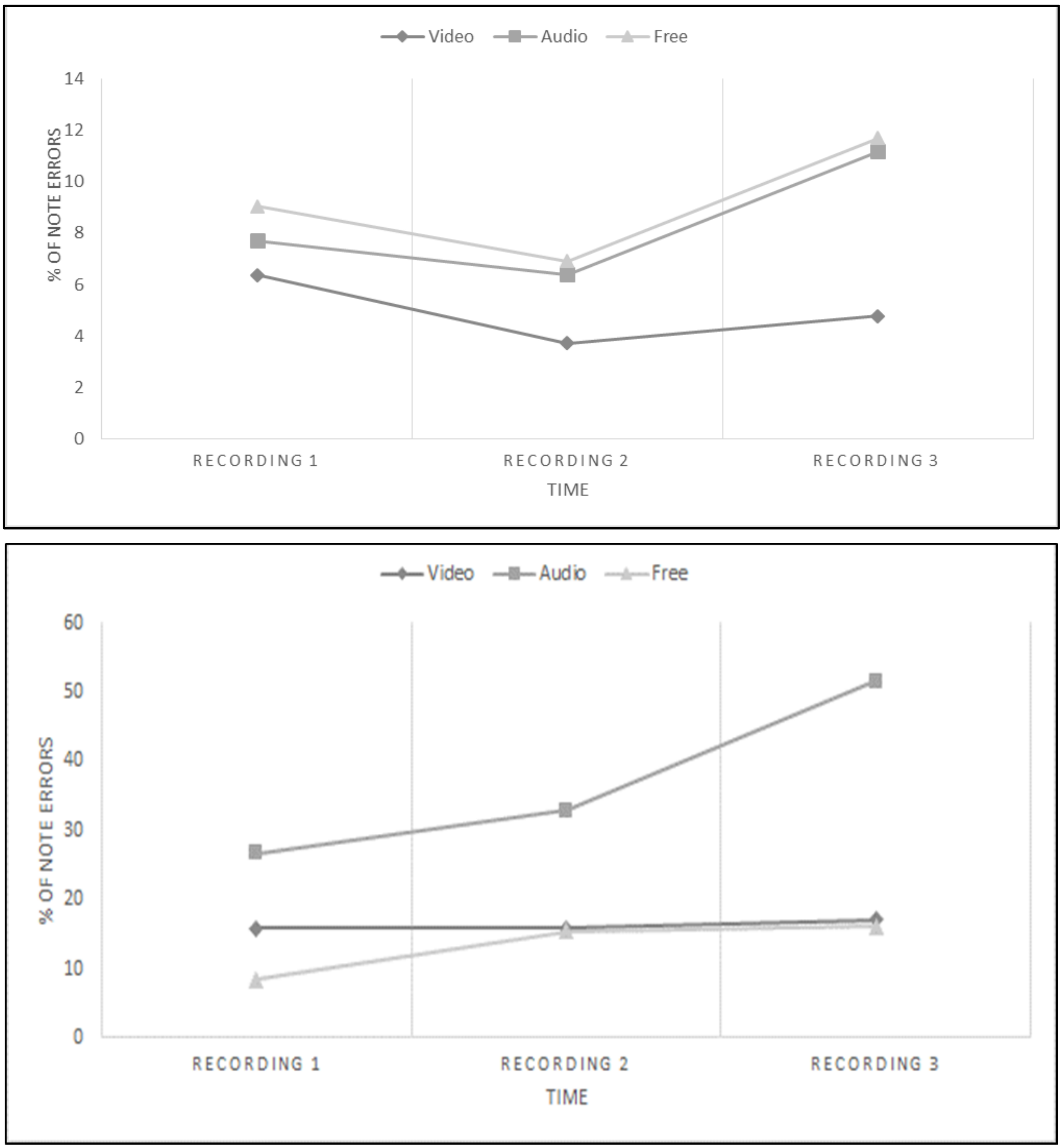

Figure 5. Mean note error ratios for Sections 1 (upper panel) and 2 (lower panel) across the three recordings for each modeling condition

Figure 5 reports the ratio of note errors for Sections 1 (upper part) and 2 (lower part) across the recordings for each modeling condition.

As can be seen in the upper portion of Figure 5, audio modeling group in Section 1 started with a 7.71 score and then went down to 6.38 on second recording, followed by an increase to 11.17 on third recording. Video modeling group had the lowest ratio of note errors with 6.36 and decreased to 3.72 on the second recording and a slight increase to 4.78 on the third recording. As for the free practice group, the ratio of note errors was 9.0 in the first recording and decreased to 6.9 on second recording, and then went up to 11.69 on the third recording.

As for the ratio of note errors in Section 2 for the three modeling conditions across time, the lower portion of Figure 5 shows that the audio modeling group had the highest ratio of note errors in section 2 starting with 26.68 on first recording and increasing to 32.93 on second recording and 51.68 on third recording. As for free practice group, the ratio of note errors in section 2 was 8.41, 15.38 and 16.1 respectively. Video modeling group ratio of note errors was the same for first and second recording with 15.86, and 17 on the third recording.

4.2 Rhythm errors

Figure 6 provides a summary of the overall (both sections together) mean number of rhythm errors. In general, it shows that the main differences between the modeling conditions occur during the third recording**.** In this third recording the mean rhythm errors were 8.50, 23.00 and 9.88 for video modeling with cues, audio modeling, and free practice, respectively**.**

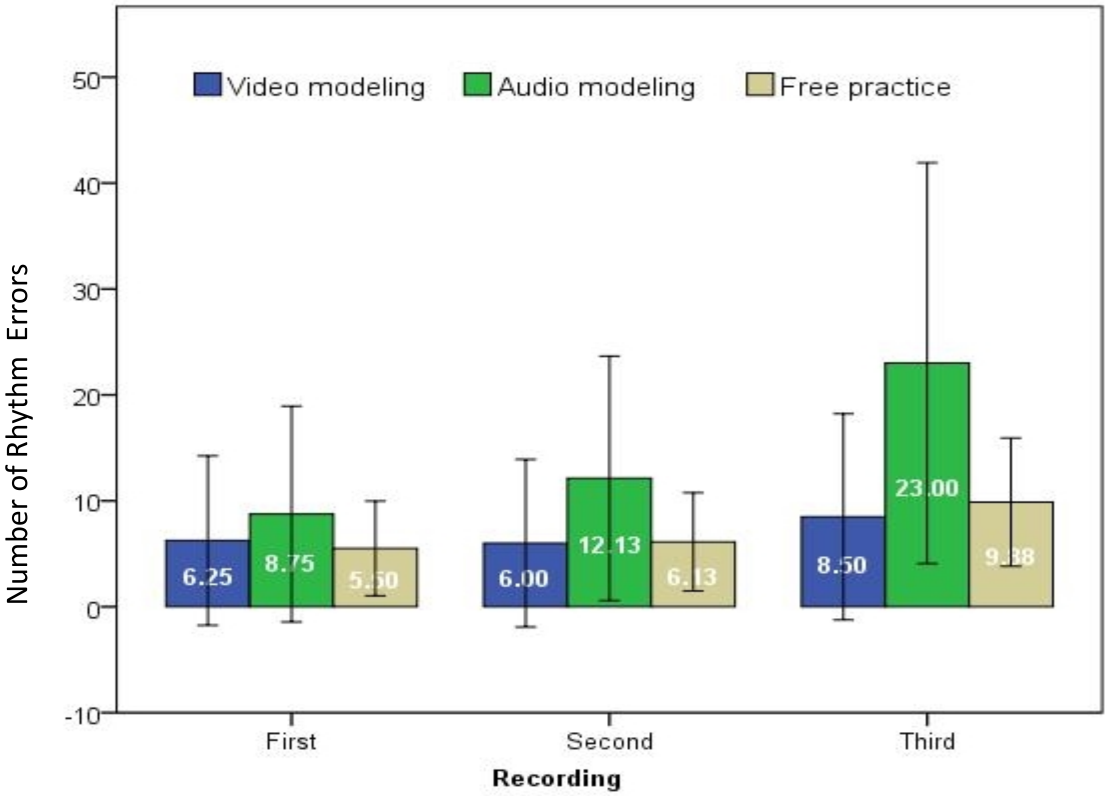

Figure 6. Mean rhythm errors (and 95% CI) in each experimental condition

The overall mean ratios (both halves together) for rhythm errors across the three recordings for video modeling, audio modeling, and free practice conditions are reported in Figure 7. As can be seen, it is in the audio modeling group that the highest ratio of rhythm errors was obtained, and ratio kept increasing across the three recordings, from 8.75 in the first recording, to 12.13 in the second recording to 23.00 in the third recording. In other conditions, the mean rhythm errors vary between 5.50 and 12.13. The figure also seems to indicate that with each modeling condition, it is in the third recording condition that the number of rhythm errors is the highest.

