Away from the Piano: Literature Review of the Role of Mental Practice

Abstract

This narrative-based literature review explores the use of mental practice in music performance, specifically piano playing. The search sample was rather broadly defined due to the relatively small amount of literature available on the topic. Material for the review was identified in keyword searches for “mental practice”, “mental imagery", "silent rehearsal", "aural modeling", "auditory imagery", and "music performance". Literature from the twenty- first century was given priority although older studies were also reviewed for background and historical context. The existing research indicates that mental practice is a valuable strategy in music practice and performance preparation. Although additional research is needed, especially in relation to novices learning to play the piano, the authors conclude that the current literature supports the use of mental practice as a beneficial practice strategy in playing piano.

Keywords: mental practice, mental imagery, aural modeling, auditory imagery, music performance

Away from the Piano: Literature Review of the Role of Mental Practice

Music performance in general, and piano playing in particular, require an extended period of technical and artistic skill development. Both cognitive and motoric demands are involved in music performance. The focus of this literature review is the use of mental practice in acquiring music performance skills. In reviewing the current literature we hope to show the relevance of mental practice in piano teaching and to identify some areas for further research.

The first section will define mental practice with a discussion of its use in music learning and performing. We will include a brief look at the use of auditory modeling in music learning and specifically in piano playing. The second section will present the empirical literature on mental practice in music performance. Finally we will provide a summary of the results of this review, suggestions for the implementation of mental practice in the private piano teaching studio, and implications for future research.

Mental Practice

Mental practice can be defined as:

> A form of practice in which subjects produce a vivid mental image of actually performing a technique; that is, they do not imagine that they are watching themselves perform, but they actually carry out the activity in their imagination without overt physical movement. Some research evidence suggests that, for a skilled person, mental practice can be as effective as actual practice (Kent, 2007, p. 430).

Mental practice is a method to promote learning in which "the performance of a task is mentally rehearsed, often using imagery techniques, in the absence of overt physical practice"(Schmidt & Lee, 2011, para. 1). The imagery techniques used most often in mental practice for music performance are auditory or musical imagery, visual imagery, and kinesthetic imagery. Auditory

imagery or, specifically, musical imagery has been defined by Godøy and Jørgensen (2001) as "our mental capacity for imagining musical sound in the absence of a directly audible sound source" although the authors do describe the difficulty of defining the term due to its complexity (p. ix). They highlight the distinction between perception and imagery, and the problem of accounting for the experiencing of musical imagery as main difficulties in creating a definition. Musical or auditory imagery may be developed with the use of auditory modeling; for example, listening to a recording of a piece of music in order to create an auditory image which in turn will help to improve performance of the piece. Visual imagery is the ability to "*see* an object or scene in your mind" (Frenkel et al., 2014, p. 225); for example visualizing the position of the hand. Finally, kinesthetic imagery is the ability to "*feel*, and thus to experience the somato-sensory feelings related to the movement, i.e. to perceive muscles contractions mentally" (Frenkel et al., 2014, p. 225-226). According to Kosslyn and Moulton (2012) mental practice can be divided into four phases: 1) storing images, 2) initial mental rehearsal, 3) image correction, and 4) advanced mental rehearsal (pp. 43-44). Initially, in learning a new skill, one needs to store in memory a clear representation of the end result obtained by carefully observing a master demonstration. The goal is to store accurately observed information which will allow one to generate a series of images later. The second phase involves the integration of what has been stored piecemeal into a single, flowing mental action; for example, integrating down/up wrist movement into the mental practice of a two note slur on the piano. If one has a good image of the model, it is possible to notice when one is not doing the mental practice correctly and to adjust the mental actions. The third phase of mental practice involves the use of physical practice as feedback. After one produces images from an internal perspective (seeing the situation as one would when actually performing the action versus external perspective, or seeing oneself as if

from another person's point of view), one can compare what happens when actually performing the action with what was expected to happen based on imagery. The final phase of mental practice has the goal of automaticity, of storing a set of new motor movements as memories and also associating each movement with cues that will immediately activate it as required.

Mental practice is an accepted method of enhancing music performance (Eldred-Evans, et al., 2013). In his study of children learning to play musical instruments, McPherson (2005) found that the children who applied mental strategies early in their learning were more likely to succeed as compared to their peers. Williamon (2004) found that mental practice could be used for the following: to improve learning and memory, to make practice more efficient, to overcome technical difficulties and develop skills, to heighten sensory awareness, to gain more interest in the music, to refocus attention during performance, to enhance general confidence and resilience on stage, to achieve greater control over negative emotions, to establish a greater connection and presence with an audience, to achieve peak experience (p. 225). In his book on playing the piano, written almost fifty years ago, Kochevitsky (1967) writes about the benefits of mental practice:

> The silent mental reading of a musical composition (or some section of it if needed) often helps better than actual playing to unite separate tones into meaningful musical lines. After perceiving the composition in all its logical connections and successions, one is able to follow inwardly the course of its sound in faster tempo, and thus play it as fast as needed (p. 50).

