THE EFFECTS OF PRACTICE PROCEDURE AND TASK DIFFICULTY ON

TONAL PATTERN ACCURACY

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The study investigated the relative effectiveness of different proportions of time spent on physical and mental practice, in the context of a music performance of a tonal pattern over harmonic progressions of two difficulty levels. Using a sampling without replacement procedure, sixty undergraduate students were assigned to four practice groups partially blocked for musical instrument. The groups included a physical practice group, a mental practice group and two combined mental and physical practice groups in the proportions of (a) 66% physical and 33% mental, and (b) 33% physical and 66% mental. Each subject performed a pretest, a 3 minute practice session, and a posttest on both harmonic progressions. Presentation of the harmonic progressions were counterbalanced to control for practice effects All pre- and posttests were recorded and scored according to number of note errors.

An ANCOVA procedure using pretest scores as covariates revealed that: (a) there were no differences between the different practice groups on the measure of note errors, (b) there was a significant difference between the two harmonic progressions on the measure of note errors, such that performance on the easy progression was significantly better than performance on the hard progression, and (c) there was a significant interaction between harmonic difficulty level and the practice groups. Post hoc comparisons between the adjusted means of the practice groups on the two tasks revealed

that for the mental and the 33:66 combined practice groups, groups consisting of a higher percentage of mental practice, performance on the easy harmonic progression was significantly better than on the hard harmonic progression. However for the physical and the 66:33 combined practice groups, groups consisting of a higher percentage of physical practice, performance on both harmonic progressions was not significantly different and was as good as the performance of all practice groups on the easy task.

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CHAPTER 1

RATIONALE, PURPOSE AND RESEARCH QUESTIONS

Rationale

Various studies in music performance have shown the benefits of different practice strategies over others (Coffman, 1987; Lim & Lippman, 1991; Rosenthal, Wilson, Evans, & Greenwalt, 1988; Ross, 1985; Rubin-Rabson, 1941). Barry (1992) showed the importance of having a structured practice regimen for obtaining maximum efficiency within the practice session. In an analysis of professional musicians' approach to practice, Hallam (1995) found a high level of individual diversity in the practice orientations of the musicians. Her conclusions were that students should be presented with a range of learning strategies, so that they may explore and develop their preferred approach when practicing.

Mental practice is a rehearsal strategy, the importance of which has been stressed by music pedagogues (Amaize, 1993) and is often required of music students by their teachers (Barry & McArthur, 1994). Mental practice instructions have been written by teachers such as Havas (1976) and Novik (1977). Havas (1976), in her book on stage fright with special reference to violin playing, described specific mental practice exercises as part of memorization techniques. One such exercise included performing on an imaginary violin:

> Put the music on the stand and play the first section, but only with an imaginary violin and bow, while singing it, naming the notes with a very powerful rhythmic pulse all through the body. Make certain that you really feel there is a violin and a bow and that all your movements are as real and accurate as if you were really playing. . . . Turn away from the music and play the section, still without the violin and the bow, but still singing and saying the names of the notes with the fingers and bow responding. If your memory breaks down, turn to the exact spot in the music where the memory lapse occurred. (p.94)

A similar technique was suggested by Novik for piano performance (1977):

> A way of creating visual memory in one not endowed with it may be achieved in the following way. Ask the student to close the piano, shut his eyes, and play the piece on the lid while attempting to visualize the printed page in the mind's eye. While his eyes are still closed, raise the lid, place his hands on the keys and encourage him to actually play the piece, thus incorporating the keyboard feel which was so carefully cultivated during the reading process. (p.403)

Mental practice as a rehearsal strategy has undergone empirical research since the 1930s. The term mental practice is used to describe the cognitive activity during a sedentary type of rehearsal where no overt psychomotor activity is observed. This type of rehearsal strategy has also been referred to as imaginary practice (Perry, 1939), covert rehearsal (Corbin, 1972), symbolic rehearsal (Sackett, 1935), implicit practice (Morrisett, 1956), and conceptualization (Egstrom, 1964). It is important to distinguish this specific definition of mental practice from the broader term of mental preparation. This more general term may include a variety of techniques that share the goal of enhancing performance (e.g., Weinberg, 1982). These techniques which may include positive imagery, psyching-up strategies, attention focusing, relaxation, self-efficacy statements, and other forms of cognitive or emotional preparation prior to performance are not included in the definition of mental practice used here.

Depending on the type of tasks and the skill of the performer, mental practice has been found to have differing performance results in areas outside of music performance (Corbin, 1972; Driskell, Copper, & Moran, 1994; Feltz & Landers, 1983; Feltz, Landers & Becker, 1988; Richardson, 1967a) as well as in music performance tasks (Coffman, 1987; Lim & Lippman, 1991; Rosenthal, Wilson, Evans, & Greenwalt, 1988; Ross, 1985; Rubin-Rabson, 1941; Theiler & Lippman, 1995). In a review of 22 studies relating to mental practice, Richardson (1967a) recognized three stages of motor performance in which mental practice research had focused on; (a) facilitating the initial acquisition of a motor skill; (b) aiding the retention of a motor skill; and (c) improving the immediate performance of a motor skill. Most of the studies reviewed indicated an improved performance on the tasks associated with mental practice procedures.

Several studies reviewed by Corbin (1972) supported the notion that subjects of higher skill and experience used mental practice more effectively than subjects of lower ability. Corbin, as well as Feltz and Landers (1983) categorized mental practice research by the type of tasks that subjects were asked to perform. The types of tasks were cognitive, ones such as mirror drawing, maze tracing and card sorting; motor skill tasks, such as basketball throwing, ring toss and baseball throws; and strength tasks, such as situps and bench presses.

In their meta-analysis of 60 studies concerning the effectiveness of various forms of mental practice, Feltz and Landers (1983) reported that mental practice had a larger effect on cognitive tasks than on motor tasks or strength tasks. In a further analysis of 48 studies Feltz, Landers, and Becker (1986) found that pre- to posttest effect sizes were largest for physical pracice followed by that of combined physical and mental practice both of which were larger than that of mental practice. Similar findings were reported by Driskell, Copper, and Moran (1994) in their meta-analysis of 35 studies that examined the effectiveness of mental practice in comparison with physical practice. Despite the categorization of tasks into cognitive, motor, and strength categories, Feltz and Landers (1983) pointed out that in a sense such a distinction between tasks was an idealization. They suggested that motor tasks be viewed as being on a continuum proceeding from tasks which have few cognitive elements to those that are primarily cognitive. According to the authors' proposed continuum, music performance may be categorized as being a motor task that is high in cognitive elements. Indeed, the amount of research that has been done regarding the cognitive aspects relating to musical activities in general and music performance in particular (e.g., Dowling & Harwood, 1986; Hargreaves, 1986; Serafine, 1988) corroborates this type of categorization.

Research studies in mental practice have also been designed to examine specific parameters that may moderate the efficacy of mental practice. Aspects such as various combinations of physical and mental practice (Hird, Landers, Thomas, & Horan, 1991) and duration and order of presentation of the mental practice period (Etnier & Landers, 1996) have been examined. Hird, Landers, Thomas, and Horan (1991) studied the efficacy of several combinations of physical and mental practice on both cognitive and motor task performance. For both tasks it was found that as the relative proportion of physical practice increased, so was performance enhanced. This was not altogether present, however, when pre- to posttest effect sizes were examined. Effect of duration and order of presentation of the mental practice period was studied by Etnier and Landers

(1996) in a basketball shooting task. Results indicated that mental practice before physical practice was more effective and that mental practice duration of 1 and 3 minutes were more effective than mental practice duration of 5 and 7 minutes. Both these studies used effect sizes to compare their results with those found in the previous meta-analyses.

Knowledge regarding the use of mental practice in music performance activities come from several types of sources. These include studies regarding the actual application of rehearsal strategies by music performers on various tasks, and studies that try to compare the effectiveness of mental practice techniques with other type of rehearsal strategies. A third type comes from the field of neurophysiology and attempts to map cortical activity during mental practice.

Mental practice has been reported to be used by musicians as (a) encoding strategies (Mikumo, 1992, 1994), (b) part of sight reading strategies (McPherson,1994), (c) a method for practicing tone production, interpretation, technical difficulties (Trusheim, 1987), and (d) a means for overcoming vocal strain or fatigue (Carter, 1993). In a study related to encoding strategies of melodies to be memorized by musicians, Mikumo (1992) found that subjects used several types of strategies. These included mental rehearsal, visualizing strategies in which tones were imagined as contours on a keyboard or in notation, and a finger tapping strategy in which an auditory melody was encoded by the fingers moving as if playing a piano. In another study, Mikumo (1994) concluded that the use of the finger tapping strategy was more effective in retaining melodies for subjects who were highly trained in music performance.

Mental practice has also been reported to play an important part in the area of sight-reading music. McPherson (1994) proposed that a distinguishing characteristic of competent sight-readers involved "a brief period of mental rehearsal of the major difficulties before commencing to play" (p.229). This type of rehearsal involved scanning the music to find and mentally rehearse difficult obstacles.

Two studies have dealt specifically with the actual application of mental practice as rehearsal strategies by professional performers (Carter, 1993; Trusheim, 1987). Through interviews with professional brass players, Trusheim (1987) revealed that mental rehearsal was for most of the musicians a conscious practice strategy, though the nature and focus of this technique was different for different players. Mental practice was used in the areas of tone production, interpretation and the overcoming of technical difficulties. In a similar study with professional singers, Carter (1993) found that mental practice was used also when vocal chords were strained or fatigued.