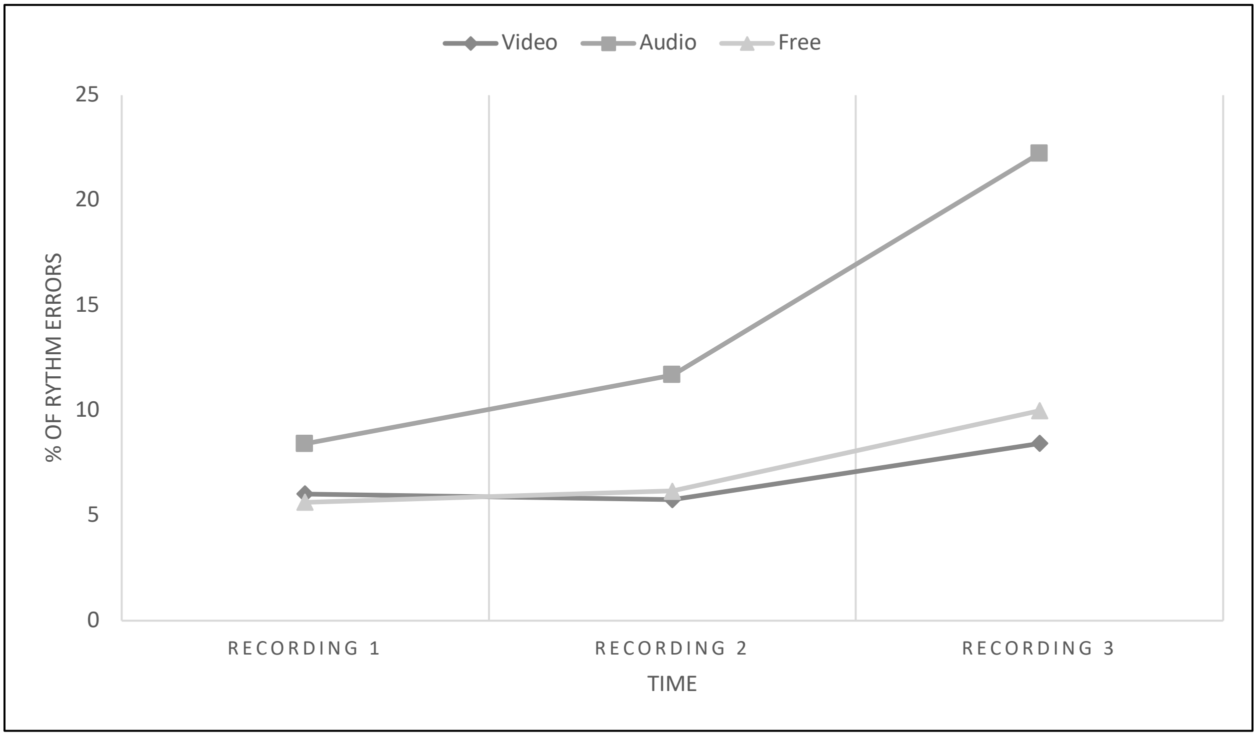

Figure 7. Mean rhythm error ratios in each modeling condition across recordings

Results of the mixed factorial ANOVA on rhythm ratios (2 x 3 x 3) revealed that there was a significant section effect, $F(1, 21) = 8.279$, $p = .009$, $\eta^2 = .28$, and a significant recording time effect, $F(1.386, 29.112) = 6.603$, $p = .009$, $\eta^2 = .24$. The ratio was higher in the second section ($M = 15.11$) than in the first section ($M = 3.63$). Contrast analyses showed that a significant effect ($p = .021$) was found between recordings 1 ($M = 6.70$) and 3 ($M = 13.55$). There was no significant interaction effect between section and recording time, $F(1.52, 31.82) = 1.31$, $p = .278$.

No significant differences were found between the modeling conditions $F(2, 21) = 1.35$, $p = .282$, but the interaction between section and modeling conditions was significant, $F(2, 21) = 3.87$, $p = .037$. The interaction effect between recording and modeling conditions was not significant, $F(2.77, 29.11) = 1.61$, $p = .212$, and there was no significant interaction effect between the three factors, section, recording and modeling, $F(3.03, 31.82) = 2.23$, $p = .103$.

Figure 8 reports the ratio of rhythm errors for Sections 1 (upper portion) and 2 (lower portion) for the three modeling conditions across time. As for Section 1, there was a significant difference between the modeling conditions, $F(2, 21) = 5.14$, $p = .015$, $\eta^2_p = .33$. Contrast analyses showed that there was a significant difference ($p = .017$) between the video modeling group ($M = 1.95$) and the free practice group ($M = 7.80$), and a significant difference ($p = .008$) between the audio modeling group ($M = 1.15$) and the free practice group ($M = 7.80$). As for Section 2, there was no significant difference between the modeling conditions, $F(2, 21) = 2.44$, $p = .112$, $\eta^2 = .19$.

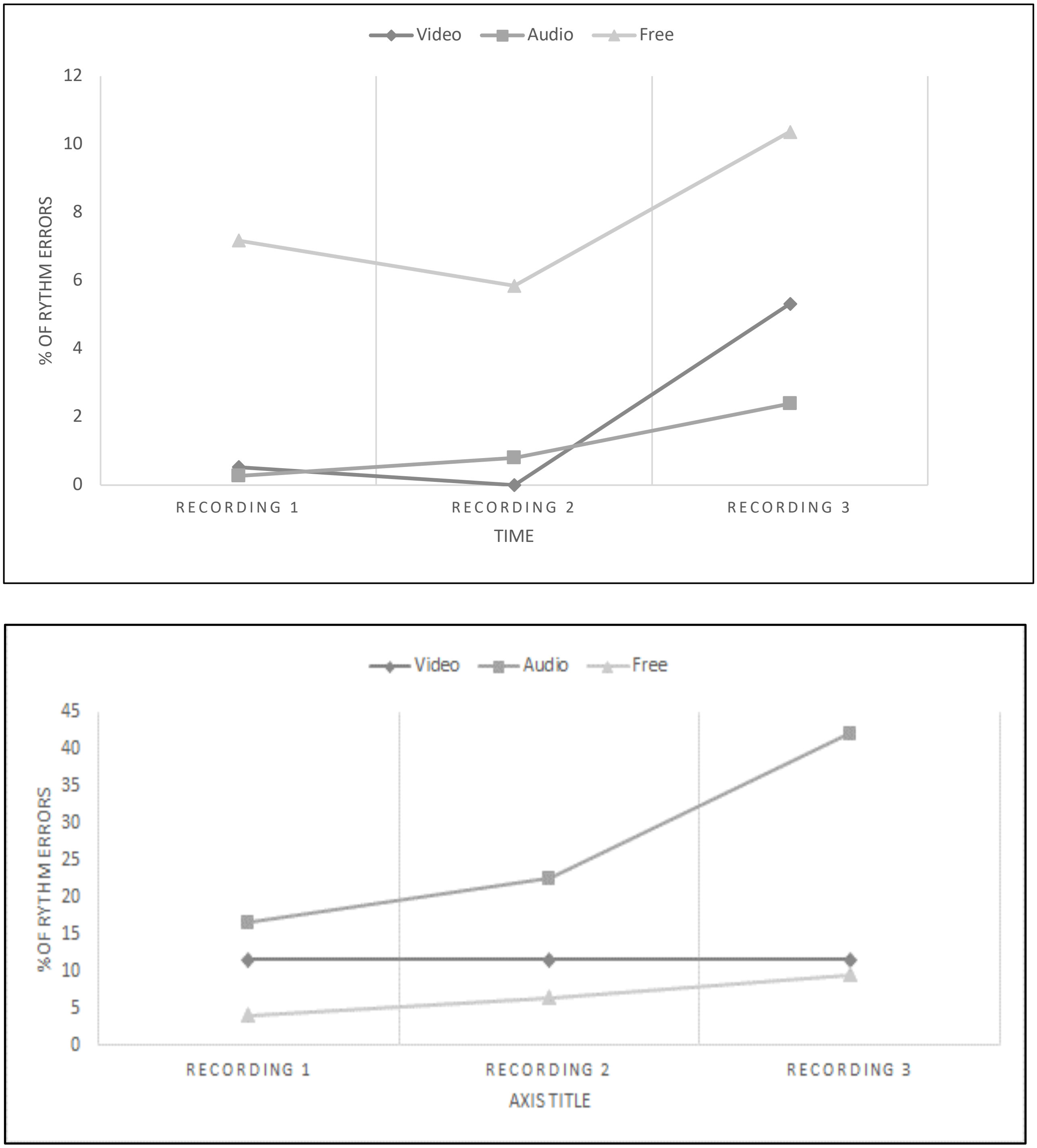

Figure 8 Mean rhythm error ratios for Sections 1 (upper panel) and 2 (lower panel) across the three recordings for each modeling condition

5. Discussion

The objective of this study was to test the effectiveness of practicing with different modeling conditions on the memorization of young piano students. As mentioned earlier, the research literature covers the use of aural modeling to improve music learning and performance, but does not explicitly cover its use for complete memorization of a piece. However, cognitive psychology stresses the role that memory plays in improvement and learning, and so it seems reasonable to hypothesize that if aural modeling has been shown to improve learning and performance then it may have a similar effect on ability to learn and perform a piece by heart. Also, the discovery of the role of mirror neurons in human memory formation provides a neuroscientific basis for the use of video modeling in this study. It enables the effectiveness of video modeling in helping students to learn a skill, as observed in the literature of cognitive psychology, to be explained in terms of specific brain function. The fact that mirror neurons not only enable a subject to mimic an action but actually to form memories of performing that action provides a further basis for the hypothesis that video modeling will support piano students in forming the memory traces required to enable them to memorize a piece of music. Accordingly, this study compared the efficacy of aural modeling with that of both free practice and visual modeling with cues. Therefore, main hypotheses were as follow:

- Subjects in aural modeling and video modeling with cues conditions would have better memorization scores than the comparison group (free practice).
- Among the modeling conditions, video modeling with cues would produce the best memorization results (fewest errors in notes, and rhythm).