Although some research has demonstrated the benefits of mental practice, it is only relatively recently that it has been possible for researchers to look at the way in which mental practice might work. In their fMRI study on music imagery in pianists, Meister and colleagues (2004) found that the different parts of the cerebral network that are active during both execution and imagery of music performance in pianists also work together: "The notion that the same areas are involved in visuomotor transformation/motor planning and music processing emphasizes the

multimodal properties of cortical areas involved in music and motor imagery in musicians" (p. 227).

Auditory Modeling

One of the most important mental imagery skills in music performance is auditory imagery. Auditory modeling is a tool that can be used in mental practice to help form these auditory images. After providing a definition of auditory modeling, its use will be explored both in general music performance and in piano playing.

An auditory model is a performance or recording used to facilitate learning. Auditory modeling is useful in the development of an auditory image of a new piece of music to be learned for example. While there is as yet no general theory of auditory imagery, a possible explanation involves the phonological or articulatory loop (Hubbard, 2010). As proposed by Baddeley and Hitch (1974) the phonological loop is the part of working memory that deals with spoken and written material. The loop is assumed to have two components: a short-term store that holds acoustic or speech based material, and subvocalization, an articulatory control process similar to inner speech (Baddeley, 1992, p. 558). This loop can maintain phonological material within the store through subvocal repetition. The phonological loop is dependent on the cooperation between the short-term store or "inner ear" and the subvocalization or "inner voice" (Smith, Wilson, & Reisberg, 1995, p. 1434). While auditory material can be stored without the use of subvocalization this is not the case for visually presented phonological material which requires the use of subvocalization for recall (Alan Baddeley: Introduction of the Phonological Loop, 2010). It is yet unclear whether this theory is specific to language or can be applied equally to music. In addition, while there is relatively good understanding of the neural encoding and perception of simple, isolated sounds, there are few coherent models of how complex sounds

are perceived (Lotto & Holt, 2010). Early in the history of mental practice research the experience of auditory imagery is described by Washburn (1916) in her book *Movement and Mental Imagery: Outlines of a Motor Theory of the Complexer Mental Processes*:

> For we can get, as conscious experiences, sensations not only from outside stimuli, but by the processes which are commonly known as 'memory' and 'imagination.'.....I can not only hear the tones of a violin playing the 'Prize Song' from the *Meistersinger* when the violinist is actually before me (or the phonograph is actually running), but I can sit here in my study, with no actual sound stimuli acting on my ears save the voices of the children across the street, and hear the tones of the violin through the entire air (p. 27).

Haddon (2007) describes the use of music imagery as an experience that "may be manifest in multiple ways including deliberate use (to rehearse musical ideas, to experience a musical work in one's mind, to analyze and imagine a new score, or to compose), and non-deliberate use, such as hearing music in the mind as an involuntary experience" (p. 301).

Auditory models may be especially useful in the early stages of learning a new piece of music to give the student a sense of the whole. If a melody is played slower and slower, as when reading a new piece, at some point it loses its sense of coherence and motion, and becomes a series of isolated tones (London, 2007). If the student can hear the piece of music as a whole before beginning to read the notes and pitches, they may have a better musical sense of the piece. Singing is a useful way of creating auditory images, however not all students are comfortable with singing. Auditory modeling may be particularly useful for students who are reluctant to sing or who lack confidence in their singing ability. Auditory models can be useful to demonstrate to students that they have the ability to form accurate auditory images regardless of their singing abilities. There is some evidence that singing ability is not often affected by perceptual deficits, but rather it is more common that motor control problems and timbre-translation problems are the causes of poor singing (Hutchins & Peretz, 2012). Given this information, it is likely that most students have the ability to perceive an auditory model accurately. While auditory models

are helpful for the development of auditory images, they are especially useful for learning new or difficult rhythms. The reason may be that rhythmic movement has been found to be more strongly attracted to auditory than to visual rhythms so that people often move in synchrony with auditory rhythms but rarely with purely visual rhythms (Repp & Penel, 2004). This rhythmic movement is important as this sense guides the motor behaviors used in the production of musical sounds (London, 2012).