Studies on the effects of mental practice on music performance tasks include the learning and memorizing of music for performance (Coffman, 1987; Lim & Lippman, 1991; Rosenthal, Wilson, Evans, & Greenwalt, 1988; Ross, 1985; Rubin-Rabson, 1941; Theiler & Lippman, 1995). These have compared the effectiveness of several rehearsal techniques, one of which included either some form of mental practice by itself, or a combination of actual physical practice and mental practice. In one of the first studies relating to mental practice in music performance, Rubin-Rabson (1941) found that a combination of mental practice with actual physical rehearsal required less physical rehearsal trials for pianists in memorizing a musical passage that was categorized as either easy or medium in difficulty. For the difficult musical passage, the physical practice condition was the most beneficial. Ross (1985) examined the improvement in performance of an etude by trombone students using either mental practice alone, physical practice, a combination of the two, or mental practice with simulated slide movement. Although not significantly better than either the physical practice technique or the mental practice with simulated slide movement, most improvement was found by those trombone players that used the combined physical and mental practice technique. Contrary to this finding, Coffman (1987) reported no significant difference between the regular physical practice technique and the combined physical and mental practice technique on the performance of non-piano major students on a chordal composition for keyboard.

Rosenthal, Wilson, Evans, and Greenwalt (1988) compared the performance of an etude by woodwind and brass players after a three minute practice period using either modeling (i.e., listening to a recording of the etude while looking at the music), singing the music from the score, free practice and silent analysis. No significant differences were found between the practice methods on correct notes but the silent analysis method was highest on rhythmic accuracy.

The inclusion of silent analysis as a form of mental practice has been addressed by Rubin-Rabson (1941). She argued that there was only a theoretical distinction between silent analysis and mental practice since even within a short period of analytical study, subjects may carry the learning to such a degree of fluency that only one or two practice trials are required in order to memorize the music.

Lim and Lippman (1991) compared the effectiveness of physical practice by piano major students, mental practice alone, and mental practice while listening to a performance of the score, on the learning and memorizing of musical excerpts that ranged from six to sixteen bars in length. The physical practice condition was found superior to both practice conditions though mental practice while listening led to more note accuracy than just mental practice alone. After a posttest, in which practice conditions were repeated, the gain of the mental practice group was most striking compared to the other groups, suggesting the need for some physical practice (in this case the test itself) in order for mental practice to be effective.

Theiler and Lippman (1995) compared the effectiveness of several practice conditions on the performance and memorization of musical excerpts by guitar players and by vocalists. The practice conditions included physical practice, a combination of physical and mental practice, a combination of physical practice with mental practice while listening to an auditory model, and a control/ motivational condition. Results showed that the combined physical and mental practice condition was effective as that of the physical practice condition and more effective than the control/ motivational condition.

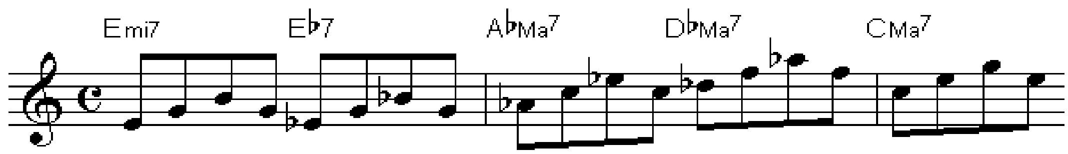
The study by Pascual-Leone, Dang, Cohen, Brasil-Neto, Cammarota, and Hallett (1995) in the field of neurophysiology sheds some light on the brain activity during mental practice of a musical task. The researchers used transcranial magnetic stimulation to study the cortical motor areas targeting muscles involved in a five finger keyboard exercise. They examined the different effects of mental practice and physical practice on the acquisition of the task as well as the modulation of the cortical motor areas targeting the long finger flexor and extensor muscles involved in the task. Mental practice alone led to fine motor skill learning but did not result in as much improvement as physical practice. However, mental practice alone led to the same plastic changes in the motor system as those occurring with the acquisitions of the task by repeated physical practice.

Music performance tasks are not limited to the performance or memorization of written music. For example music improvisation is a category within music performance defined by the Harvard Dictionary of Music as "the creation of music in the course of performance" (Randel, 1986, p.392). There are various genres of music that make use of improvisation and each genre differs in its approach to improvisation. Jazz is one such genre and even within this type of music there are various styles that use different improvisational approaches. In the classical jazz tradition such as swing and bebop, improvisations are based on the harmonic progression of tunes.

The creation of music in the course of a jazz performance requires various musical skills. These can be studied and learned through the performance of musical exercises as exemplified in methodology books on jazz improvisation (e.g., Abersold, 1992; Coker, 1991; Crook, 1991; Haerle, 1980). Through interviews with jazz performers, Berliner (1994) described the various developmental stages that artists go through in acquiring jazz improvisational skills and the types of exercises they had to master along the way. These included, among other things, the learning of multiple scales, patterns and musical motives all of which were generally practiced in all keys and later practiced in relation to harmonic progressions of tunes.

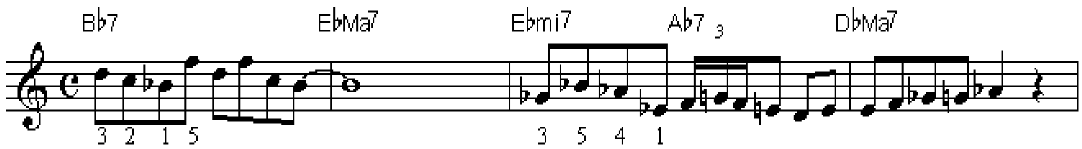
One of the musical exercises that is practiced by jazz improvisation students includes the playing of tonal patterns over chord changes. There are various types of tonal patterns, one of which has been termed as digital patterns (Coker, 1989) or otherwise referred to as scale patterns (Crook, 1991), or melodic structures (Bergonzi, 1992). These are usually 4 to 8 note melodic patterns that are structured according to the numerical value of each note of the chord or the scale. Coker gives an example of a 4 note tonal pattern of 1-3-5-3 applied to a harmonic progression as shown in Figure 1.

Figure 1. Four note tonal pattern of 1-3-5-3 applied to a harmonic progression (Coker 1991, p.9)



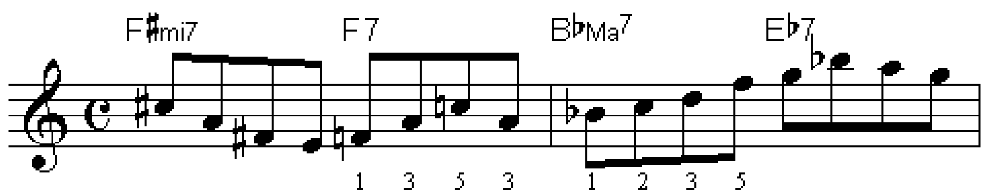
The practice of tonal patterns is a type of exercise that can later be used within the context of an improvisation. As Crook (1991) pointed out "scale patterns . . . can be practiced on chords and eventually used in an improvised solo, e.g., as 'send off' ideas to begin a melodic phrase" (p.67). This is exemplified in one of Crook's exercises for practicing scale patterns titled "Using scale patterns as send-offs" (p.70). This exercise required that improvisational phrases on chords begin with a tonal pattern and end with an improvisation. Figure 2 is an excerpt from a written example by Crook in which different scale patterns begin each musical phrase. In this excerpt (bars 8-11 of the original example) the tonal patterns include 3-2-1-5 and 3-5-4-1 of the relevant chords.

Figure 2. Tonal patterns as send-offs in an improvisational phrase (Crook, 1991, p.71).



In examples from recorded solos, Coker (1991) showed a variety of transcribed solos in which tonal patterns were used. One of these included that of trumpeter Fats Navarro's improvisation as shown in Figure 3. This solo excerpt shows Navarro's use of the pattern 1-3-5-3 as well as the pattern 1-2-3-5. Tonal patterns are regarded as one of the simplest and basic elements of the jazz language (Bergonzi, 1992; Coker, 1991) and have been used since the early days of jazz (Coker, 1991).

Figure 3. Use of Patterns 1-3-5-3 and 1-2-3-5 on a section of Fats Navarro's solo (Coker 1991, p.11).



Mental practice has been found to be not only a beneficial means of learning and memorizing written music (Coffman, 1987; Lim & Lippman, 1991; Rosenthal, Wilson, Evans, & Greenwalt, 1988; Ross, 1985; Rubin-Rabson, 1941; Theiler & Lippman, 1995), but also part of the overall practice strategies used in music performance (Carter, 1993; McPherson, 1994; Trusheim, 1987). Yet, unlike the area of performance of written music which has received the main focus of mental practice research in music, other areas such as music improvisation or musical tasks such as the performance of tonal patterns on chord progressions have not been addressed by mental practice researchers. Regarding music improvisation, maybe part of the reason for this neglect has been the lack of evidence related to mental practice and music improvisation as expressed by Pressing (1988). In his review of methods and models of improvisation, he compared the use of mental practice in fixed music as opposed to improvisation. Pressing concluded that "mental practice away from the instrument can be important for performers of fixed music, based on internal hearing of scores, but there seems very little record of its use in improvisation" (p.140).

Contrary to this conclusion, jazz performer and educator Jerry Bergonzi (1992) claimed that mental practice was a legitimate means for learning and practicing improvisation. Bergonzi emphasized the importance of mental practice to the art of improvisation and devoted a chapter in his book on improvisation to mental practice or as he called it, visualization: "for a musician, visualization is the process of picturing in our mind's eye what we hear in our mind's ear" (p.31). Bergonzi believed that not only do jazz musicians visualize their improvisations but that "visualization speeds up the process of learning how to improvise" (p.31). From interviews with jazz performers, Berliner (1994) also concluded that "ultimately, control over alternative forms of imaging leads improvisers to master the language of jazz" (p.114).