This section will review the results regarding note errors and rhythm errors.

5.1 Note errors

Main findings in the note error indicate that there was slight significance between section of the piece and experimental conditions in favour of video modeling with cues compared to free practice and aural modeling. Results shows that section of the piece and experimental condition interaction indicated that the change in error rates across the sections marginally depended on experimental condition. That is the trend for the note error ratio rate to be higher in the second section occurred within each experimental condition in a relatively similar fashion. This difference can be explained by second section being more demanding: it had more notes, (52 versus 47), more complex rhythmic patterns played simultaneously especially on third line of the piece, each hand playing different articulation (RH legato versus LH staccato) and rhythm values which requires dissociation of hands and good coordination, and there was a shift in hand position from C to F. What was interesting is that the error rate change from section 1 (S1) to section 2 (S2) was much larger in the aural modeling condition compared to the other conditions and was marginally significant. This finding contradicts Cash et al. (2014) and Frewen (2010). Cash et al. (2014) studied the effect of aural modeling and saw an improvement in performance after a series of practice intervals in the evening, and again, 12 hours later. However, it is important to note that the students in this study were only asked to perform 13 notes, a much less demanding task than in the current study. Frewen (2010) showed that children who became familiar with a four-measure melody after listening to it through aural modeling performed the melody on the keyboard with increased accuracy. These studies could mean that aural modeling can be useful for memorizing easy and simple pieces. However, aural modeling might not be a sufficient tool to be solely used when it comes to memorizing more complex and demanding pieces. Hence, the lack of visual cues showing finger movements and the shifting of hand position might have had an effect on the increasing number of errors in the current study. This finding is in line with other studies that looked into the effect of audio modeling on the quality of performances. Woody (2006) who compared several instructional approaches to elicit expressivity and found that the audio modeling approach made little change in performance and didn't demonstrate the students' own expressiveness, rather primarily an imitation of the model's performance. Morrison, Montemayor, and Wiltshire (2004) examined the difference in ensemble performance using audio models versus no models. Judges' evaluations showed no difference in achievement between pretreatment and posttreatment performances.

Even though there was not a large enough difference between conditions to be deemed statistically significant due to averaging each modeling conditions (3 separate means when comparing video modeling, audio modeling and free practice), some interesting findings were apparent when looking at modeling conditions across time. When examining the interaction between modeling conditions and the point at which the recording was made, results showed that there was a marginal interaction. The timing of the recording, whether made immediately, after 10 minutes or after 24 hours, had an effect on the performances for the different modeling conditions. Recording 3, which took place after 24 hours, had a much higher error rate than the other recordings, but this increasing error rate does not occur with the video modeling condition. However, the study showed higher error rates with the audio modeling and free practice conditions, particularly with audio modeling. This could be related to the fact that students in the video modeling with cues group memorized the piece in more comprehensive way. The use of video provided several modes of representation being: aural, visual, and kinesthetic, which might have contributed to a more reliable retention of the piece.

There was no significant interaction between section, recording and experimental condition in relation to note error ratios (i.e. the experimental condition effect on note error ratio will depend on which recording and section it is). Examining the 2-way interactions allowed us to see marginally significant interactions between the experimental condition and section, and the experimental condition and recording. However, when looking at the 3-way interaction all variables/levels are involved in the analysis, this involves looking into the modeling condition, section of the piece, and recording time simultaneously. Therefore, means that the mean error rate for the participants in the video modeling condition for recording 1 in section 1, and so on and so forth. This process is then repeated for the audio modeling and then the free practice conditions. The change in these mean error rates are compared and so it is harder to establish any particular differences in trends across experimental conditions, thus the non-significant result.

5.2 Rhythm errors

Results showed no significant difference in rhythm error ratios when comparing the free practice, video modeling and aural modeling conditions. This could be due to averaging the rhythm error ratios across sections and recordings according to each experimental condition (comparing 3 separate means for video modeling, audio modeling and free practice). Therefore, there was not a large enough difference between them to be deemed statistically significant.

However, there was a significant difference in rhythm error ratios across the three recordings. For each modeling condition, the third recording had the highest number of rhythm errors. However, it is interesting to note that the aural modeling group had the highest ratio of rhythm errors followed by the free practice group and that the video modeling with cues had the lowest ratio of rhythm errors; this suggests that video modeling with cues has a stable and consistent memory retention over time and may well be a reliable tool for long-term retention.

There was also a significant interaction between section and experimental condition in relation to rhythm error ratios. In Section 1, free practice had the highest number of mistakes, followed by video modeling and audio modeling. Interestingly, this changed in section 2 where audio modeling had the highest number of mistakes, followed by video modeling then free practice. This again shows that audio modeling isn't sufficient for memorization across time and wasn't reliable when memorizing a more challenging section. Free practice errors increased in a steady manner across the section 2 recordings. Video modeling, on the other hand, had a decreasing number of errors in section 2 across recordings.

As mentioned earlier, section 2 was more challenging in terms of more number of notes, shifting hand positions, playing two different articulations and rhythm values in each hand so it is interesting to see how each modeling condition did in each section. Better performance with the video modeling with cues condition could be related to the fact that participants in this group got to visually see finger movements with finger numbers, more specifically hearing and seeing at the same time how to play the rhythm correctly.

These findings support some motor learning studies that stress the importance of adding cues to a video of a model demonstrating a skill. Rothstein and Arnold (1967) showed that using cues that direct viewers' attention to specific aspects of the video had a positive effect on their performance. Linklater (1994), working with beginning clarinet students, also found that the video modeling group had the best and longest retention period compared to aural modeling group. Zetou et al. (2002) showed that video modeling with cues helped elementary school children acquire and retain set and serve volleyball skills. Similar positive effects of video modeling with instructions on skills acquisition on accuracy in handball shoot were found in the by Nahed, Zahra, and Elham (2013).

In addition, findings of this study on video modeling confirms the research in neuroscience regarding mirror neurons. Work on mirror neurons confirms the notion that brain regions responsible for the planning of movement and movement itself gets activated when observing actions (Buccino et al., 2004; Schlosser, 2011). Also research in neuroscience shows a tight, automatic and long term coupling between auditory, visual, and motor networks in the brains of musicians (Bangert & Altenmüller, 2003; Haslinger et al., 2005). This was the case for video modeling group who got to observe the finger movement of the student who was playing the piece. They were listening to the piece while watching the hands and finger movement of the model during the experiment. Therefore, having aural, visual and motor aspects helped in solidifying the memorization and retention of the piece even after 24 hours.

Conclusion

Based on the notion of modeling initiated by Bandura's theory of observational learning, the core of this study was an exploration of what kind of modeling is most effective when memorizing piano music. Bandura's theory of observational learning (1977) relates to the four stages in the learning of skills: attention, retention, reproduction, and motivation, with each stage influenced by the quality of visual demonstration and modeling of skills. Video modeling with cues seems to effectively utilize each stage in this theory. It combines the essential elements needed for observational learning to happen especially with regards to the first two stages. In the attention phase, the learner should observe and pay attention to a person (the model) who is performing the skill to be learned. Thus, in the video modeling condition, participants watched a video of the model playing the piece. In the retention stage, the subject converts the observed movement pattern into a representational form and stores it in memory. Bandura believed that this process was the function of imaginal sub-processes that act to extract patterns from visual information. In the video modeling with cues condition, the visual information was the use of finger numbers to guide the participant's attention to finger movement. Reproduction, the third stage, is the active rehearsal of an observed skill. In this case, participants of the video modeling with cues condition practised the piece right after watching the model. The fourth stage is motivation. Bandura proposed the concept of self-efficacy, which is the belief in one's ability to acquire and master a skill or task. Modeling plays an essential role in enhancing the learner's level of self-efficacy especially when the model has similar abilities to that of the learner's. Subjects in the video modeling with cues group watched a model with similar abilities.