Auditory imagery is central to Kochevitsky's (1967) system for the development of motor skill in playing the piano. Kochevitsky stressed the importance of an auditory rather than a visual starting point for playing piano. His scheme is as follows: "auditory stimulus (the inwardly heard tone) →anticipation of motor act →motor act resulting in actual sound →auditory perception and evaluation of the actual sound" (p. 30). Auditory models are necessary tools for the development of auditory imagery which in turn can positively influence movement learning through entrainment or synchronization: "When we are entrained, our attention literally 'moves with the music,' and this engenders and encourages our bodily movements as well" (London, 2012, p. 5). Auditory models could be used to synchronize movements such as those used in pressing the piano keys for example. This idea is seen in the work of piano pedagogue Abby Whiteside (1997) and the foundation of her approach; that is, the concept of a basic body rhythm. Whiteside felt that the transfer of the idea of music to the actual production of music involved the whole body as centrally controlled by the auditory image. Auditory modeling, in providing an image of the "big picture", can help to balance what Whiteside saw as the harmful effect of training fingers for tone production which results in the conditioning of listening habits to a note-wise procedure (Whiteside, 1997, p. 5). Piano pedagogues Bigler and Lloyd-Watts (2011) who

specialize in the Suzuki method of music learning, list several benefits of frequent listening to auditory models:

1. Familiarity with the melody and harmonies
2. A feeling for the rhythmic patterns
3. Exposure to a model of appropriate performance
4. Exposure to a beautiful piano sound
5. Sensitivity to nuance such as dynamic contrast and rubato (p. 19)

The authors suggest that parents begin early to play recordings of the music that children will eventually learn. Bigler and Lloyd-Watts recommend that recordings be played as often as possible, at least a year ahead of learning the material on the piano (Bigler & Lloyd-Watts, 2011).

Despite the benefits of using auditory models in practice, models are often not used at all. In a study of instrumental music students by Hallam (2004), the author found that very few listened to recordings of the work they were learning and very few used self-recordings for listening and providing feedback. This reluctance to use auditory models may be changing as awareness of benefits increases and as technology makes auditory models more readily accessible.

The next section will address mental practice in the scientific literature. A background is provided with a brief outline of the history of research on mental practice. We will then review the literature examining mental practice in music performance.

Empirical Studies

In North America, research on the effects of mental practice can be traced back to the early twentieth century and the writings of Washburn (Weinberg, 1982). In the abstract to her

work *Movement and Mental Imagery: Outlines of a Motor Theory of the Complexer Mental Processes*, Washburn (1916) writes:

> Since psychology undertook to call itself a science, there has existed a strong desire to connect the facts of the mind with the facts of bodily movement. The excuse which the present essay would offer for its own existence is that while the facts of attention, perception, and emotion have had their relation to bodily movement fully discussed, there still remain many phenomena connected with the complexer life of the mind, the revival of past experiences and the construction of new thoughts and ideas whose connection with motor processes has not been satisfactorily traced. This book seeks to connect movement, the ultimate facts of physical sciences, with the domain of mental imagery, the world of imaginary objects (abstract).

The connection between movement and mental imagery put forth by Washburn was validated by Jacobson (1932) in his study showing that muscular activity occurs when one imagines performing a physical skill. Using electromyography Jacobson showed that the action current produced in participants was quite specific to the body part which was moved in the imagination. The study of mental practice related to music performance, specifically piano, began around the middle of the last century. In her study on mental practice in piano performance, Rubin-Rabson (1941), found that an analysis of piano material before completing memorization at the keyboard was better than physical practice alone. The author also found that the mid-way learning period of mental practice was preferable to other time distributions, and suggested that students pause mid-way through learning for mental practice until the mental performance can be accomplished smoothly (Rubin-Rabson, 1941). For the remainder of the twentieth century studies on mental practice continued to demonstrate its positive effects in the development of motor skill (Clark, 1960; Shepard, 1978; Ross, 1985; Rosenthal, Wilson, Evans, & Greenwalt, 1988; Driskell, Copper, & Moran, 1994; Theiler & Lippman, 1995) and study in this specific area of music performance has continued, if on a relatively small scale. Recent literature will be presented in the next section.