The application of mental practice to musical exercises other than learning and memorizing written music has also not been addressed by mental practice studies. That mental practice may be applied to such exercises was exemplified by Bergonzi (1992) who gave specific musical tasks, such as visualizing the changes to a tune or visualizing the notes of a chord. These tasks were very similar to the teaching methods of jazz pianist

Alan Swain who, in interviews by Berliner (1994), stated that he drilled his students so that “they can visualize precise key clusters for every chord symbol” (p.110).

The task of performing tonal patterns over chord changes is a type of musical exercise which lends itself well to the methodology of mental practice research in which improvement can be measured. Unlike the music performance tasks of learning or memorizing written music which have been used by those studies that examined the effectiveness of mental practice, the performance of tonal patterns is a task very different in its cognitive requirements. On the one hand, the performance of tonal patterns does not require musical notation reading skills, which are at the heart of learning and memorizing written music. On the other hand, this type of task requires knowledge of chord symbols and the ability to delineate from the chord sequence the correct notes to be performed in the prescribed rhythm of the pattern.

As reported earlier, Feltz and Landers (1983) as well as Driskell, Copper, and Moran (1994) found that mental practice had a larger effect on cognitive tasks than on motor tasks or strength tasks. Apart from the meta-analysis that compared effectiveness of mental practice from multiple studies which used various types of tasks and reached the above conclusions, studies on mental practice tend not to compare effectiveness of mental practice on tasks of different levels of difficulty. There have been comparisons on different types of tasks such as the study by Hird, Landers, Thomas, and Horan (1991) who compared the effectiveness of various combinations of mental practice by subjects on two types of tasks: a pegboard task which was categorized as essentially cognitive in nature and a pursuit rotor task which was categorized as essentially motor in nature.

Although Goginsky and Collins (1996) challenged methodological issues of the study by Hird, Landers, Thomas, and Horan (1991), and its conclusions, the design of comparing same subjects on different tasks is legitimate.

Studies comparing mental practice effects on the same type of task yet at different difficulty levels is scarce if at all available. In the field of music performance, only the study by Rubin-Rabson (1941) ranked the task material according to difficulty. Her finding was that the combined physical and mental practice condition showed a tendency for superiority on the easy and medium compositions, whereas the physical practice condition was superior for the difficult compositions. This was perhaps the first study to deal with mental practice in music performance, and its experimental design has since been repeated with certain modifications (e.g., Lim & Lippman, 1991; Theiler & Lippman, 1995), but no attempt has been made to continue the examination of mental practice effects on musical tasks of varying difficulty.

Purpose and Research Questions

Three main issues regarding mental practice research related to music performance should be addressed. First and foremost, mental practice studies in music have concerned themselves with the tasks of either performing or memorizing selections of written music. Musical tasks that are different in nature such as the performance of tonal patterns over written harmonic progressions have not been examined. Secondly, within the tasks of performing or memorizing music, save the Rubin-Rabson study (1941), no attempt has been made to see if the difficulty of the musical selections influence the effectiveness of mental practice. Third and last, all the studies have limited themselves to effects of mental practice alone or to effects of a specific combination of physical and mental practice. Comparisons between the effectiveness of varying combinations of physical and mental practice on musical tasks have not been performed and as Hird, Landers, Thomas and Horan (1991) point out: "although the effects of physical practice alone and mental practice alone are well documented, the effects of various combinations of physical and mental practice relative to physical practice alone are less understood" (p.281). Therefore, the purpose of this study was to investigate the relative effectiveness of different proportions of time spent on physical and mental practice, in the context of performing a tonal pattern over harmonic progressions of different difficulty levels.

The specific questions were:

1. Were there differences on the measure of note errors between the different practice groups of physical practice, combined physical and mental practice in the proportions of 66% physical and 33% mental practice, combined physical and mental practice in the proportions of 33% physical and 66% mental practice, and mental practice?

2. Was there a difference between the easy harmonic progression and the hard harmonic progression on the measure of note errors?

3. Was there an interaction between the difficulty levels of the harmonic progression and the practice groups on the measure of note errors?

CHAPTER 2

RELATED LITERATURE

In this chapter, a brief chronological outline of mental practice research is presented as well as an in-depth summary of critical reviews regarding research related to mental practice. Information concerning the use of mental practice by musicians is summarized including a detailed description of those studies that have dealt specifically with the effectiveness of mental practice in music performance. Explanatory theories regarding the effectiveness of mental practice are outlined and their applicability are discussed. The chapter closes with a detailed explanation concerning the performance of tonal patterns based on chord changes and how this type of musical task differs from musical tasks that have been used in mental practice research.

Mental Practice Research: The Beginnings

Mental practice research may be traced to Washburn who in 1916 wrote a book titled "Movement and mental imagery" which dealt with the phenomenon of imaging in movement. Many of the ideas that were put forward in the book were based more on speculation than on fact but, as Corbin (1972) pointed out, "Washburn did make some observations that provide a basis for current study of the effects of mental practice on the development of skilled motor behavior" (p.95). Washburn argued that movements of slight magnitude occurred when one simply imagined oneself performing an activity and that this movement was basically the same as those movements produced by the actual movement itself.

The first empirical study in which evidence was found that actual muscular activity did occur during imaging a physical skill, was conducted by Jacobson (1932). He measured the slight changes in the action potentials of the nervous and muscular system during mental activities and found that muscular activity did occur during imagining of physical tasks. Although this work did not address the issue of whether mental practice improved motor performance, it did provide important information as to the relationship between practicing a skill mentally and the muscular activity that was produced during that activity.

In a similar type of study, Shaw (1938) measured muscular action potentials during the imaging of various types of activities. Of particular interest regarding this study was the fact that several of the activities imagined were related to music activities such as singing and the playing of the clarinet. Twelve subjects were asked to imagine singing a popular song ("Dinah") and nine subjects were asked to imagine playing the song on clarinet. Although information regarding the background of the subjects was scarce, action potentials of arm and leg muscles were found to increase during imaging.

One of the first studies designed specifically to test the effectiveness of mental practice, was conducted by Sackett (1934). He compared the effectiveness of two methods of "symbolic rehearsals" with that of no rehearsal on the task of retaining a previously learned maze. The rehearsals included either a week of mental rehearsal of the maze, or a week of rehearsal, which required the drawing of the maze several times from memory. In a second study, Sackett (1935) attempted to determine the relationship between the retention of a maze habit and the various number of mental rehearsals carried out within the period of a week. In both studies the mental practice group fared better than no practice.

Vandell, Davis, and Clugston (1943) have been cited within the mental practice literature as being probably the first to have conducted a study that used a motor skill task (e.g., Corbin, 1972; Weinberg, 1982). They evaluated the effects of mental practice on the acquisition of a motor task. Subjects included three different age groups of 12 males each; (a) college freshmen, (b) junior high school boys, and (c) high school boys. Each group was divided into three conditions: one group of four receiving no practice, one group of four practicing overtly and physically for 20 days, and one group of four practicing mentally for 20 days. Subjects in the three conditions were equated on intelligence, chronological age, motor ability, and physique. Each age group received different tasks. The college students performed a dart-throwing task, the high school boys a basketball throwing task, and the junior high school boys a dart-throwing task. Although no statistical tests were conducted, results indicated that both the physical practice and the mental practice groups displayed increases in performance. This study provided both the impetus for future investigations concerning the effect of mental practice on motor performance and the basic methodology for this type of research.

Twinning (1949) examined the effect of mental practice and physical practice when learning a ring-tossing task. Subjects were divided into three groups of physical practice, mental practice, and no practice. Each subject was tested by throwing 210 rings on day 1 and on day 22. The physical practice group practiced by throwing 70 rings on each day between day 1 and day 22. The mental practice group practiced mentally for fifteen minutes each day while the control group had no practice sessions between the test days. An important difference between this study and the previous one was that statistical procedures were used in interpreting the data. Results indicated that both mental practice and physical practice groups performed better than the control group. In addition, Twinning suggested that after about five minutes of mental practice, subjects could not adequately concentrate on the task indicating that there may be an optimal amount of time in which mental practice is most effective.

Critical Reviews on Mental Practice Research

From the initial research in the area of mental practice, various types of tasks and methodologies have since been used in an attempt to answer questions relating to different aspects of mental practice. At the same time, a number of critical reviews and analyses have been written by Richardson (1967a,b), Corbin (1972), Feltz and Landers (1983), Feltz, Landers and Becker (1986), Hinshaw (1991) and Driskell, Copper and Moran (1994). These reviews and analyses have summarized the findings within mental practice research and have posed questions regarding the validity of certain aspects within this field of research.

In a review of 22 studies, Richardson (1967a) recognized three areas of performance on which mental practice research had focused. These included facilitating the initial acquisition of a motor skill, aiding the retention of a motor skill, and improving the immediate performance of a motor skill. Most of the studies reviewed were acquisition type of studies, which usually had 3 groups of subjects divided into mental practice groups, physical practice groups and a control group. The number of subjects varied from as few as four to as many as 72 per group while mental practice rehearsal ranged from 1 minute to 30 minutes. The majority of studies reviewed supported the basic hypothesis that mental practice facilitated the acquisition of a skill. Two studies showed negative results for mental practice, yet showed that a combination of physical and mental practice was greater than physical practice alone.