The main hypotheses of this study were that the subjects in both modeling conditions would have better memorization scores than the comparison group (free practice) and that video modeling with cues would produce the best results, i.e., fewest errors in notes and rhythm. As for the second hypothesis, the results have indeed shown that video modeling with cues did have the best memorization results based on low rhythm and note errors across recordings when compared to aural modeling and free practice. The use of video provided several modes of representation being: aural, visual, and kinesthetic, which might have contributed to a more reliable retention of the piece. Also, observing the model play the piece in video modeling serves as an actual practice according to neuroscience research on mirror neurons, which solidifies the memorization.

However, both modeling conditions were not equally effective—the aural modeling group did not score better than the free practice group. As mentioned earlier, aural modeling could be a useful guide when memorizing simple and short pieces but not long and complex ones. For this study, the second section of the piece was complex rhythmically and technically, which means that listening to the piece only without any visual aid maybe quite abstract and subsequently not very effective. Therefore, free practice, which entailed the actual playing of the piece might have been more useful in figuring out how to play the rhythm compared to merely listening to it. This may be one of the reasons why aural modeling didn’t score better than the free practice group.

Future research and limitation of the study

This study serves as a starting point in understanding the complex nature of memorizing and the effectiveness of different modeling conditions in memory retention. It would be interesting to explore how video modeling with cues can be used as a home practice tool for students who practice regularly and need constant support at home. This implies a need for teachers to record pieces that students are working on so they can use them for home practice. Music teachers hope that their students retain pieces over time especially when working towards concerts and exams. Further study could certainly aid in developing customized and appropriate tools to make students' practicing more fully conscious, rather than simply mindless or mechanical repetition. For example, using videos with main indications on what to focus on in practicing might increase the memory retention of students preparing for concerts and exams. A longitudinal study tracking students who practice using different modeling conditions over time in preparation for exams or concerts would provide a clearer idea about the effectiveness of these methods in the long term.

This study had some limitations and results should be considered carefully. The number of participants was small since it covered a specific age range and piano grade level, and it required a long period to recruit participants. Despite the small sample size, however, some statistically significant results were found, which shows the effect size (Eta squared) was large enough to indicate the importance of effect. However, a longitudinal study might allow the increase of sample size. Also, despite having students at same level, there was an age difference, which might have affected the way participants worked at the experiment. In addition, there was not a standardized pre-test to evaluate level of the students and the researcher relied on piano teacher's judgement, which could be a limitation. A future procedure that can be used to overcome such limitation is by developing a standardized test to make sure students had same scores at all levels including sight reading, technique, etc.

To conclude, the present project was a quasi-experimental study that tested the effectiveness of practicing with different modeling conditions on the memorization of young piano students. Video modeling with cues can help students memorize their pieces more efficiently since it engages the minds of young piano students in three different ways (aural, visual, and motor). It also can help improve home practice and a build a better communication link between teachers and parents.

References

Adams, J. (1986). Use of the model's knowledge of results to increase the observer's performance. *Journal of Human Movement Studies, 12*, 89-98.

Acevedo, I. (2009). Accuracy of letter reproduction using video modeling versus in vivo modeling in children with autism. *Dissertation Abstracts International*. (UMI no.1468430)

Ahrens, C. & Atkinson, G. (1955). *For piano teachers*. Canada: The Frederick Harris Music Co. Limited.

Babin, A. Number of ORMTA teachers. (Personal communication, March, 2015).

Baddeley, A. D. (2000). The episodic buffer: A new component of working memory? *Trends in Cognitive Sciences*, *4*(11): 417-423.

Baker, D. S. (1980). The effect of appropriate and inappropriate in-class song performance models on performance preference of third- and fourth-grade students. *Journal of Research in Music Education, 28*, 3-17.

Baker-Jordan, M. (2004). *Practical piano pedagog*y. USA: Alfred Music.

Bandura, A. (1977). *Social Learning Theory*. New York: General Learning Press.

Bandura, A. (1986). *Social Foundations of Thought and Action*. Englewood Cliffs, NJ: Prentice-Hall.

Bandura, A. (1997). *Self-efficacy: The exercise of control*. New York: W.H. Freeman.

Bandura, A. (2007). Analysis of modeling processes. In A. Bandura (Ed.), *Psychological Modeling: Conflicting Theories* (pp. 1-62). USA: Aldine Transaction.

Bandura, A., Jeffrey, R. & Bachicha, D. (1974). Analysis of memory codes and cumulative rehearsal in observational learning. *Journal of Research in Personality*, *7*, 295- 305.

Bangert, M. & Altenmüller, E. (2003). Mapping perception to action in piano practice: A longitudinal DC-EEG-study. *BMC Neuroscience, 4*, 26-36.

Bastien, J. W. (1995). Memorization techniques. In J.W. Bastien (Ed.), *How to Teach Piano Successfully* (pp.245-246). San Diego, CA: Neil A. Kjos Music Co.

Bernstein, S. (1981). With your own two hands: Self-discovery through music. New York: Schirmer Books.

Boyers et al. (2009). Video modeling by experts with video feedback to enhance gymnastics skills. *Journal of Applied Behavior, 42*(4), 855–860.

Broughton, J. (1956). *Success in piano teaching*. New York: Vantage Press.

Bruser, M. (1997). The art of practicing: A guide to making music from the heart. New York: Bell Tower.

Buccino, G., et al. (2004). Neural circuits underlying imitation learning of hand actions: An event-related fMRI study. *Neuron, 42*, 323–334.

Calvo- Merino, B., et al. (2004). Action observation and acquired motor skill: An fMRI study with expert dancer. *Cerebral Cortex, 15*, 1243- 1249.

Camp, M. (1992). Teaching piano: The synthesis of mind, ear and body. Los Angeles: Alfred.

Chaffin, R., & Imreh, G. (1997). Pulling teeth and torture: Musical memory and problem solving. *Thinking and Reasoning, 3*(4), 315–336.

Carroll, W.R., & Bandura, A. (1990). Representational guidance of action production in observational learning: A causal analysis. *Journal of Motor Behaviour, 22*, 85-97.

Cash, C., Allen, S., Simmons, A., & Duke, R. (2014). Effects of model performances on music skill acquisition and overnight memory consolidation. *Journal of Research in Music Education*, 62:89.

Clark, F. (1992). Questions and answers: A practical advice for piano teachers. Northfield: The Instrumentalist.

Coates, B. & Hartup, W. (1969). Age and verbalization in observational learning. *Developmental Psychology, 1*, 556-562.

Coker, C.A. (2004). *Motor learning and control*. USA: Holcomb Hathaway Publishers.

Colprit, E. (2000). Observation and analysis of Suzuki string teaching. *Journal of Research in Music Education, 48*, 206-225.

Creswell, J. (2013). *R*esearch design: Qualitative, quantitative, and mixed methods approaches. USA: Sage Publications.

C. Donkin. (Personal communication, November, 2013).

Donkin. C. Bio. Last retrieved April 2015 from http://www.christinedonkin.com/bio/

Darden, G.F. (1997). Demonstrating motor skills-rethinking the expert demonstration. *Journal of Physical Education, Recreation and Dance, 68*(6), 31-35.

Davis, H., et al. (2008). fMRI BOLD signal changes in elite swimmers while viewing videos of personal failure. *Brain Imaging and Behavior, 2*, 84–93.

Dickey, M. R. (1991). A comparison of verbal instruction and nonverbal teacher-student modeling in instrumental ensembles*. Journal of Research in Music Education, 39*(2), 132-142.

Dickey, M. R. (1992). A review of research on modeling in music teaching and learning. *Bulletin of the Council for Research in Music Education,* 113: 37.

Dubé, F. (2006). Les repères microstructuraux dans l'apprentissage mnémonique de partitions de piano. Unpublished doctoral dissertation, Université Laval, Canada.

Duke, R. A. (1999). Teacher and student behavior in Suzuki string lessons: Results from the International Research Symposium on Talent Education. *Journal of Research in Music Education*, *47*, 293-307.

Ebie, B. (2004). The effects of verbal, vocally modeled, kinesthetic, and audio- visual treatment conditions on male and female middle-school vocal music students' abilities to expressively sing melodies. *Psychology of Music*, *32*(4), 405-417.

Edwards, W. (2010). Motor learning and control: From theory to practice. USA: Brooks Cole.

Emmen, H. et al. (1985). The effect of video-modeling and video-feedback on the learning of the tennis service by novices. *Journal of Sports Sciences, 3* (2), pp. 127-138.

Ellsworth, V. & Kantorski, V. (1991). The effect of instructional videotape modeling on nonmusicians' visual and aural double bass performance. *Dialogue in Instrumental Music Education,* 15.

Eyesnck, M. & Keane, M. (2010). *Cognitive psychology: A student's handbook*. (6th Ed.). Psychology Press.

Franzone, E., & Collet-Klingenberg, L. (2008). Overview of video modeling. Madison, WI: The National Professional Development Center on Autism Spectrum Disorders, Waisman Center, University of Wisconsin.

Frewen, K.G. (2010). Effects of familiarity with a melody prior to instruction on children's piano performance accuracy. *Journal of Research in Music Education, 57*(4) 320-333.

Froseth, J. O., & Delzell, J. K. (1981). *The individualized instructor teaching skills workbook*. Chicago: GIA Publications, Inc.