In the twenty first century, studies on mental practice in music performance are relatively few; nine were found for review. While most studies looked at the effects of mental practice on performance, two studies examined the understanding of, use of, and value attributed to mental practice (Fine & Bravo, 2011; Haddon, 2007). In the most recent of these studies, Fine and Bravo (2011) examined the perceived meaning and usefulness of the terms "mental practice" and "score analysis". Eighty-nine experienced musicians completed an online questionnaire consisting of eighteen questions, both open and closed, providing quantitative and qualitative data. Participants were asked how they understood the terms "mental practice" and "score analysis", how useful they found these strategies, in what circumstances they used them, and what information they obtained from "score analysis". Interpretative phenomenological analysis was used to investigate open-ended responses to the two terms. The authors found that mental practice increased familiarity and aided performance preparation. Seventy percent of participants found "mental practice" very useful or vital, while only forty-eight percent considered "score analysis" to be very useful. Over ninety percent stated that they always or frequently reheard the music in their head. While it was generally agreed that mental practice referred to practice in the "head" or "mind", participants disagreed as to whether mental practice took place with or without the score, the instrument, or a recording. Limitations were not discussed by the authors although they did suggest further study into specific aspects of mental practice such as listening, as well as study into specific groups of musicians; for example pianists.

A study with a similar purpose was a survey conducted by Haddon (2007) where the author explored the way that musicians and music teachers understand and use mental practice. The survey focused on a university population of eleven third-year music students, ten of their professors, and four instrumental and vocal teachers. Participants completed a short

questionnaire where they described their understanding of the term "mental musical imagery". They were also asked to rate their awareness of musical elements, such as melody, timbre, and rhythm when imagining music as well as how often they used mental practice. Data was analyzed using predictive analytic software and thematic analysis. Results showed that almost all participants agreed with the definition of musical mental imagery as "rehearsing music in your head" (Haddon, 2007, p. 303). Many also agreed with the definitions "rehearsing physical movements in your mind", "visualizing a successful performance", and "realizing your mind is playing its own soundtrack and you are not consciously controlling it". Participants also rated highly their awareness of elements such as melody and rhythm in their mental practice. Many participants reported using mental practice for specific musical activities such as practice, composition, and performance, although it was not necessarily a developed skill. Participants found imagery to be especially helpful with memorization and interpretation. Interestingly, the study respondents reported that while mental practice was the least popular aspect of music learning, they found it to be a useful part of practice.

Most of the literature looked at the effects of mental practice on music performance in experienced youth and adults. The effect of mental practice on two aspects of movement timing, anticipation and coordination, was investigated by Bernardi, De Buglio, Trimarchi, Chielli, & Bricolo (2013). The authors studied sixteen experienced adult pianists who were divided into two groups of eight. All study participants were first trained in mental practice techniques such as an exercise focusing on the participant's internal sense of touch and of the position and movement of their body parts. A digital piano was used to record MIDI data, and motion-capture equipment used to record the hand and wrist movements of the participants. Baseline performances were collected from all participants who were subsequently assigned to one of two groups: mental

practice or physical practice. A control group, whose participants were not allowed to practice, was also used to confirm that the changes observed were not due to repetition during testing. The piece of music chosen for the study was a short technical exercise unfamiliar to the participants. Using their choice of mental practice techniques, while avoiding movement of the fingers/hands, the participants in the mental practice group completed two short practice periods (seven minutes each) interspersed with a performance and questionnaire about the mental strategies used. Members of the physical practice group followed the same procedure, of practice/performance and questionnaire; practice/performance and questionnaire, but added physical practice to their preparation. Using performance and motion-capture data as well as responses to mental practice questionnaires the authors found that both mental and physical practice could improve performance, specifically with movement speed, timing, and coordination. This study also represents the first evidence that mental practice results in movement anticipation shown here as an earlier rate of top movement speed and as a change in the coordination of the wrist and fingers; i.e. the wrist movement speed leads that of the fingers. The authors identified the main limitations of the study as the small sample size (sixteen) and variability in music experience and motor performance of the participants.

In a similar study Cahn (2008) compared the effects of two combinations of mental and physical practice with physical practice and mental practice alone. The sixty participants in the study were all undergraduate students who were experienced instrumentalists and were screened for their ability to fulfill the task. The study involved four practice condition groups: three minutes of physical practice, half a minute of mental practice and one minute of physical practice, three minutes of mental practice, and half a minute of physical practice and one minute of mental practice. The mental practice component consisted of looking at the score, facing away

from the instrument and mentally hearing the notes and playing the prescribed pattern while imagining hand movements, without actual movements. Before and after practicing, participants performed a tonal pattern over two chord progressions: one easy and one difficult. Errors in recorded performances were judged by two professional musicians who were blind to whether the performance was pre or post-test. Despite the result that the dominant physical practice group performed better on the difficult task than did the dominant mental practice group, the author did not find significant differences between the mental practice and physical practice groups overall. The reason for a lack of significant differences found between the practice groups was thought to be due to: the number of participants, difficulty of task, and type of task; for example the task may have been better suited to physical practice. Notwithstanding the lack of significant differences between the practice groups, the author recommended that mental practice be a compulsory part of music learning.