Of the 22 studies only 2 were mentioned as coming under the category of immediate performance, i.e. mental rehearsal of a skill prior to its execution. One of the retention related studies was by Rubin-Rabson (1941) on piano performance. She found that the combined physical and mental practice group achieved the best retention of a musical excerpt (a detailed description of this study appears later on in the chapter).

Richardson (1967a) concluded that regardless of methodological inadequacies, most of the studies indicated an improved performance on the task associated with mental practice procedures. Of those reviewed, 11 were statistically significant, seven showed a positive trend, three reported negative findings, and one was equivocal. Also, a trend existed in which alternate physical and mental practice trials were as good or better than physical practice trials alone. Several conclusions were made regarding length of practice and familiarity with the task. It was concluded that mental practice sessions should not last more than 5 minutes if concentration was to be maintained, and that the degree of familiarity with the physical performance of the task was related to the efficiency of mental practice.

Richardson (1967a) listed the different individual variables that had been studied in an attempt to understand those factors that may facilitate the amount of improvement gained from mental practice. These variables included abstract reasoning, games ability, imagery, intelligence, kinesthesia, mechanical reasoning, motor ability, selective attention, gender, and spatial relations. In a summary of the findings related to the different variables, Richardson pointed out that "only games ability and one of the two studies on motor ability, imaging ability, and the capacity for selective attention show a significant relation to amount of gain from MP [mental practice]" (p.105). In his second paper, Richardson (1967b) discussed several methodological problems relating to mental practice research. He pointed out that little attention was given to the instructions of mental practice or to the accuracy with which mental practice was carried out.

Corbin (1972) addressed the issues of mental practice and task specificity, and discriminated between three types of tasks in relation to mental practice; ideational tasks, motor skill tasks, and physical fitness tasks. Ideational tasks or symbolic activities included such tasks as mirror drawing, maze tracing and card sorting. These tasks emphasized symbolic rather than motor aspects of skilled performance. A total of five studies and one review were cited as suggesting the effectiveness of mental practice in these kinds of tasks.

Motor skill tasks that were reviewed all related to throwing types of activity which included basketball throwing, dart throwing, ring toss, baseball throw, and wand juggling. Apart from one of the wand juggling studies, all the others showed some kind of benefit for mental practice. Of interest were the findings of some studies which concluded that some degree of physical skill had to be present so that the subject could gain maximal effect from mental practice. Physical fitness tasks included tasks that were related to the effects of mental practice on muscular endurance and physical fitness. No effects of mental practice were found on these type of tasks.

Corbin (1972) described several conditions that effected mental practice. These included length of practice sessions and duration of the learning experience. Of special interest was his discussion on the phenomenon of reactive inhibition, i.e., the tendency of task repetition to interfere with task learning of performance. According to this phenomenon, as the length of practice becomes more excessive, performance decreases. This suggested an optimal length for practice sessions. The same issue was discussed concerning duration of the learning experience in terms of days, weeks or months. A similar effect of optimal time was recognized for the duration of practice. Additional practice beyond this time limit may have resulted in decreased performance known as the paradoxical distance effect. Also of concern was the issue of scheduling of practice sessions. Research indicated that distribution of practice was more effective than massed practice.

Corbin (1972) discussed several individual characteristics that may have effected mental practice. The hypothesis of previous experience to be a prerequisite for effective use of mental practice was supported by several studies. These studies indicated that performers of higher skill used mental practice more effectively than performers of lower ability. Regarding gender or intelligence, no correlation was found between these factors and the effectiveness of mental practice. Corbin (1972) also discussed the issue of mental practice instructions. He suggested that the type of instructions (written, audio, none, visual) and the time of their administration (before or during mental practice) may have effected the outcome.

Unlike both the reviews by Richardson and Corbin that were based on a somewhat selective summary of findings, the rationale behind the work of Feltz and Landers (1983) was to assess the knowledge on mental practice based on a statistical analysis of the research that had been done. The main criticism put forward by Feltz and Landers regarding previous reviews relating to mental practice, specifically the reviews by Richardson (1967a) and Corbin (1972), were that the studies were chosen on a selective basis. They included both statistically significant and non-significant findings that made it hard to obtain a clear picture of the effectiveness of mental practice. Feltz and Landers gave several reasons as to why conclusions about mental practice gained from these reviews may have been distorted. They claimed that too few studies were included in the reviews to portray the overall empirical findings and suggested that possible bias on the reviewers' part may have influenced the selection process. Another aspect that was criticized was the various variables that were suggested as influencing the effectiveness of mental practice. These, they claimed, were speculative in nature and were presented in a more narrative and rhetorical fashion than technical and statistical. The last argument put forward against the reviews was that tools for sophisticated research integration, which would have taken into account the issue of relationship strength, were not available at the time.

Feltz and Landers (1983) utilized a meta-analysis procedure, which is a way of statistically analyzing the findings of many individual sets of data. As the researchers pointed out, "the research on mental practice is systematically compatible with the meta-analysis approach in that considerable research employs identical or conceptually similar variables, and therefore, statistical procedures can be reliably employed" (p.27). The criteria for selection of studies for the meta-analysis were only those studies that included groups that were (a) given only mental practice and (b) had either pretest scores or a control group to be compared with.

The selected studies were coded into those categories that according to the literature reviews were believed to moderate the effects of mental practice (cf. Corbin, 1972; Richardson, 1967a, 1967b). The categories were divided into three characteristics; subject, task-type, and design characteristics. Subject characteristics included gender, age, and experience with the task. Task-type characteristic differentiated between motor, strength and cognitive tasks as well as self paced tasks (closed skills) and reactive tasks (open skills). For design characteristics, studies were coded as having either a pre-post only design, a simple control group, or a motivational control group. Also coded were the number of practice sessions given before the posttest and the length of each practice session (in trials or minutes). Studies were also coded as to whether the posttest was given immediately after mental practice (within 10 minutes) or whether it was delayed. The final variable coded was whether the research had been published or not. The reason for this was that published studies tended to be more biased toward statistical significance, which may have lead to overly optimistic estimates of the effectiveness of mental practice.

Out of 98 identified studies, 28 did not meet the criterion and 10 were unobtainable, thereby leaving 60 with which to perform the meta-analysis. Some of these measured mental practice on more than one task or under more than one condition, therefore the number of effect size measures exceeded the number of studies and reached a total of 146 effect sizes. The effect sizes were calculated as the differences between posttest scores of the mental practice group and the posttest score of the control group divided by the within group standard deviation.

The overall average effect size for mental practice was ES = 0.48 which implied that mentally practicing a motor skill influenced performance somewhat better than no practice at all. Furthermore, analysis indicated that the only significant comparisons were between cognitive and motor tasks, cognitive and strength tasks, and published and unpublished tasks. Cognitive tasks had a larger average effect size (ES = 1.44) than motor tasks (ES = 0.43) or strength tasks (ES = 0.20). Also, the average effect size of published studies (ES = 0.74) was more than double the average effect size in unpublished studies (ES = 0.32).

A significant third-degree polynomial relationship between length of practice sessions and effect size and between number of practice trials per session and effect size was found. Practice sessions that were under one minute or between 15 to 25 minutes and studies that employed less than 6 trials or between 36 to 46 trials per practice session produced the largest mental practice effects. The type of task seemed to moderate the amount of mental practice. Cognitive tasks were associated with very few trials/ minutes and motor and strength tasks generally required many more trials/ minutes to achieve large effect sizes.

In their discussion of the results, Feltz and Landers (1983) stressed some of the limitations of applying meta-analysis to the studies of mental practice. These included non-randomness of studies and unequal distributions which did not permit examination of interaction effects among predictors. On the other hand, the major advantage of the meta-analysis was the ability to break down the variables of interest, in this case subject, task, and design characteristics thought to be important.

Of all the coding characteristics examined, the most important findings related to the task characteristics. Cognitive tasks like peg board test, maze learning, card sorting, and finger maze had much larger effect sizes than tasks that were essentially motor or strength related. Also cognitive tasks were most often achieved in a relatively short practice session (M=3.17 min.) and with only a few trials (M= 4.17) compared to motor (M = 7.3 min. and 17.97 trials) and strength tasks (M = 7.5 min. and 10.0 trials).

In a revised meta-analysis by Feltz, Landers and Becker (1986), results of which were published two years later (Feltz, Landers and Becker, 1988), 48 studies were reviewed, 69 % of which had already been analyzed in the previous work. This time the purpose was to examine learning effects by means of effect sizes for pre- to posttest differences. They also compared mental practice effects to those of no practice, physical practice, and the combination of physical and mental practice. Investigations chosen for the review were only those that contained complete data for pretest and posttest comparisons. Pre- to posttest effect sizes were mostly calculated as the difference between pretest and posttest divided by the pretest standard deviation. In two studies where pretest standard deviation was not reported, the posttest standard deviation replaced the pretest standard deviation in the computation of the effect size.

Results revealed that physical practice had the largest effect size of ES = 0.79 followed by that of the combined physical and mental practice groups which was ES = 0.62. The mean weighted effect size of pre- to posttest change for mental practice was ES = 0.47 whereas the effect size of the control groups were only ES = 0.22. One of their suggestions for future research was to find out whether the effect size difference between physical practice and combined physical and mental practice could be decreased by increasing physical practice proportion of the combination to ratios such as 60:40 or 70:30 physical to mental practice trials.