Garguilo, R. & Metcalf, D. (2012). Teaching in today's inclusive classrooms: A universal design for learning approach. USA: Cengage Learning.

George, T. Felt, L. & Chase, A. (1992). The effect of model similarities on self-efficacy and muscular endurance: A second look. *Journal of Sport and Exercise Psychology, 14*, 237-248.

Ginsborg, J. (2004). Strategies for memorizing music. In A.Williamon (Ed.), *Musical excellence: Strategies and techniques to enhance performance* (pp.123-140). Oxford: Oxford University Press.

Ginsborg, J. (2007). Off by heart: Musicians' strategies for memorizing music. Paper presented at the Fryderyk Chopin Academy of Music, Warsaw, Poland.

Gould, D. & Weiss, M. (1981). The effect of model similarity and model talk on self-efficacy and muscular endurance. *Journal of Sport Psychology, 3,* 17-29.

Greer, D. (1980). *Design for Music Learning*. New York: Teachers College Press.

Hand, J. & Sidaway, B. (1993). Relative frequency of modeling effects on the performance and retention of a motor skill. *Research Quarterly for Exercise and Sport, 4*, 122-126.

Haslinger, B. et al. (2005). Transmodal sensorimotor networks during action observation in professional pianists. *Journal of Cognitive Neuroscience, 17*, 282-293.

Hay, R. (2006). The science of learning: A systems theory perspective. Florida: Brown Walker Press.

Henley, P. T. (2001). Effects of modeling and tempo patterns as practice techniques on the performance of high school instrumentalists. *Journal of Research in Music Education 49*(2), 169-180.

Herbert, E.P. & Sidaway, B. (1994). Effects of learning model and augmented feedback on tennis skill acquisition. *Research Quarterly for Exercise and Sport, 65*(3), 250-257.

Hewitt, M. (2001). The effects of modeling, self-evaluation, and self-listening on junior high instrumentalists' music performance and practice attitude. *Journal of Research in Music Education, 49: 307.*

Hodges, N.J., Chua, R., and Franks, I.M. (2003). The role of video in facilitating perception and action of a novel coordination movement. *Journal of Motor Behavior*, 35, 247-260.

Hughes, E. (1915). Musical memory in piano playing and piano study. *Musical Quarterly*, *1*, 592-603.

Ishikura, T. & Inomata, K. (1995). Effect of angle of model demonstration on learning of a motor skill. *Perceptual and Motor Skills, 80*, 651- 658.

Jacobson, J. M. (2006). Professional piano teaching: A comprehensive piano pedagogy textbook for teaching elementary-level students. Sherman Oaks, CA: Alfred Pub. Co.

Keele. S. W. (1977). Current status of the motor program concept. In R. Christina & D. Landers (Eds.), *Psychology of motor behavior and sport* (pp. 2-16). Champaign, IL: Human Kinetics.

Kostka, M. (1984). An investigation of reinforcements, time use, and student attentiveness in piano lessons. *Journal of Research in Music Education, 32*, 113-122.

Kudirka, M. (2012). Mirror neurons. Last retrieved April 2015 from http://www.michaelkudirka.com/papers/papers.html

Lau,E.(2016). "Re: ABRSM and RCM equivalency" E-mail message to {Nisreen Jardaneh}.

Linklater, R. (1994). A comprehensive investigation of the effects of audio and video tape models on the musical development of beginning clarinet students. Doctoral dissertation, The University of Michigan.

Mcleod, R. (2010). A comparison of instructional strategies used by experienced band and orchestra teachers when teaching a first-year class an unfamiliar music excerpt. *Bulletin of the Council for Research in Music Education*, *185*, 49-61.

Madsen, C. K., Greer, R. D., & Madsen, Jr., C. H., (Eds.) (1975). *Research in music behavior*. New York: Teachers College Press.

Matthay, T. (1970). *Musical interpretation*. Greenwood Press: Westport, Connecticut.

McCullagh, P. & Caird, J.K. (1990). Correct and learning models and the use of model knowledge of results in the acquisition and retention of a motor skill. *Journal of Human Movement Studies, 18*, 107- 116.

McCullagh, P. and Weiss, M.R. (2001). Modeling: Considerations for motor skill performance and psychological responses. In R.N. Singer, H.A. Hausenblas, and C.M. Janelle (eds.) *Handbook of sport psychology* (pp.205-238). New York: John Wiley and Sons.

Mishra, J. (1999). *The effects of altering environment context on the performance of memorized music*. Unpublished doctorate dissertation. Kent State University, Kent, Ohio.

Mishra, J. (2005). A theoretical model of musical memorization. *Journal of Psychomusicology*, *19,* 1 (75- 89).

Mishra, J. (2007). Correlating musical memorization styles and perceptual learning modalities. *Visions of Research in Music Education*, 9-10.

Morrison, S., Montemayor, M., & Wiltshire, E. (2004). The effect of a recorded model on band students' performance self-evaluations, achievement, and attitude. *Journal of Research in Music Education, 52*(2), pp. 116-129.

Mortin, G. (2013). Memorization. Last retrieved November, 20 from http://www.ottawakiwanismusicfestival.com/about.htm

Murray, S. (2012). Video modeling for young children with autism spectrum disorders: A practical guide for parents and professionals. Jessica Kingsley Pub.

Nahed, S., Zahra, N. & Elham, A. (2013). Effects of video modeling on skill acquisition in learning the handball shoot. *European Journal of Experimental Biology*, *3*(2), 214-218.

Nellons, C. E. (1974). An experimental investigation of the effect of blocking on the memorization of selected piano literature. *Dissertation Abstracts International*.

Newman, W.S. (1984). The pianist’s problems: A modern approach to efficient practice and musical performance. New York: Harper & Brothers.

Peter, H. (2008). *Designing and reporting experiments in psychology* (3rd Edition). USA: Open University Press.

Pollock, B.J. & Lee, T.D. (1992). Effects of the model’s skill level on observational motor learning. *Research Quarterly for Exercise and Sport, 63*, 25-29.

Powell, M. C. (1988). *Focus on Suzuki piano*. Secaucus, N.J.: Suzuki Method International: Summy-Birchard.

Puopolo (1970). The development and experimental application of self- instructional practice materials for beginning instrumentalists. PhD. diss., Michigan State University.

Reynolds (2013). The use of video modeling plus video feedback to improve boxing skills. Masters of Arts, University of South Florida.

Rizzolatti G. (2005). The mirror neuron system and its function in humans. *Anat Embryol, 210 (5-6):419-21).*

Rosenthal, R. K. (1984). The relative effects of guided model, model only, guide only, and practice only treatments on the accuracy of advanced instrumentalists' musical performance. *Journal of Research in Music Education*, *32*(4), 265-273.

Rosenthal, R. K., Wilson, M., Evans, M., & Greenwalt, L. (1988). Effects of different practice conditions on advanced instrumentalists' performance accuracy. *Journal of Research in Music Education, 36*(4), 250-25.

Ross, D., Bird, A. M., Doody, S.G. & Zoeller, M. (1985) Effects of model and videotape feedback with knowledge of results on motor performance. *Human Movement Science 4*, 149-157.

Rothstein, A.L. & Arnold, R.K. (1976). Bridging the gap: Application of research on videotape feedback and bowling. *Motor Skills: Theory into Practice 1,* 35-62.

Salmoni et al. (1984). Knowledge of results and motor learning: A review and critical appraisal. *Psychological bulletin, 95*, 355-386.

Sang, R. C. (1987). A study of the relationship between instrumental music teachers' modeling skills and pupil performance behavior. *Bulletin of the Council for Research in Music Education, 91*, 155-159.

Shea, C., Wright, D., Wulf, G., & Whitacre, C. (2000). Physical and observational practice afford unique learning opportunities. *Journal of Motor Behavior, 32*, 27-36.

Shea, C., Wulf, G., Park, J., & Gaunt, B. (2001). Effects of an auditory model on the learning of relative and absolute timing. *Journal of Motor Behavior, 33*, 127-138.

Schlosser, M. (2011). Minding the music: Neuroscience, video recording, and the pianist. *International Journal of Music Education 29(4),* 347–358.

Schmidt, R.A. & Lee, T.D. (2005). *Motor control and learning: A behavioural emphasis* (4th ed.). Champaign, IL: Human Kinetics Publishers.

Shockley, R. P. (1980). An experimental approach to the memorization of piano music with implications for music reading. *Dissertation Abstracts International*. (UMI no.8103151)

Shockley, R. (2001). *Mapping music: For faster learning and secure memory* (2nd ed.). Middleton, WI: A-R Editions.

Siebnaler, D. (1997). Analysis of teacher-student interactions in the piano lessons of adults and children. *Journal of Research in Music Education*, *45*, 6-20.

Speer, D. (1994). An analysis of sequential patterns of instruction in piano lessons. *Journal of Research in Music Education, 42*, 14-26.

Stefan, K. Et al. (2005). Formation of a motor memory by action observation. *The Journal of Neuroscience*, *25* (41): 9339 –9346.