The following two studies by Brown and Palmer (2013) and Highben and Palmer (2004), highlight the effects of two specific areas of mental practice or imagery abilities: auditory and motor mental practice. In the most recent of these studies, Brown and Palmer (2013) examined the effects of auditory and motor imagery abilities on musicians' learning and recall of musical sequences, and whether these imagery abilities compensate for missing information or affect sensitivity to interference. After being tested on their auditory and motor imagery ability, twenty-four experienced adult pianists learned short unfamiliar melodies and subsequently performed them from memory. Performance data were recorded using a MIDI keyboard, and headphones were used by participants for auditory input. Twenty-four melodies (four melodies per learning-interference condition) were learned by listening alone (auditory learning) or by playing, with the right hand, on a silent keyboard (motor learning) and subsequently were performed in the recall

phase with auditory feedback. There were three interference conditions: auditory interference where participants simultaneously heard a different melody from the one being learned, motor interference where participants performed, with the left hand, an additional motor sequence, or no interference. These conditions created six learning-interference conditions: 1) auditory learning with no interference - participants heard a recording of the melody six times while viewing the notation and holding their hands in fists to prevent movement, 2) auditory learning with auditory interference, 3) auditory learning with motor interference, 4) motor learning with no interference - participants performed the melody six times from notation hearing only the first pitch of each melody, 5) motor learning with auditory interference, and 6) motor learning with motor interference. Two experiments were conducted, one with the interference conditions presented during learning, and the other with the interference conditions presented during recall. Using the MIDI data, the authors compared pitch accuracy and temporal regularity during recall performance with independent measures of the participants' auditory and motor imagery abilities. Because pitch errors commonly increase temporal variability, only pitch-perfect recall trials were included thus allowing timing to be examined separately from the influence of pitch errors. The authors found that both auditory and motor imagery abilities assisted with learning and recall; for example both abilities improved pitch accuracy. In particular, auditory imagery assisted learning of pitch order in music sequences and recall of temporal features suggesting that auditory imagery skills decrease vulnerability to interference and compensate for lack of auditory feedback in learning. The authors also found that performance is most susceptible to motor interference. The study findings are the first to demonstrate that performance from memory is more accurate following auditory learning than following motor learning. The authors noted possible limitations. Because of the use of notation, visual imagery abilities could have been

involved and this influence is unknown. In addition, the motor interference task required participants to synchronize their movements which may have made this task more disruptive than the auditory interference task.

A similar study was conducted a few years earlier by Highben and Palmer (2004) to examine the effects of auditory and motor imagery abilities in learning to perform an unfamiliar piece of music. In this study, sixteen experienced adult pianists learned short unfamiliar melodies after being tested on their auditory and motor imagery ability. The equipment, design and procedure were very similar to the previously described study except that two extra conditions were added and there were no interference conditions. The four practice conditions were: auditory practice - where participants heard the piece without moving while imagining the required finger movements, motor practice - where participants moved their fingers on the keys while imagining auditory feedback, normal practice, and covert practice where participants neither moved nor heard the music but were instructed to depress the pedal each time they imagined sound and movements for the piece of music. In analyzing errors during performance and imagery ability tests, the authors found that the removal of auditory or motor feedback in learning caused significant memory deficits in performance. They also found that participants with strong auditory imagery abilities were least affected by the lack of auditory feedback in learning. This was also true for participants with a high self-rating of playing by ear. These findings suggest that an accurate auditory image is important for performance from memory. The authors outlined possible limitations which may have made the practice effects less visible; practice conditions such as practicing ten times without stopping or correcting mistakes may have been artificial. They also suggested that the material may have been too easy for the caliber of participants.

Three studies examined the effect of auditory modeling on music performance (Henley, 2001; Morrison, Montemayor, & Wiltshire, 2004; and Frewen, 2010). The effects of auditory modeling and tempo patterns were examined by Henley (2001). Only the discussion about modeling is relevant here. Sixty adolescent wind and brass instrumentalists practiced an étude which was sight-read once as a pre-test, practiced six times for twenty minutes with or without a recorded auditory model, and played once as a post-test. All of the recorded performances were evaluated by the author, and twenty percent of them by an objective observer, for pitch, rhythm, and articulation. The author found that the use of an auditory model assisted rhythm and tempo mastery but may or may not have affected pitch discrimination. He recommended replication of the study using a larger group of participants and a longer practice period for further insight into differences between the model conditions.