Hinshaw (1991) applied a meta-analysis to 21 published studies, 18 of which had been included in the Feltz and Landers' (1983) analysis. The criterion for selection of studies was that they included adequate control and that one condition be mental practice alone. Also, investigations that included a combined physical and mental practice group or did not provide the necessary statistics were eliminated from the sample. Studies were coded according to categories similar to those that had been used by Feltz and Landers (1983), some with slight variation, and other categories were added. The main variation was in the coding of task variable. Though tasks were coded into cognitive, motor, and strength tasks, the motor tasks were separated into athletic and laboratory skills. Athletic tasks were those that could be incorporated in competitive situations such as free throw shooting and dart throwing, Laboratory tasks included research-oriented skills such as stabilometer manipulation. The rationale behind these two categorizations was that mental practice may have a differential effect on tasks that subjects would have had previous experience with, than on tasks that subjects would unlikely have had experience with such as the laboratory tasks. Categories that were new compared with the Feltz and Landers analysis (1983) concerned mainly methodological issues. These included the overall length of the study (duration), the type of mental practice required (internal, external or not reported), the manner in which the instruction were given (audio, visual, written or verbal), whether relaxation was required prior to rehearsal, and the total number or amount of mental rehearsal completed by the subject during the whole duration of the study.

A total of 44 effect sizes were calculated and an overall average effect size of ES=0.68 was found for mental practice. Only two significant findings were reported. One was a significant main effects for type of mental practice in which internal imagery produced a significantly larger effect size than external imagery. The second was a significant main effect for number of mental practice trials as measured in minutes. Trial sessions of less than or equal to one minute and trials of ten to fifteen minutes produced significantly larger effect sizes than trial sessions that were between three to five minutes in length. No significant differences were found between the athletic motor tasks and the laboratory tasks and apparently no significant differences were found between cognitive, motor and strength tasks.

No attempt was made by Hinshaw (1991) to explain results in light of the findings by Feltz and Landers. For example, the larger overall effect size for mental practice of ES=0.68 compared with the Feltz and Landers (1983) somewhat smaller overall effect size of ES=0.48 was in need of some sort of explanation. Especially in light of the fact that 85% of the studies used in the meta–analysis had already been analyzed by Feltz and Landers (1983). One may only suggest that the larger effect size was attributed to the non-inclusion in the Hinshaw (1991) study of unpublished studies. These studies had been found in the Feltz and Landers study to have an overall low effect size of ES=0.32. Indeed, the overall average effect size of ES=0.68 of the Hinshaw analysis is closer to the average effect of published studies found by Feltz and Landers of ES=0.74.

Hinshaw (1991) did not find significant differences between task types although such significant differences were found by Feltz and Landers (1983) between the effect sizes of cognitive tasks with those of motor or strength tasks. Since only one study out of those selected by Hinshaw to be included in the analysis utilized a cognitive type task, it was not quite clear why statistical comparisons regarding this type of task were even attempted.

Driskell, Copper, and Moran (1994) also applied a type of meta-analysis (defined by them as a meta-analytic integration) to mental practice studies that were selected based on specific criteria different from those used by Feltz and Landers (1983). The latter included in their meta-analysis studies that used various types of mental practice with interventions such as combined physical and mental practice, combined mental practice with modeling, combined mental practice and audiovisual instruction, combined visual imagery-relaxation and broadly defined psyching-up strategies. According to Driskell, Copper, and Moran (1994), this type of selection made it difficult to ascertain whether or not the effect reported was derived from the interventions themselves and not from mental practice per se. To provide a clearly defined and unambiguous test of the effects of mental practice on performance, selection criteria for the meta-analysis involved a precise, unidimensional operationalization of mental practice. The works included had to provide a clear examination of the effects of mental practice, defined as the "cognitive rehearsal of a task prior to performance" (p.482). Therefore, investigations in which the mental practice manipulation was some composite of physical and mental practice, mental practice with modeling, mental practice and relaxation, positive imagery, or emotional arousal were not considered as legitimate tests of the effects of mental practice on performance and were excluded. Furthermore, the selection criteria specified that the hypothesis test had to compare the performance of subjects engaging in mental practice with the performance of subjects engaging in no practice. For that reason studies that did not include a specific no-practice control group were not included. The use of such precise and rigorous criteria for inclusion was to focus the current analysis exclusively on mental practice and not on more broadly defined mental preparation techniques.

Driskell, Copper, and Moran (1994) had two primary goals. The first goal was to establish the overall magnitude of the effect of mental practice on performance, and the second goal was to test hypotheses about the nature of the relationship of mental practice to performance; that is, under what conditions mental practice was most effective. Five factors were expected to moderate the relationship between mental practice and performance: the type of task (cognitive as opposed to physical), the retention interval (the time interval between practice and assessment), the experience level of trainees, the number of trials or duration of practice, and the type of control group used. Type of control group included a no-contact type of group that received no contact between initial assignment to treatment and a contact control group which engaged in some non-treatment activity for a period equivalent to the practice time of the treatment group.

A total of 35 studies, 51% of which had been previously included in the analysis by Feltz and Landers (1983), met Driskell, Cooper, and Moran's (1994) required criteria. These consisted of 100 separate hypothesis tests representing the behavior of 3214 subjects. Results of the analysis indicated that the effectiveness of mental practice for enhancing performance was statistically significant. A comparison of the difference between the overall magnitude of the effect for mental practice and the magnitude of effect for physical practice was significant, indicating that mental practice was less effective than overt, physical practice.

Several trends were found concerning the five moderating factors some of which were consistent with the previous analysis by Feltz and Landers (1983). The more the task involved cognitive activities, the more effective was mental practice. Regarding retention interval, the longer the delay between practice and performance, the weaker the effects of mental practice on performance. The effect of experience was moderate in magnitude and significant for both experienced and novice subjects. However, the overall basic effect of experience was qualified by the type of task. For novice subjects, the results indicated stronger effects of mental practice for cognitive tasks than for physical tasks. For experienced subjects, there was no significant difference for cognitive or physical tasks.

The data indicated no significant relationship between the number of trials and the magnitude of effect of mental practice. There was a significant negative relationship between the duration of mental practice and the magnitude of effect suggesting that as the overall length of the mental practice intervention increased, the beneficial effect of mental practice on performance decreased. In other words, although the overall effect of mental practice on performance was positive, the longer someone mentally practiced, the less beneficial it became.

The effects of mental practice on performance for the 20 hypothesis tests using equivalent control groups was small in magnitude and non-significant. The effects of mental practice for the 39 hypothesis tests using no-contact control groups was somewhat larger and significant. However, focused comparison of effect sizes obtained for equivalent versus no-contact control groups was not significant. Therefore, although there was a trend for mental practice to be more effective in comparison with a no-contact control group than in comparison with an equivalent control group, this difference was not significant.

It can be concluded from these reviews and analysis that mental practice research has concerned itself not only with the general question of the effectiveness of mental practice but also with the various types of tasks that may benefit more from mental practice. These include acquisition, retention and immediate performance of various types of tasks which are characterized as being on a continuum between high on cognitive elements to low on cognitive elements. These tasks have been categorized as being of either cognitive, motor or strength characteristic. In all of these tasks, mental practice has been found to be effective to a certain degree.

Moderating Factors on Mental Practice

From the previous reviews and analysis it was found that the efficacy of mental practice was also dependent on variables such as length and duration of mental practice, distributed practice vs. massed practice, experience vs. inexperience, and complexity of task. Several studies in mental practice have tried to further examine the specific parameters that moderate the efficacy of mental practice such as various combinations of physical and mental practice (Hird, Landers, Thomas, & Horan, 1991) and duration and order of presentation of the mental practice period (Etnier & Landers, 1996).

Hird, Landers, Thomas, and Horan (1991) examined the effects of different ratios of physical and mental practice on the performance of tasks classified as essentially cognitive or motor. The tasks included a pegboard task, which was categorized as a cognitive task and a pursuit rotor task, which was categorized as a motor task. The pegboard task included a square like apparatus where on one side it had 30 red and blue squares arranged in a checkerboard fashion numbered in arbitrary sequence with the restriction that red squares had odd numbers and the blue squares had even numbers. In the center of each red square there was a square hole and in the center of every blue square there was a circular hole. On the left hand side of the apparatus there were 15 square red pegs, and on the right hand side there were 15 round blue pegs. Subjects took a square red peg with their left hand and placed it in square 1. Then, with their right hand they took a round blue peg and placed it in square 2. The remaining squares were then filled in numerical order with the remaining pegs. Each subject had four 60-s trials per session. Each trial was separated by a 60-s inter-trial interval. The subject's trial score was the total number of squares in which the subject had placed a peg. The subject's score for pre- and posttest sessions was the mean of the last four trials.

To perform the pursuit rotor task, subjects kept a stylus in their dominant hand to track the target, which moved in a circular pattern on a turntable at a speed of 45 rpm. Subjects performed eight 15-s trials per session in which they were required to keep the tip of the stylus in contact with the target for as long as possible. Each trial was separated by a 15-s inter-trial interval during which the subjects were verbally instructed to count backwards from 500 by 3s. The subject's score for pre- and posttest sessions was the mean time-on-target for the eight trials.

Seventy-two subjects (36 male and 36 female) blocked on gender were randomly assigned to one of six experimental and control treatments for each task. Subjects were randomly assigned to a task order either cognitive/motor or motor/cognitive. The six treatment groups included (a) a physical practice group; (b) a 75:25 combined practice of mental practice on trials 1 and 5 and physical practice on trials 2-4 and 6-8 on the pursuit rotor task. For the pegboard task mental practice on trial 3 and physical practice on trials 1,2, and 4; (c) a 50:50 combined practice which for the pursuit rotor included mental practice on trials 1,3,5, and 7, and physical practice on trials 2,4,6,and 8. On the pegboard task mental practice was performed on trials 1 and 3 whereas physical practice was performed on trials 2 and 4; (d) a 25:75 combined practice which included mental practice on trials 1-3 and 5-7 and physical practice on trials 4 and 8 for the pursuit rotor and mental practice on trials 1-3 and physical practice on trial 4 on the pegboard task; (e) a mental practice group and (f) a motivational control group that practiced on a stabilometer task.