Sullivan, K., Kantak, S., Burtner, P. (2008). Motor learning in children: Feedback effects on skill acquisition. *Physical Therapy, 88* (6), 720-732.

Taylor, G. & MacKenney, L. (2008). *Improving human learning in the classroom: Theories and teaching practices.* USA: R&L Education.

Uszler, M. (1999). The well-tempered keyboard teacher (2nd ed.). USA: Cengage Learning.

Webster, M. & Sell, J. (2007). *Laboratory experiments in the social sciences*. USA: Academic Press.

Weeks, D.L. & Anderson, L.P. (2000). The interaction of observational learning with overt practice: Effects on motor skill learning. *Acta Psychologica, 104*, 259-271.

Weaver, M. A. (1981). A survey of modes of student response indicative of musical learning in elementary instrumental music. Master's thesis, The University of Michigan.

Wheatley, S.E. (1991). An application of chunking to the memory and performance of melodic patterns. *Dissertation Abstracts International*. (UMI no.9208693)

Whiteside, A. (1997). Memorizing. In J. Prostakoff & S. Rosoff. (Eds.). *Abby Whiteside on piano playing* (pp.61-62). Portland, OR: Amadeus Press.

Williamon, A. (1999). The value of performing from memory. *Psychology of Music, 27*, 84-95.

Wilding, J. & Valentine, E. (1997). *Superior memory*. Hove, UK: Psychology Press.

Wilson, M. (2012). Interactive modeling: A powerful technique for teaching children. USA: Northeast Foundation for Children.

Woody, R. (2006). The Effect of various instructional conditions on expressive music performance. *Journal of Research in Music Education, 54:21.*

Zetou, E., Tzetzis, G., Vernadakis, N., & Kioumourtzoglou, E. (2002). Modeling in learning two volleyball skills. *Perceptual and Motor Skills*. *94* (1), 131–1142.

Zurcher, W. (1972). *The effect of model-supportive practice on beginning brass instrumentalists*. Ed.D. dissertation, Teachers College, Columbia University.

Appendices

Appendix A. Level 2 requirements

Source: Royal Conservatory of Music Syllabus 2015 edition Level two requirements p.26

Level 2 Requirements	Marks
Repertoire	**56**
one selection from List A	16
one selection from List B	18
one selection from List C	16
Memory (2 marks per repertoire selection)	6
Technical Requirements	**24**
Technical Tests	12
Etudes: *one* etude from the *Syllabus* list	12
Musicianship	
Ear Tests	**10**
– Clapback	2
– Intervals	2
– Chords	2
– Playback	4
Sight Reading	**10**
– Rhythm	3
– Playing	7
Total possible marks (pass = 60)	**100**

Appendix B. Music composition

Music composition written by Composer Christine Donkin

Appendix C. Invitation

Invitation to Participate in a Research Project

This study is undertaken as part of the doctorate research project of Nisreen Jardaneh, under the supervision of professor Louise Mathieu at the Faculty of Music of Université Laval.

Objective of the Study

This study will examine the effect of practicing with different modeling conditions on the memorization of young piano students doing grade 3 piano of Royal Conservatory of Music, Canada (RCM). These modeling conditions are: aural modeling, video modeling alone, and video modeling with cues. The performance of participants will be analyzed by experienced piano teachers, and the following parameters will be evaluated: number of correct notes, rhythm, articulation, dynamics, and tempo.

Role of Participants

The experiment will take place on two days.

The first day, participants in this study will practice in two separate sessions. Each session will be around 20 minutes long with a 10 minute break in between. The total amount of time needed for this first day experiment will be an hour. During the practice session, the following will happen:

- Researcher will introduce the piece to be practiced through explanation and playing;
- Participant will be assigned to one of these conditions: Participant practices the piece either through listening to CD or watching and listening to a video of a student performing the piece; or without any modeling condition.
- After practicing, the participant will take 10 minutes break
- After the break, the participant will practice again for 20 minutes
- After the two practice sessions, the participant will be asked to perform the piece from memory

- The two practice sessions, as well as the performance will be video recorded.

The second day, the participant will be asked to perform the piece from memory. The performance will be video recorded.

Voluntary Participation and Confidentiality

Each participant is free to participate only if he/she wants to. Each participant has the right to withdraw from the study at anytime without any negative consequences. All personal information about participants is confidential.

Interested?

If you are interested to participate, please send an e-mail directly to nisreen.jardaneh.1@ulaval.ca by March 10th, 2016.

Your cooperation is valuable to conduct this study and I thank you for your consideration.

Nisreen Jardaneh

Doctorate student, Faculty of music, Université Laval, Québec, Canada.

nisreen.jardaneh.1@ulaval.ca

Appendix D. Advertisement

Looking for Piano Students for a Research Project

This study is undertaken as part of the doctorate research project of Nisreen Jardaneh, under the supervision of professor Louise Mathieu at the Faculty of Music of Université Laval.

Objective of the Study

This study will examine the effect of practicing with different modeling conditions on the memorization of young piano students doing grade 3 piano of Royal Conservatory of Music, Canada (RCM). These modeling conditions are: aural modeling, video modeling alone, and video modeling with cues. The performance of participants will be analyzed by experienced piano teachers, and the following parameters will be evaluated: number of correct notes, rhythm, articulation, dynamics, and tempo.

I'm writing to ask if you have grade 3 piano students who would be interested to participate in this project.

Role of Participants

The experiment will take place on two days.

The first day, participants in this study will practice in two separate sessions. Each session will be around 20 minutes long with a 10 minute break in between. The total amount of time needed for this first day experiment will be an hour. During the practice session, the following will happen:

- Researcher will introduce the piece to be practiced through explanation and playing;
- Participant will be assigned to one of these conditions: Participant practices the piece either through listening to CD or watching and listening to a video of a student performing the piece; or without any modeling condition.
- After practicing, the participant will take 10 minutes break
- After the break, the participant will practice again for 20 minutes

- After the two practice sessions, the participant will be asked to perform the piece from memory
- The two practice sessions, as well as the performance will be video recorded.

The second day, the participant will be asked to perform the piece from memory. The performance will be video recorded.

Voluntary Participation and Confidentiality

Each participant is free to participate only if he/she wants to. Each participant has the right to withdraw from the study at anytime without any negative consequences. All personal information about participants is confidential.

Interested?

If you have piano students doing grade 3 piano RCM and you think they will be interested to participate, please provide them with the flyer for piano students, the parent consent form, the student consent form, and request that they contact me directly by e-mail to this address: nisreen.jardaneh.1@ulaval.ca by March 20th, 2016.

Your cooperation is valuable to conduct this study and I thank you for your consideration.

Nisreen Jardaneh

Doctorate student, Faculty of music, Université Laval, Québec, Canada.

nisreen.jardaneh.1@ulaval.ca

Appendix E. Parent Consent Form

Presentation of Researcher

This study is undertaken as part of doctorate research project of Nisreen Jardaneh, under the supervision of professor Louise Mathieu at the Faculty of Music at Université Laval.

Before accepting to participate in this research project, please take the time to read and understand the following information. This document explains the nature of the study, role of your child, and advantages, ricks or inconveniences possible. Please feel free to ask any question after reading this document.

Nature of the Study

This study will examine the effect of practicing with different modeling conditions on the memorization of young piano students doing grade 3 piano of Royal Conservatory of Music, Canada (RCM). These modeling conditions are: aural modeling, video modeling alone, and video modeling with cues. Your child's performance will be analyzed by experienced piano teachers, and the following parameters will be evaluated: number of correct notes, rhythm, articulation, dynamics, and tempo**.**

Role of Participants

The experiment will take place on two days.

The first day, your child in this study will practice in two separate sessions. Each session will be around 20 minutes long with a 10 minute break in between. The total amount of time needed for this first day experiment will be an hour. During the practice session, the following will happen:

- Researcher will introduce the piece to be practiced through explanation and playing;
- Your child will be assigned to one of these conditions: practices the piece either through listening to CD or watching and listening to a video of a student performing the piece; or without any modeling condition.

- After practicing, your child will take 10 minutes break
- After the break, your child will practice again for 20 minutes
- After the two practice sessions, your child will be asked to perform the piece from memory
- The two practice sessions, as well as the performance will be video recorded.

The second day, your child will be asked to perform the piece from memory. The performance will be video recorded.

Advantages, Risks or Inconvenience Possible from Participating in the Study

Upon participating in this study, your child will help in examining which modeling condition results in better memorization of piano music.

There is no direct benefit associated with participation. A gift will be given to your child in recognition of his/her participation.

Your child's piano teacher has authorised this research, and the fact that you participate or not in it or withdraw from it will not affect the quality of the piano courses provided to your child.

Voluntary Participation and the Right to Withdraw from the Study

Your child is free to participate only if he/she wants to. Your child has the right to withdraw from the study at anytime without any negative consequences or justification given. If your child decides to withdraw from the study, all personal information will be discarded.