A study examining the effects of recorded ensemble models on band students' performance self-evaluations, achievements, and attitude was conducted by Morrison, Montemayor, and Wiltshire (2004). Five bands from middle schools and high schools participated in the five week study. Recorded auditory models were used systematically; for example, instructions to play the entire piece once a week while band members follow their individual parts. Each week students also completed a self-evaluation "progress report" rating their performance with and without the use of a model. Pre and post-test recordings were independently evaluated by five experienced instrumental music teachers, and student evaluations were analyzed. The authors found no differences in performance achievement between model and no-model conditions. Reasons for this finding, as suggested by the authors, could be insufficient assessment, or the transference of modeling effects to pieces where no model was used. The student assessments showed lower achievement gains in the model

condition which may have been influenced by factors such as the need to generate their own personal standard of performance quality in the absence of a model. Despite this assessment the students did not have a negative attitude toward the model use and some younger students were more enthusiastic toward the model pieces particularly with regard to expression and phrasing.

Of particular interest to those who teach beginner piano to children, is the study on the use of auditory modeling in keyboard performance by Frewen (2010) because it is the only study that looks at children and the only one to look at novices. As participants for her study, Frewen (2010) used ninety-seven children in kindergarten through grade four (ages five to ten) with no formal instrumental instruction. Her study examined auditory modeling in keyboard performance of an unfamiliar melody. The participants were divided into two groups; one group listened repeatedly to a model of the melody to become familiar with the music prior to learning to play it. This group was then assessed using a melodic error recognition test to ensure familiarity. All participants were subsequently taught the melody by rote on a MIDI keyboard. Using the MIDI data Frewen found that the group that became familiar with the melody through the use of auditory modeling played significantly more correct notes than did the children not familiar with the melody. The author also found that older children performed the last two measures of the melody better than younger children did. The first two measures of the melody were easier to play, and were not much affected by familiarity or age. Frewen suggested that this finding shows that auditory modeling may be particularly advantageous when learning to perform more difficult or longer melodies (Frewen, 2010).

Of the nine studies examined for this review, only one looked at mental practice using children as the subject (Frewen, 2010). The others studied older participants, from adolescents to adults: middle school to secondary school students (Morrison, Montemayor, & Wiltshire, 2004),

secondary school students (Henley, 2001), adults (Bernardi, De Buglio, Trimarchi, Chielli, & Bricolo, 2013; Brown & Palmer, 2013; Cahn, 2008; Fine & Bravo, 2011; Haddon, 2007; Highben & Palmer, 2004). Four studies focused on mental practice and keyboard playing (Bernardi et al., 2013; Brown & Palmer, 2013; Frewen, 2010; Highben & Palmer, 2004), while the other five included other musical instrumentalists. Of the instrumentalists studied, almost all were experienced musicians; only one study looked at novices (Frewen, 2010). While most studies were focused on the effects of mental practice on performance, two examined how participants understood mental practice, how they used it, and how useful they found mental practice to be (Fine & Bravo, 2011; Haddon, 2007). Almost all study results demonstrated some benefits of mental practice in music performance. While two studies found no significant difference in performance after using mental practice techniques, the authors and some participants still found mental practice to be valuable (Cahn, 2008; Morrison et al., 2004). The other studies examining mental practice in music performance all found stronger evidence of benefits (Bernardi et al., 2013; Brown & Palmer, 2013; Fine & Bravo, 2011; Frewen, 2010; Haddon, 2007; Henley, 2001; Highben & Palmer, 2004). Specifically, performance improvements were found in the following areas: movement velocity, timing, and coordination (Bernardi et al., 2013); pitch accuracy and vulnerability to interference (Brown & Palmer, 2013); rhythm and tempo mastery (Henley, 2001). Four of the studies focused specifically on auditory imagery and modeling rather than on the other aspects of mental practice (Brown & Palmer, 2013; Frewen, 2010; Henley, 2001; Morrison et al., 2004). In addition to the benefits listed earlier, Henley (2001) found that the auditory model provided a rhythmic example that appeared to act as a teaching tool. Except for Morrison and colleagues (2004) the others found strong evidence of the benefits of auditory modeling.

Although the participants were not children and were experienced instrumentalists, three other studies looked at mental practice in keyboard performance (Bernardi et al., 2013; Brown & Palmer, 2013; Highben & Palmer, 2004). As with the Frewen (2010) study, all three found benefits in mental practice; specifically for performance (Bernardi et al., 2013), learning and recall of melodies (Brown & Palmer, 2013), and learning and performance from memory (Highben & Palmer, 2004).