On day 1, each subject was pretested on both tasks in a randomly determined order. On days 2-8 subjects practiced according to their designated group. On day 9 subjects were posttested on both tasks.

Results of the analysis of variance revealed a significant treatment by pre-post interaction for both tasks. Also, with the exception of the control group for the pegboard task, all treatment conditions showed significant differential improvement from pre- to posttest. Effect sizes were calculated so that observed mean differences could be compared to findings of previous meta-analysis. Two types of effect sizes were presented in the study that showed somewhat contradictory findings. The first of these effect sizes were posttest effect sizes which were calculated as the differences between posttest scores of each practice group and the posttest score of the control group divided by the within group standard deviation. The posttest effect sizes showed a linear trend in which as the proportion of physical practice was higher, the posttest effect sizes of the groups increased. Mental practice had the least posttest effect size and physical practice had the largest posttest effect size. Regarding the combined practice groups, the higher the proportion of physical practice, the larger the posttest effect size of that group. The posttest effect size of the mental practice group for the cognitive (pegboard) task was found to be higher than for the motor (pursuit rotor) task as was anticipated.

The second type of effect sizes calculated were the pre- to posttest effect sizes of each group using the same method that was used in the Feltz, Landers, and Becker (1986) study. The pre- to posttest effect size was calculated as the difference between the pretest and posttest divided by the pretest standard deviation. The results of their pre- to posttest effect sizes revealed a totally different pattern of effect sizes. For example, for the pegboard task the largest effect sizes were of the 75:25 and 50:50 combined practice groups. What was even more suspect in light of previous studies in mental practice was that on the pursuit rotor task, mental practice had a larger effect size than all the other practice groups including that of the physical practice group. The authors suggested that this disparity was caused by the different pretest standard deviations.

An alternative explanation for the apparent inconsistency found between the posttest effect sizes and the pre- to posttest effect sizes has to do with the violation of a basic assumption concerning the calculation of pre- to posttest effect sizes. This calculation relied on the assumption that both pre- and posttest scores had equal variances (Becker, 1988) and equal standard deviations (Cohen, 1969). As Becker (1988) pointed out the consequence of this assumption meant that the standard deviation of either the pretest or the posttest may be used as the denominator. In the study by Hird, Landers, Thomas and Horan (1991) the assumption of equal standard deviations was clearly not met due to the large differences in the standard deviations of the pre- and posttests that, in the extreme case, reached that of 700% difference. In light of this difference, had the posttest standard deviation been used as the denominator a different trend of pre- to posttest effect size would have been obtained. To illustrate this, Table 1 presents a comparison of their originally calculated pre- to posttest effect sizes for each group on each task, and the recalculated effect sizes using as the denominator the posttest standard deviations. As can be seen from the comparison, the new pre- to posttest effect sizes revealed a pattern that was more consistent with findings in general regarding physical and mental practice, and more consistent with the study's own findings using posttest effect sizes. On both tasks the effect size of the physical practice group was larger than that of the mental practice group. All the effect sizes of the combination practice groups were smaller than the physical practice group, and all but the 50:50 combined practice group effect size were larger than the mental practice group. Regarding the combination groups there was no clear pattern in which the higher the proportion of physical practice the larger the effect size.

Table 1: Comparison of Original Pre- and Posttest Effect Sizes as Presented in the Hird, Landers, Thomas and Horan (1991) Study and The Recalculation

	Original effect size using pretest SD		Effect size using posttest SD	
Group	Pegboard	Rotor	Pegboard	Rotor
PP	8.32	3.78	2.44	3.74
75:25	10.73	3.41	2.26	2.89
50:50	10.12	4.58	1.44	2.78
25:75	5.08	2.98	2.05	3.13
MP	7.38	4.76	1.97	2.71
Control	0.90	1.27	0.53	1.40

These newly calculated effect sizes, though not entirely consistent with the posttest effect sizes reported by Hird, Landers, Thomas and Horan (1991), were more in tune with the study's own results in which as the proportion of physical practice was higher, so was the posttest effect of that practice group larger. Therefore the conclusions made by Hird, Landers, Thomas and Horan (1991) that were based on the pre- to posttest effect sizes should be reexamined. Specifically the conclusion that the higher pre- to posttest effect size of the mental practice group on the cognitive task compared to the lower pre- to posttest effect size on the motor task was to be expected. The newly calculated results using the posttest standard deviations, show that the pre- to posttest effect size of the mental practice group on the cognitive (pegboard) task was lower than that of the motor skill (pursuit rotor) task.

Goginsky and Collins (1996) have criticized another conclusion made by Hird, Landers, Thomas and Horan (1991) on the grounds of methodological error. This was the conclusion that the higher posttest effect size for mental practice on the cognitive (pegboard) task compared to that of the motor (pursuit rotor) task was to be anticipated. Goginsky and Collins claimed that the different effect sizes of the mental practice method on the cognitive task and the motor task may have been attributed to the amount of practice time which for the cognitive task was a total of four minutes whereas for the motor task was a total of only two minutes.

Etnier and Landers (1996) reexamined the influence of the procedural variables of temporal length of mental practice and temporal location of mental practice on performance. Subjects included 153 student volunteers with basketball experience ranging from no past experience to that of having previous experience. Performance ability was measured by a 3-minute basketball-shooting task. Subjects attempted to make as many baskets as possible within the 3 minutes, and their performance was scored as number of baskets made. They were then randomly assigned to a practice group. The practice schedule of each group included 3 minutes of physical practice and either a 1, 3, 5, or 7 minute mental practice period which was procedurally placed before or after the physical practice period adding to a total of 9 groups (the ninth being a control group were there was no mental practice). After a 5-minute warm-up and a 1-minute rest period each subject began his practice schedule. Following the practice schedule, the subject was asked to again perform the 3-minute shooting task (Trial 2). This was followed by another 1-minute rest period, performance of the same practice schedule, and another performance of the shooting task (Trial 3).

Analysis using repeated measures of multiple analyses of variance (MANOVAs) were performed with improvement at trial 2 and at trial 3 as the dependent variables and with time of measurement as the within subject factor. Results indicated that the interaction effect for order (mental practice before or after physical practice) x trial number was significant. Examination of the mean improvement at trial 2 showed that the control group and the groups who began with mental practice improved more than the groups who began with physical practice. For trial 3 all groups fared better than the control group. However the same trend in which groups beginning with mental practice improved more than the groups beginning with physical practice repeated itself.

The interaction effect for duration x trial number was also significant. The nature of the interaction effect was such that the mean improvement at trial 2 was larger for the groups who received 3-min., 1-min. or no mental practice than for the 5- or 7-min. mental practice. Mean improvement at trial 3 showed that the groups who received 1- or 3-min. mental practice improved more than the other groups. However at trial 3 all mental practice groups were better than the control group.

The Use of Mental Practice by Musicians

Evidence regarding the use and benefits of mental practice exist in various studies related to specific musical tasks. For example, McPherson (1994) measured 101 high school instrumentalists for their ability to sight read in an attempt to find what strategies were characteristic of sight-readers of high ability. A content analysis of interviews with the eight high scoring and eight low scoring subjects on the sight reading measure showed that the higher scoring subjects were more cognizant of important details regarding the piece to be performed prior to beginning their performance. One of the subjects was quoted as saying:

> I first look at the key and time signatures, and then look through the music to see if there are any different parts, for example, if there are sixteenth notes, triplets, or accidentals. I then try and run over the harder sections by singing them in my mind as I finger them on my instrument. (p.227)

This type of comment was typical of the highest scoring subjects all of whom mentioned the strategy of scanning the music to find and mentally rehearse difficult obstacles. Based on the results of the study, McPherson proposed that one of the characteristics of competent sight-readers was a self-regulatory approach that included mental rehearsal of the major difficulties before commencing to play.

Encoding strategies have also been found to include mental rehearsal techniques. From preliminary questionnaire data, Mikumo (1992) found that subjects used several strategies for encoding pitch information. These included, among other things, "mental rehearsal, visualization (in which tones were visualized as contours, on a keyboard, or in notation) or finger tapping as if playing on the piano" (p.73). In a study designed specifically to examine the efficiency of finger tapping as opposed to other types of encoding strategies, Mikumo (1994) found that from among twelve subjects, those who were highly trained in music used the external tapping strategy more effectively than the internal encoding strategies.

In a more inclusive study designed to gain information about the use of mental imagery in musical performance, Trusheim (1987) interviewed 26 professional orchestral brass players. In developing an interview guide, several major topics were included, among them the topic of mental practice. Questions regarding mental practice were divided into (a) mental rehearsal during practice and training, and (b) mental rehearsal during performance. The interviews were recorded and later analyzed in four major stages based on a qualitative research design model.

Of the 26 players, 24 regarded mental practice as a useful and important technique in their preparation for performance. Analysis of the responses revealed several major issues regarding the application of mental rehearsal strategies in both practice and performance situations. Trusheim (1987) differentiated between two types of mental rehearsal. The first he called spontaneous mental rehearsal which could occur during activities that were not associated with actual practice, such as during a car ride or whilst running. The second type was a more conscious and controlled fashion of mental practice used during rehearsal. Twenty-two of the players reported such instances though the nature of the mental practice and the musical aspect upon which the mental practice focused differed between players. The various musical elements they focused on included aspects of sound and the conquering of technical difficulties, such as fingering or intricacies in rhythm. Trusheim included within mental practice such elements as mentally hearing accompaniments while practicing or visualizing techniques in preparation for performance. In addition to mental practice during regular practice, eleven subjects made specific comments about mental practice during performance. This included mental rehearsal during intermission or just prior to the actual performance of a difficult passage.