Confidentiality and Management of Data

The following steps will be used in order to insure confidentiality of personal information:

- The name of participants will not appear in the final reports;
- Only hands will be videotaped when recording the memorized performances ;
- The various documents of the research will be coded and only the researcher will have access to the list of names and codes;
- The individual results of participants will never be disclosed;

- Research materials, including data and records will be retained (eg my home, files will be locked in a cabinet and electronic files will be locked with a secret password). Data will be destroyed after two years of the end of the research. Research will be the subject of publications in scientific journals, and no participant will be identified;
- A short summary of the research results will be sent to participants upon request indicating the address where they would like to receive the document, just after the space for signature ;
- Confidentiality will be respected as prescribed by the laws of Quebec and Canada.

Acknowledgements

Your cooperation is valuable for us to conduct this study and we thank you for participating.

Signatures

I, ______________________consent freely to let my child/ren _________________________

participate in the research entitled: “Examining the Effect of Practicing with Different Modeling Conditions on the Memorization of Piano Music”. I have read the form and I understand the purpose, nature, benefits, risks and inconveniences of the research project. I am satisfied with explanations, clarifications and answers the researcher provided me, if any, for my participation in this project.

I, ________________ give the permission to you to include my child videotape in this study.

____ _________________________

Signature of the Parent Date

A brief summary of the research results will be sent to participants upon request indicating the address where they would like to receive the document. The results will not be available before January 2017. If this address changed by this date, you are prompted to inform the researcher of the new address where you wish to receive this document.

The address (email or postal) to which I wish to receive a short summary of research results is as follows:

I have explained the purpose, nature, benefits, risks and inconveniences of the research participant. I answered to the best of my knowledge to questions and I checked the understanding of the participant.

____

Signature of Researcher Date

Additional Information

If you have questions about the research, the implications of your participation or if you wish to opt out of the research, please contact Nisreen Jardaneh at the following email address: nisreen.jardaneh.1@ulaval.ca or supervisor Louise Mathieu at the following telephone number: (418) 656-2131 poste 7446 or at the following email address: Louise.Mathieu@mus.ulaval.ca

Complaints or critical

Any complaints or reviews of the research project may be sent to the Ombudsman's Office of Université Laval:

Office of the Ombudsman

Pavillon Alphonse-Desjardins, office 3320

2325, rue de l'Université

Université Laval

Québec (Québec) G1V 0A6

Information- Secretary: (418) 656-3081

Toll Free: 1-866-323-2271

e-mail: info@ombudsman.ulaval.ca

Appendix F. Consent Form For Piano Students

This research project is undertaken by Nisreen Jardaneh , doctorate student at the faculty of music at Université Laval, Québec, Québec. This project has been approved by Ethics committee of Université Laval (no d'approbation 2015-143/ 16-07-2015).

What is the objective of this project?

This study will examine the effect of practicing with different modeling conditions on the memorization of young piano students. These modeling conditions are: aural modeling, video modeling alone, and video modeling with cues. The participants' performances will be analyzed by experienced piano teachers, and the following parameters will be evaluated: number of correct notes, rhythm, articulations, dynamics, and tempo.

Who is invited to participate?

Young piano students at the grade 3 level of Royal Conservatory of Music (RCM)

What will you do at the experiment?

You will be asked to practice a piece of music by using one of the following: listen to a CD of the piece, or watch and listen to video of a peer playing the piece, or watch and listen to a peer playing with the piece with visual aids (signs and symbols), or practice without any CD or video. You will practice in two separate session, each will be 20 minutes long. After second session, you will be asked to play the piece from memory. You will play the piece again after 10 minutes break. The following day, you will be asked to perform the piece again from memory.

Will I be identified in the project?

The practice sessions and performances will be video recorded. Only hands will be videotaped when recording the memorized performances . These videos will not be disseminated, they will be used for research purposes only. Your name and your contact details will be kept "top secret", and only the researcher will have access to this information.

What will I gain from participating?

There is no direct benefit associated with participating in this study. A gift will be provided in appreciation of participating in this study.

Am I obliged to participate?

You are completely free to participate or not. At any time, you can stop participating, for whatever reason. All you have to do is to inform the researcher. In this case, I will destroy all the information, video and data that are related to you.

Your piano teacher has authorised this research, and the fact that you participate or not in it or withdraw from it will not affect the quality of the piano courses provided to you.

Will I be able to know the results of the study ?

When the research is completed, you will receive a copy of the results of the study, which will offer you some tips and recommendation about memorizing piano music.

Questions?

If you have any questions about this research, contact the researcher Nisreen Jardaneh, at the following e-mail address: nisreen.jardaneh.1@ulaval.ca

Yes, I want to participate in this project:

____

Signature of participant

I accept that my practice and performance be video recorded:

____

Signature of participant

I have explained the purpose, nature, benefits, risks and inconveniences of the research participant. I answered to the best of my knowledge to questions and I checked the understanding of the participant.

_____________________________________ Date: ______________

Signature of Researcher

For any complaint or criticism about the project, contact the Ombudsman of Université Laval at the following address, ombudsman@ombuds.ulaval.ca , or at the following phone number, (418) 656-3081

Appendix G. Video Release Form for the Student Model

This study is undertaken as part of doctorate research project of Nisreen Jardaneh, under the supervision of professor Louise Mathieu at the Faculty of Music at Université Laval.

This study will examine the effect of practicing with different modeling conditions on the memorization of young piano students doing grade 3 piano of Royal Conservatory of Music, Canada (RCM).

Participants in this study will practice a piece either through listening to CD or watching and listening to a video of a student performing the piece; or without any modeling condition.

Role of Student Model

In order to meet the condition of practicing through watching and listening to a video of a student performing the piece, there is a need to produce a videotape of a piece played by a student who will serve as a model that participants can watch and listen to during their practice sessions. Therefore this participant (model) will be videotaped performing the piece.

The model will be asked to practice and learn the piece under study very well in order to be able to perform it well and be able to video record it.

The video recording session should be around 20 minutes long. The video recording will take place at OPUS Academy. The video will show the model playing the piece with correct notes, rhythm, articulation, dynamics, and tempo. This video will be used by the video modeling alone and video modeling with cues groups. Participants of these groups will watch the video as part of the practicing condition.

Advantages, or Inconvenience Possible from Participating in the Study

There is no direct benefit associated with participating in this study. A gift will be given to the student model in recognition of the participation. Your piano teacher has authorised this research, and the fact that you participate or not in it or withdraw from it will not affect the quality of the piano courses provided to you.

Voluntary Participation and the Right to Withdraw from the Study

The student model is free to participate only if he/she wants to. The student model has the right to withdraw at anytime without any negative consequences or justification given. If the student model decides to withdraw from the study, all personal information will be discarded.

Confidentiality and Management of Data

The following steps will be used in order to insure confidentiality of personal information:

- The name of participant will not appear in the video or final reports;
- Only the hands will be recorded while performing the piece;
- The video will only be used for the purpose of this project and will not be made available to public in any way;
- The various documents of the research will be coded and only the researcher will have access to the list of names and codes;
- The individual results of participants will never be disclosed;
- Research materials, including data and records will be retained (eg my home, files will be locked in a cabinet and electronic files will be locked with a secret password). Data will be destroyed after two years of the end of the research. Research will be the subject of publications in scientific journals, and no participant will be identified;
- A short summary of the research results will be sent to participants upon request indicating the address where they would like to receive the document, just after the space for signature ;
- Confidentiality will be respected as prescribed by the laws of Quebec and Canada.

Acknowledgements

Your cooperation is valuable for us to conduct this study and we thank you for participating.

Signatures

I, _______________________________agree to be the student model in the research entitled: “Examining the Effect of Practicing with Different Modeling Conditions on the Memorization of Piano Music”. I have read the form and I understand the purpose, nature, benefits of the research project. I am satisfied with explanations, clarifications and answers the researcher provided me, if any, for my participation in this project.

I,_______________ give permission to you to videotape my performance of the piece in this study.

_________________________ _________________________

Signature of the student model Date

I have explained the purpose, nature, benefits, the research participant. I answered to the best of my knowledge to questions and I checked the understanding of the participant.

____

Signature of Researcher Date

Additional Information

If you have questions about the research, the implications of your participation or if you wish to opt out of the research, please contact Nisreen Jardaneh at the following email address: nisreen.jardaneh.1@ulaval.ca or supervisor Louise Mathieu at the following telephone number: (418) 656-2131 poste 7446 or at the following email address: Louise.Mathieu@mus.ulaval.ca

Complaints or critical

Any complaints or reviews of the research project may be sent to the Ombudsman's Office of Université Laval:

Office of the Ombudsman

Pavillon Alphonse-Desjardins, office 3320

2325, rue de l’Université

Université Laval

Québec (Québec) G1V 0A6

Information- Secretary: (418) 656-3081

Toll Free: 1-866-323-2271

e-mail: info@ombudsman.ulaval.ca

Appendix H. Video Release Form

Dear Parent/Guardian:

This study is undertaken as part of doctorate research project of Nisreen Jardaneh, under the supervision of professor Louise Mathieu at the Faculty of Music at Université Laval.