Conclusions

Almost all studies showed benefits of mental practice. Only the studies by Cahn (2008) and Morrison and colleagues (2004) found mixed results with no significant difference found in performance achievement using mental practice. All authors found enough value in mental practice to warrant further study. The two studies examining the understanding and use of mental practice found that mental practice was considered to be very useful by participants (Fine & Bravo, 2011; Haddon, 2007). Participants in these two studies found mental practice to be especially useful for increasing familiarity with the music (Fine & Bravo, 2011), performance preparation (Fine & Bravo, 2011; Haddon, 2007), as well as for aiding in memorization (Haddon, 2007). Some very specific benefits were found; for example, motor imagery was associated with greater changes in movement speed, while auditory imagery was associated with greater movement anticipation (Bernardi et al., 2013). In addition, Bernardi and colleagues state that their study is the first to show evidence of an anticipatory influence following mental practice (Bernardi et al., 2013). Auditory imagery was found to aid in pitch accuracy, performance from memory, and to protect from interference (Brown & Palmer, 2013). Mental practice was found to be especially effective when combined with physical practice (Cahn,

2008). Auditory models were found to be beneficial (Brown & Palmer, 2013; Frewen, 2010; Henley, 2001), but not unreservedly (Morrison et al., 2004).

Implications for Music Pedagogy

The current literature on mental practice in music performance demonstrates many benefits of this technique. The studies on mental practice used guided mental practice, in other words, the participants were instructed on how to use the technique. This is particularly important for the field of music pedagogy as students may be introduced to mental practice techniques early to allow these skills to develop over time (Cahn, 2008). Some of the participants in Cahn's study on the effects of varying ratios of mental and physical practice were surprised at what they could achieve mentally and "all subjects regretted not having been made aware of mental practice earlier in their musical training"(Cahn, 2008, p. 189). The teacher, therefore, is important in setting the foundation for students to learn mental practice techniques. Teachers need to be cognizant of the fact that people differ from each other in their imagery experiences and skills (MacIntyre, Moran, Collet, & Guillot, 2013). As an example it appears that those learners with absolute pitch and instrumental/vocal teachers have the highest use of imagery (Haddon, 2007).

Mental practice can be taught in formal ways; for example, teaching learners to follow specific procedures such as imagining the hand movements and mentally hearing notes, without moving fingers, touching, or looking at the piano (Cahn, 2008). For beginner instrumentalists learning to memorize music, McPherson (2005) outlines five mental strategies: 1. thinking about how the melody would sound, 2. chanting of rhythm or letter names of the notes, 3. trying to sing the melody but not explicitly linking this with instrumental fingerings, 4. trying to chant the rhythm or pitch with rough contour while fingering, and 5. linking the sound of the melody to

fingerings by mentally rehearsing as they study the notation (pp. 21-22). Less formal ways of learning to use mental practice are also useful; for example using observational and dyad practice where learners listen to and observe performances of their teachers or of each other (Wulf & Mornell, 2008). The use of observational and dyad practice can also be motivating for learners (Wulf & Mornell, 2008). Watching someone learn a motor skill is an effective teaching strategy (Lee, Swanson, & Hall, 1991). Hearing, in advance of learning to play, music with the use of auditory models is also helpful (Bigler & Lloyd-Watts, 2011). The accessibility of auditory models for use by teachers and their students has greatly increased thanks to recent advances in technology; for example, YouTube and music streaming services like Spotify as well as more traditional digital formats such as CDs and MP3s. Using devices like smartphones, both teachers and students can also create auditory models by playing and recording the music themselves. Observational practice as well as other forms of mental practice is particularly useful for injury avoidance or for use with learners who are recovering from injury. The occurrence of playing-related musculoskeletal disorders in piano players is most likely to be found in those who have played for the longest time, practiced for the most hours, and most regularly (Allsop & Ackland, 2010). The use of mental practice together with a reduction of physical practice can help to avoid the injuries caused from physical practice. In a similar way, mental practice could be an especially useful technique in situations where learners are unable to physically practice due to non-music related injuries. Music students may also find resource saving benefits in the use of mental practice in cases where studio time is limited or where there is limited access to a piano, while traveling or away from home for example. Mental practice can also assist with interpretive aspects of performance in giving the learner a sense of the whole. In *The Art of Piano Playing* Kochevitsky (1967) writes:

> The whole composition which is being studied should be read mentally from time to time. We must remember Busoni's warning that one easily forgets about the musical meaning during the motor work at the piano. By mental reading without actual playing we can revive the clear acoustic picture of the composition in our mind and are stimulated in our efforts to master it technically (p. 50).

An opportunity exists for teachers to provide the benefits of mental practice to students of all stages of learning with the inclusion of mental practice strategies in the teaching curriculum.