In a similar study based on the same type of interview methodology, Carter (1993) interviewed eleven professional singers on their use of imagery. Here too, mental rehearsal was included as a category. All singers used some form of mental practice. Five of the singers would mentally hear the vocal line whereas six of them would mentally see and hear the accompaniment. Interestingly, the use of mental practice was enhanced when the voices of the singers were strained or fatigued.

The fact that mental practice is a necessary component of sight reading skills and that it is used as encoding strategies or as a legitimate practice strategy by professional musicians does not give any indication regarding its effectiveness in comparison to other forms of practice. The comparison of rehearsal strategies has been the major issue regarding mental practice in general and mental practice related to music performance in particular.

Effectiveness of Mental Practice in Musical Performance

From its beginning, mental practice research utilized musical tasks as part of the general physical tasks which subjects were to imagine or recollect. Already within the first investigation published which provided empirical evidence that muscular activity occurred during imaging a physical skill (Jacobson, 1932), musical tasks were part of the overall tasks required from the subjects while imaging and recollecting. Instructions in preliminary tests on imagination included "Imagine playing the piano" (p.682) while instructions in recollection included activities such as playing the violin. As mentioned earlier, Shaw (1938) in part of his study required from his subjects to imagine the musical activities of singing and playing the clarinet to measure muscular action potentials during imaging.

The first study specifically related to mental practice in music learning was by Rubin-Rabson (1941). She compared three methods of rehearsal in learning and retaining short piano excerpts. In all methods, 5 minutes of analytical study was allowed before actual practice on the keyboard began. The first method, (A), followed the analytical study with five physical practice (PP) keyboard trials, four minutes of mental practice (MP) and then physical practice keyboard trials to the criterion of a perfectly memorized performance (PP-MP-PP). The second method, (B), followed the analytical study with physical practice keyboard trials to the above criterion and then four minutes of mental practice (PP-MP). The third method, (C), followed the analytical study with physical practice keyboard trials to the above criterion followed by four minutes of extra physical practice keyboard trials (PP). Mental practice subjects were asked to "perform the material mentally with eyes closed, to maintain the image of the notes as firmly as possible, and to refer to the music only when there was confusion or uncertainty" (p.595).

The subjects included nine adult pianists and the experimental materials included nine short but complete musical periods ranging from five to ten measures in length from unfamiliar piano pieces. The variables of subjects, methods, materials, and order were rotated according to the Latin-Greek square so that each subject performed the experiment three times giving a total of twenty seven learnings for each method. In order to assess retention a relearning period was done two weeks later and then seven months later.

The results showed that during the study period method A (PP-MP-PP) needed less physical practice trials in total than method C (PP) but achieved the same retention ability after two weeks. Method B (PP-MP) exhibited less retention than the other two methods. An analysis of the experimental materials ranked according to difficulty showed some tendency toward a superiority in method A (PP-MP-PP) for the three easiest and the three medium difficulty pieces, but for the three most difficult pieces method C (PP) was the most effective. Retention after seven months showed no superiority for any method. In an attempt to explain the superiority of method A (PP-MP-PP) the author suggested that "the interruption for mental rehearsal may provide a literal `pause that refreshes' due to the cessation of hand movements and an opportunity to think through and reorganize points of confusion without the necessity of maintaining an unbroken rhythm" (p.599).

Ross (1985) examined the relative effectiveness of several practice procedures in improving trombone performance. Thirty college music students majoring in trombone were randomly assigned to five groups, each group assigned to one of five practice procedures: three physical practice trials (PP); three mental practice trials (MP); three mental practice with simulated slide motions trials (MPS); a combination of one physical practice trial, one mental practice trial, and one physical practice trial (PP-MP-PP); and a no practice (NP) control (subjects read a motivational article on sight-reading). Subjects performing the mental practice were encouraged "to `see', `hear', and `feel' themselves as vividly as possible" (p.224). A pretest and posttest design was used in which an etude was performed and scored by assigning one point for each measure that was played correctly with respect to pitch, rhythm and articulation. Gain scores were computed by subtracting pretest from posttest scores, the results of which were analyzed using an analysis of covariance.

The results showed that the combined practice group (PP-MP-PP) received the most substantial gain though not significantly better then either the physical practice group or the MPS group. The only significant differences lay between the combined practice (PP-MP-PP) and both the NP control and mental practice groups and between the physical practice and the control group.

Coffman (1987) examined the effects of both (a) physical and mental practice and (b) aural knowledge of results, on improving keyboard performance. A total of four physical and mental practice conditions included six physical practice trials, six mental practice trials, three alternating physical and mental practice trials (for a total of six practice trials) and NP (subjects read a motivational article on sight-reading). Each practice condition was divided into two groups of either receiving aural knowledge of results (KR) or receiving no aural knowledge of results (no KR) for a total of eight practice conditions altogether. Aural knowledge of results was gained either through the synthesizer or through a taped performance. In the case of mental practice with knowledge of results, a taped performance was sounded and in the case of physical practice with no knowledge of results the synthesizer was turned of when practicing.

Eighty music students whose major or minor instrument was not piano but who had completed at least two semesters of group piano study were assigned to one of eight practice conditions. Subjects performing a mental practice condition were instructed "to mentally `see' and `feel' themselves playing" (p.77). A pretest and posttest design was used in which an eight measure chordal composition was used. Half of the composition was used for the pretest and the other half for the practice conditions and the posttest. The halves were rotated between pre- and posttest placement. Performance was measured in terms of time duration and scored one point for every pitch and/or rhythm errors. Piano experience was used as a covariate in the analysis of covariance (ANCOVA). Imagery ability of the mental practice condition students (that had been tested using a portion of Sheehan's version of Betts vividness of imagery scale) was used as a covariant in the mental practice analysis of covariance.

Results showed that the speed of performance was the only dependent variable with significant differences among the 8 groups. PP and PP+MP groups were significantly greater than the MP group but not significantly different from each other. Significant positive correlations were found between auditory and overall imagery scores (which included also tactile, kinesthetic and visual imagery) and the time needed to perform the posttest. Also a positive correlation was found between piano experience and performance duration times. No significant effects were found for knowledge of results or for gender.

Rosenthal, Wilson, Evans, and Greenwalt (1988) examined relative effectiveness of five practice procedures each lasting for a duration of three minutes. Sixty college music students majoring on either a woodwind or brass instrument were randomly assigned to the following practice conditions: listening to a recording of the composition, with the written music available (modeling); singing the composition (singing); silent analysis (MP); free practice (PP); NP control (subjects practiced an unrelated musical composition). Although no specific mental practice instructions were given both the modeling and the silent analysis can be viewed as a form of mental practice. The continuum between analysis and mental practice had already been pointed out by Rubin-Rabson (1941).

> A theoretical distinction is drawn between this analytical study and `mental rehearsal' or `imaginary practice' of the material when it is already learned or well on its way to a given criterion. Practically, however, the two may coalesce when within even a short study period very gifted subjects not only complete the analysis but carry the learning to such a degree of fluency as to require only one or two keyboard trials to meet the standard. (p.593)

A posttest design was used in which an etude was performed after the practice session. Scoring of performance was based on correct notes, rhythms, articulation, phrasing, and tempo. These were analyzed using the Kruskal-Wallis non-parametric analysis of variance. Results showed that performance of correct notes did not significantly differ among the practice groups although subjects in the model group obtained the highest scores. The silent analysis group's score on rhythmic accuracy was highest and differed significantly from scores in the singing and control groups.

Lim and Lippman's purpose (1991) was to compare three practice procedures on learning and memorizing piano music. The three procedures included mental practice, mental practice with listening (MPL), and physical practice. The test was a pretest, posttest 1, and posttest 2 design in the following manner: practice procedure for ten minutes, two memorized performances (pretest), two physical practice (sight-reading), two memorized performances (posttest 1), practice procedure for 10 minutes, two memorized performances (posttest 2). Mental practice subjects were given the score and instructed to "maintain as vivid a mental image as possible . . . incorporating all three modes of mental imagery: visual, auditory, and kinesthetic." (p.24)

The subjects were seven piano master class college students and the musical material included six musical excerpts ranging from six to sixteen bars in length with a total duration of 25 to 37 seconds. Each subject was tested on six consecutive days, each day a different method (total of two for each practice conditions), with the six excerpts rotated in a Latin-square fashion across practice conditions. Performances were rated on a scale from 1 to 7 on four musical attributes: note accuracy, rhythmic accuracy, phrasing and articulation, and dynamics or musical expression. Separate analyses of variance (ANOVA) were conducted for each musical attribute, comparing pretest to posttest 1 on the factors of practice condition, replication (first, second occasion for testing the condition) and test. Rating sheets were developed so subjects could describe the levels of visual, auditory and kinesthetic imagery experienced during the mental practice.

The performance results showed a general trend in which physical practice yielded the best performance, followed by mental practice with listening (MPL) and then mental practice alone. The ANOVA for note accuracy scores revealed significant main effects for practice conditions, replication and test. The test and replication effect indicated improvement in performance. The replication effect indicated a gain in proficiency over two occasions in which the same practice condition had been tested, probably indicating adaptation to novel learning and test procedure. Physical practice was superior to both mental practice and MPL, but MPL led to more note accuracy than just mental practice.