This study will examine the effect of practicing with different modeling conditions on the memorization of young piano students doing grade 3 piano of Royal Conservatory of Music, Canada (RCM).

Participants in this study will practice a piece either through listening to CD or watching and listening to a video of a student performing the piece; or without any modeling condition.

This form is for the video release of the student model whose video will be watched by participants in the video modeling and video modeling with cues groups.

Role of Student Model

In order to meet the condition of practicing through watching and listening to a video of a student performing the piece, there is a need to produce a videotape of a piece played by a student who will serve as a model that participants can watch and listen to during their practice sessions. Therefore this participant (model) will be videotaped performing the piece. The video recording session should be around 20 minutes long. The video recording will take place at OPUS Academy. The video will show the model playing the piece with correct notes, rhythm, articulation, dynamics, and tempo. This video will be used by the video modeling alone and video modeling with cues groups. Participants of these groups will watch the video as part of the practicing condition.

Advantages, or Inconvenience Possible from Participating in the Study

There is no direct benefit associated with participating in this study. A gift will be given to the participant in recognition of the participation. Your child's piano teacher has authorised this research, and the fact that you participate or not in it or withdraw from it will not affect the quality of the piano courses provided to your child.

Voluntary Participation and the Right to Withdraw from the Study

The participant is free to participate only if he/she wants to. The participant has the right to withdraw at anytime without any negative consequences or justification given. If participant decides to withdraw from the study, all personal information will be discarded.

Confidentiality and Management of Data

The following steps will be used in order to insure confidentiality of personal information:

- The name of participant will not appear in the video or final reports;
- Only the hands will be recorded while performing the piece;
- The video will only be used for the purpose of this project and will not be made available to public in any way;
- The various documents of the research will be coded and only the researcher will have access to the list of names and codes;
- The individual results of participants will never be disclosed;
- Research materials, including data and records will be retained (eg my home, files will be locked in a cabinet and electronic files will be locked with a secret password). Data will be destroyed after two years of the end of the research. Research will be the subject of publications in scientific journals, and no participant will be identified;
- A short summary of the research results will be sent to participants upon request indicating the address where they would like to receive the document, just after the space for signature ;
- Confidentiality will be respected as prescribed by the laws of Quebec and Canada.

Acknowledgements

Your cooperation is valuable for us to conduct this study and we thank you for participating.

Signatures

I, _______________________________consent to let my child _________________________ participate in the research entitled: “Examining the Effect of Practicing with Different Modeling Conditions on the Memorization of Piano Music”. I have read the form and I understand the purpose, nature, benefits, of the research project. I am satisfied with explanations, clarifications and answers the researcher provided me, if any, for my participation in this project.

I,_________________ give permission to you to include my child’s videotape in this study.

______________ _________________________

Signature of the Parent Date

I have explained the purpose, nature, benefits, risks and inconveniences of the research participant. I answered to the best of my knowledge to questions and I checked the understanding of the participant.

____ ________________________

Signature of Researcher Date

Additional Information

If you have questions about the research, the implications of your participation or if you wish to opt out of the research, please contact Nisreen Jardaneh at the following email address: nisreen.jardaneh.1@ulaval.ca or supervisor Louise Mathieu at the following telephone number: (418) 656-2131 poste 7446 or at the following email address: Louise.Mathieu@mus.ulaval.ca

Complaints or critical

Any complaints or reviews of the research project may be sent to the Ombudsman's Office of Université Laval:

Office of the Ombudsman

Pavillon Alphonse-Desjardins, office 3320

2325, rue de l’Université

Université Laval

Québec (Québec) G1V 0A6

Information- Secretary: (418) 656-3081

Toll Free: 1-866-323-2271

e-mail: info@ombudsman.ulaval.ca

Appendix I. Letters from Schools

15 May 2015

Attention : Ethics Committee of Université Laval

Subject: Approval of use of the list of piano teachers (dossier Nisreen Jardaneh)

To whom it may concern,

I want hereby confirm that Academie OPUS Academy Inc. will make available to Nisreen Jardaneh its list of piano teachers for the purpose of recruitment as part of her doctoral research « Examine the effect of practicing with different modeling conditions on the memorization of young piano students». More specifically, Academie OPUS Academy Inc. will advertise the project by e-mail to teachers it deems likely to participate in this research and gather responses from them.

Hoping everything conforms to your request, please accept Sir, Madam, the assurances of my highest consideration.

3 March 2016

Attention : Ethics Committee of Université Laval

Subject: Approval of use of the list of piano teachers and confirmation for Nisreen Jardaneh to conduct research at The Music School Hub

To whom it may concern,

I want hereby confirm that the Music Hub School will make available to Nisreen Jardaneh its list of piano teachers for the purpose of recruitment as part of her doctoral research « Examine the effect of practicing with different modeling conditions on the memorization of young piano students». More specifically, the Music Hub School will advertise the project by e-mail to teachers it deems likely to participate in this research and gather responses from them. I also confirm that Nisreen Jardaneh has been welcomed to conduct research and experiments at The Music Hub School.

Hoping everything conforms to your request, please accept Sir, Madam, the assurances of my highest consideration

Appendix J. Introduction to the piano piece: Script

Hello! Today I'm going to introduce the piece that you will practice:

- First, listen to the piece (the researcher plays the whole piece)
- Let's look at the key signature: there are three flats B, E, A. (Camera zooms at the score, and then zooms at the piano while the researcher plays the 3 notes on the piano). We are in c minor (camera shows the researcher playing slowly the c minor scale).
- Notice hand position: the piece starts on a five-finger position for both the RH and the LH (camera zoom at both hands, researcher plays C- D- E^b- F- G with left hand; after, play C- D- E^b- F- G with right hand.
- The researcher plays the first two bars of the piece
- Then, at the beginning of the second section, hand position shifts from c to f (the researcher demonstrate the shift without playing on the piano.
- Another point to pay attention to is the fingering that is written on the score (Camera zooms at the score and the researcher points out the fingering of bar 1, bar 5, bar 9 (right and left hands) and bar 15**.**
- Here, for example, (the researcher points at the score) the thumb, finger no. 1, is on G, so you can easily reach the following G with finger no. 5 (the researcher plays it).
- Another example is here (the camera zooms at the score, and the researcher points out the number 5 at the beginning of bars 9-10-11-12). We play like this (the researcher plays only the left hand of bar 9-10-11-)
- Pay attention to the third and forth lines as the left hand is playing staccato (the researcher plays the left hand alone, bars 9-10) and the right hand plays legato (the researcher plays the right hand alone bars 9-10-11-12).
- After this introduction, you will use this practice tool, which will guide you throughout your practice. Please listen to and follow instructions carefully. You will finish your practice session once you hear "end of the practice session". Thank you for your attention, and enjoy your practice!

Appendix K. Procedure

1- Greetings: Hello, how are you? Thank you very much for your participation in this project.
2- I want to say few points before we start: this is not a test or evaluation of your performance, I'm just interested in the method of practicing, also all information will be used for research purposes only.
3- The practice session and performances will be video recorded.
4- You will practice this piece in two sessions, each session is around 20 minutes with a 5 minute break in between. After you finish the two sessions, you will play the piece from memory. Then we take 10 minutes break, after what we take a second recording of you playing the piece from memory.
5- So this is what will happen. You will watch a video that will guide you through the practice session. First, the piece that you have to practice will be introduced to you, then, instructions will be given to you to tell you when to start practising and when to stop, you just have to follow the instructions.
6- Tomorrow, you will play the piece from memory for the third time, and it will be recorded. Please, don't practice your piece after this session, and before tomorrow's recording.
7- Let me know if you have any question.
8- At the end of the session, the participant gets 15 Canadian dollars in a thank you envelope.

NOTES:

1- Fill consent forms during the 5 minutes break.
2- Put the score of the piece to be used during the practice session in front of the participant, remove it when the participant plays from memory.
3- Make sure video camera is on an angle that shows clearly the hands ONLY of the participant.

Appendix L. Coding Protocol for Data Entry

No.	Label	Information	Code
1	ID	Identity of participant	
2	Gender	Gender of the participant	0=F, 1=M
3	Age	Age of participant	Enter number
4	Grade	Latest level of participant	Enter level number
5	ConditionNR	Independent variable	0= video modeling with cues, 1= audio modeling, 2= free practice
6	Rec1NoteError	Number of note errors for the first recording	Enter number
7	Rec1RhythmError	Number of rhythm errors for the first recording	Enter number
8	Rec1Time	Length of hesitation for the first recording	Enter number of seconds
9	Rec2NoteError	Number of note errors for the second recording	Enter number
10	Rec2RhythmError	Number of rhythm errors for the second recording	Enter number
11	Rec2Time	Length of hesitation for the second recording	Enter number of seconds
12	Rec3NoteError	Number of note errors for the third recording	Enter number
13	Rec3RhythmError	Number of rhythm errors for the third recording	Enter number
14	Rec3Time	Length of hesitation for the third recording	Enter number of seconds