Future Research

Current and past research has demonstrated positive effects of mental practice in music performance but there is still much to be learned. Specificity was sometimes lacking; for example, Haddon (2007) examined mental practice in instrumental music performance in general rather than examining one specific instrument and/or one type of skill. Some studies on mental practice in music performance did set more specific purposes however and used a more specific participant group (Bernardi et al., 2013; Brown & Palmer, 2013; Frewen, 2010). Another area that was lacking in specificity was the focus of instrument. While some music studies looked at keyboard practice, slightly more than half examined instrumentalists in general. It seems possible that different instrumentalists might experience the effects of mental practice differently; for example pianists may or may not find more benefit from mental practice than musicians who read only one line of music and not both treble and bass. For this reason, it may be advantageous to focus on one group of soloist musicians. Research investigating the amount of mental practice that is optimal for learning or performing would also be welcome. Various quantities of mental practice were used in the studies reviewed here from half a minute one time (Cahn, 2008) to longer periods over a span of weeks (Morrison, Montemayor, & Wiltshire, 2004).

Due to new developments in brain science, the study of mental practice has become more sophisticated but is ever evolving. As scientists understand more about how the brain works, questions about the process and effects of mental practice may be addressed more clearly. It has been established that mental practice is beneficial in music performance, but it is not clearly understood as to why this is so; for example: in what way/s does mental practice assist in music learning and/or performance? Further research on hearing, auditory imagery, perception, and processing will advance the mental practice research; for example in examining the development of the ability to hear music in our heads (Haddon, 2007). Forms of mental imagery, other than auditory, are also of interest in the study of mental practice, raising questions such as the possibility of separating different imagery techniques in the study of mental practice. Also of interest is the way in which individuals understand and use mental practice; for instance, does everyone use mental practice in the same way? Does everyone have the same capabilities in their use of mental practice and imagery? Highben and Palmer (2004) found, for example, that individual differences suggest that performers (their study used experienced adult pianists) differ in their motor imagery and learning versus their auditory imagery and learning.

Related to the separation of various aspects of imagery is the question of whether or not mental practice can be considered as completely separate from physical practice. If physical and mental practice can be separated for the purposes of research, is it possible to know what the optimal proportions are for each type of practice? Cahn (2008) found that previous studies on mental practice were inconsistent in the proportions of mental and physical practice thereby creating differences in their effects that varied depending on the proportions of each type of practice suggesting that the proportions of mental and physical practice could be significant. It is important that physical practice be included as a control in all studies on mental practice. It

would have been instructive to know how the results of a physical practice condition might have compared with the auditory and motor learning conditions in the study by Brown and Palmer (2013). Research on the application of mental practice would also be useful. Cahn (2008) and Frewen (2010) both raise the question of whether or not the beneficial effects of mental practice are the same with both easy and complex music? With regard to the application of mental practice in different aspects of practice, Henley (2001) suggests that future research could include examination of mental practice and aspects such as intonation, phrasing, and dynamic contrast. A clear and standardized definition of the term "mental practice" would be welcome to create more clarity in study design and results; for example mental practice or "musical mental imagery" can be defined in many different ways such as "rehearsing music in your head", "visualizing a successful performance", and "realizing that your mind is playing its own soundtrack" (Haddon, 2007, p. 303). Mental practice needs to be precisely defined in order to produce precise study designs and results.

Other questions for further research involve the users of mental practice whether students, or teachers. For whom is mental practice best suited? Further research could examine different populations with regard to the benefits of mental practice; for example, novices, experts, children, and adults. Do beginner pianists and/or children have the same capacity for using mental practice strategies as experts/adults? In examining the use of mental practice in music performance, specifically piano performance, most current research has used adult participants (Bernardi et al., 2013; Brown & Palmer, 2013; Cahn, 2008; Fine & Bravo, 2011; Haddon, 2007; Highben & Palmer, 2004). Some research has adolescents as the focus of study (Henley, 2001; Morrison et al., 2004). Frewen's (2010) is possibly the only current study examining the use of mental practice in keyboard performance that uses novice children as

participants. Given that the majority of piano students are children, a focus on children (and/or beginners of any age) and the use of mental practice would be welcome. It would also be interesting to know whether or not intelligence plays a role in the effectiveness of mental practice? The role of the teacher is of interest for future study as teachers are influential in the use of mental practice techniques. It would be helpful to know if the role of the teacher changes depending on the stage/age of the student using mental practice. In other words, should the teacher have a greater role in assisting beginner/younger students in the use of mental practice? An increase in research on mental practice is welcome given the benefits of mental practice and the potential impact that these strategies offer to music teaching and learning.

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