A similar result was found for the ANOVAs of rhythmic accuracy and dynamics, though for the first, no difference was found between the two mental practice conditions. In the ANOVA of phrasing, physical practice did not differ overall with MPL and both were superior to mental practice. The ANOVA for phrasing scores revealed a main effect of practice condition and a practice condition x test interaction. This interaction indicated that pretest to posttest 1 trends differed for each practice condition. In all, physical practice and MPL did not differ from each other and both were superior to mental practice. Separate examination of pretest and posttest 1 performances showed that MPL was superior even to physical practice. However, MPL actually exhibited a decrease in performance from pretest to posttest 1. The authors suggested that "the sight reading activity gave rise to a personal interpretation that conflicted with the model that had been provided" (p.27). The gain by the mental practice group was particularly striking, suggesting that for production of good phrasing, some actual physical practice as provided by the interpolated sight reading activity, may be important. All these trends were generally repeated for the posttest 2 performance evaluations.

In the self-ratings of imagery, subjects reported that when given auditory or visual information, or when making actual muscle movements, it was impossible to form an image. The MPL subjects reported that auditory images were weak or absent, but these subjects also reported having had the most vivid visual images. The mental practice condition gave rise to the most reported imagery and all subjects reported imagery of hands superimposed on a keyboard. Questions about the practice conditions showed that all but one preferred the physical practice condition which overall produced the best performance.

Theiler and Lippman (1995) compared the effectiveness of four practice conditions on two forms of musical performance, guitar and vocal performance, each of which were characteristically different in their production demands. Practice conditions included a total of 12 minutes of either physical practice, alternating 3 minutes of physical practice with 3 minutes of mental practice, alternating 3 minutes of physical practice with 3 minutes of mental practice while listening to an auditory model of the piece in question (MPL), and alternating 3 minutes of physical practice with 3 minutes rest periods while reading excerpts from a self help book on performance anxiety (CM). This last condition was intended to provide a baseline control for motivational and arousal variables. After the 12 min rehearsal period participants were recorded as they performed the excerpt twice with the score present, followed by two performances from memory.

Experimental procedures were based on a repeated measures design similar to that used by Rubin-Rabson. The subjects, which included 7 guitar majors and 7 voice majors from the undergraduate level, were individually tested two times for each of four practice conditions, with a total of 8 performances. Four excerpts of eight measures from 17th century dance pieces were used for the guitarists and sight-singing exercises ranging from 13-20 measures were used for the vocalists. The performances were independently evaluated by two professional guitar instructors or two graduate voice students. All performances were rated on 6 dimensions: pitch accuracy, rhythmic accuracy, articulation and phrasing, dynamics and expression, tempo, and tonal quality. Raters also scored students for the proportion of the excerpt performed by memory, to the nearest quarter of a measure.

Ratings for guitarists and vocalists were analyzed separately. A series of 4 x 2 ANOVAs were conducted for learning condition (PP, PP+MP, MPL, CM) x Trial (two trials with each condition per participant) for each performance dimension. Separate ANOVAs were conducted for both type of performances; (a) performance with the musical score and (b) performances by memory.

For the guitar performances, none of the analyses revealed main or interactive effects with trials. There were significant practice condition effects for ratings of pitch accuracy and tonal quality on the performance from the score and for proportion of piece played during the performance by memory. For performance with musical score the highest mean rating for pitch accuracy was found under PP+MP followed by physical practice followed by mental practice while listening to an auditory model of the piece

(MPL) with the lowest mean score found for the controlled motivational (CM) condition. The only significant difference was found between PP and PP+MP to CM. For tonal quality ratings only MPL was found superior to CM. In the performances from memory the only significant practice effect was between MPL and CM.

For the vocal performances, only one trial x condition interaction was obtained. In the performance with the score, there were significant practice condition effects for ratings of pitch accuracy, dynamics and expression, tempo, and tonal quality. Most significant differences demonstrated the superiority of MPL condition over the other conditions. For tonal qualities PP+MP was also superior to PP and CM. Rhythmic accuracy was the only scale that did not reveal a significant effect for practice condition. The scores for proportion of piece sung by memory were significantly higher under the mental practice while listening to an auditory model of the piece (MPL) condition than in the controlled motivation (CM) condition.

In their discussion, the authors pointed out that performances after the PP+MP condition showed improvement equal to those following PP. Most of the significant differences in performance ratings that occurred in this study were between the mental practice conditions and the control/motivational condition.

A summary of the differences between these six studies in terms of number of subjects, musical task, dependent variables, and experimental design is given in Table 2. Of particular interest is to compare the different combinations of physical and mental practice. Both Ross (1985) and Coffman (1987) used number of trials as opposed to length in minutes. Ross (1985) in the combined physical and mental practice required one

Table 2: Summary of Methodologies Used

Study	N	Task and Excerpt	Dependent Variables	Independent Variables	Length/No. of Trials	Design
Rubin-Rabson (1941)	9 Adult pianists	Keyboard memorization: 5-10 measures adapted from piano excerpts	1) Keyboard trials	1) PP-MP-PP 2) PP-MP 3) PP	5 min pre-analysis, 5 PP &/or 4 min MP & PP to criterion	Latin-Greek Square rotation
Ross (1985)	30 slide trombone music students	Trombone performance: Sight-reading etude of 34 measures	1) Performance of notes rhythm & articulation	1) PP 2) MP 3) MPS 4) PP-MP-PP 5)NP	3 practice trials (1 of each for D)	Pretest Posttest
Coffman (1987)	80 music education and music therapy students	Piano Performance: 8 measure four-part chordal composition adapted from a church hymn	1) Duration 2) Pitch 3) Rhythm	1) PP/KR 2) PP/no KR 3) MP/KR 4) MP/no KR 5) PP+MP/KR 6) PP+MP/no KR 7) NP/KR 8) NP/no KR	6 practice trials	Pretest Posttest
Rosenthal et al. (1988)	60 wood wind and brass music students	Woodwind & Brass Performance: Etude for brass instruments	1) Notes 2) Rhythms 3) Articulation 4) Phrasing or dynamics	1) listening 2) singing 3) MP 4) PP 5) NP	3 min practice + one performance before testing	Posttest
Lim & Lippman (1991)	7 freshman to graduate	Memorizing piano: 6-16 measure excerpts equal in difficulty and length;	1) Notes 2) Rhythm 3) Phrasing 4) Dynamics	1) MP 2) MPL 3) PP	10 min practice pretest, 2 PP, posttest 1, 10 min practice posttest 2	Latin Square rotation. Pretest Posttests 1,2
Theiler & Lippman (1995)	14 (7 gtr + 7 vcl) freshman to senior	guitar/ vocal performance & memory: 8 measure excerpts for gtr & 13-20 measure excerpt for singers	1) Notes 2) Rhythm 3) Articulation & phrasing 4)Dynamics & expression 5) Tempo 6) Tonal quality	1) PP 2) PP+MP 3m alt 3) MPL 4)CM 3 pp + 3 self help reading	12 min practice	Latin Square Rotation

PP - physical practice MPL - mental practice with listening CM - Control for motivation NP - no practice
MP - mental practice MPS - mental practice and simulation KR - knowledge of results

trial of physical practice, one trial for mental practice and one more for physical practice which added to a total of 66% physical practice and 33% mental practice. Coffman (1987) however, required 6 practice trials which alternated between one physical and one mental trial adding up to the percentage of 50% physical practice and 50% mental practice. Theiler and Lippman (1995) also used the percentage of 50% physical practice and 50% mental practice. They required three minutes of alternating physical and mental practice for a total of twelve minutes. Unlike the previous studies, the Rubin-Rabson (1941) used a combination of number of trials and length of practice. This mixture of length and trial amounts, plus the fact that overall practice amount was determined by the criterion of a perfect memorized performance, limits any percentage comparison between amounts of mental practice versus physical practice. It is also interesting to note that all the studies that included combinations of physical and mental practice, excluding that of Rubin-Rabson (1941), required the use of physical practice prior to mental practice. This order of practice according to results of the Etnier and Landers study (1996) was found to be less effective than combinations of physical and mental practice that required that mental practice be performed first. Only Rubin-Rabson (1941) required five minutes of analytical study for all subjects. This analytical study can be considered as a type of mental practice.

Neurophysiological Aspects of Mental Practice

In addition to the studies that have tried to measure the relative effectiveness of mental practice in music performance, there exists another type of study from the field of neurophysiology that attempted to measure brain activity and changes in the brain due to mental practice. In a sense these type of studies are directly related to the first studies in mental practice that were carried out by Jacobson (1932) and Shaw (1938). As described before, these studies also measured action potentials of the nervous and muscular system during several mental practice tasks. In a study by Pascual-Leone, Dang, Cohen, Brasil-Neto, Cammarota, and Hallett (1995), transcranial magnetic stimulation (TMS) was used to study the cortical motor areas in the brain that controlled the contralateral long finger flexor and extensor muscles in subjects learning a five finger exercise on the piano.

Of particular interest is the second experiment reported in the study in which the different effects of physical and mental practice were studied as well as the changes in the cortical motor areas targeting muscles involved in the task. In this experiment, 15 subjects were randomly assigned to a physical practice group, a mental practice group, and a control group. In contrast with the previous studies none of the subjects had experience playing the piano or any other musical instrument.

The subjects were taught a one-handed, five-finger exercise which consisted of the following sequence of hand movements (and notes): thumb (C), index finger (D), middle finger (E), ring finger (F), little finger (G), ring finger (F), middle finger (E), index finger (D). A metronome marked a rhythm of 60 beats per minute, and the subjects were asked to match the thumb and little finger movements to the beat, intercalating the movements of the other fingers between the beats. Subjects were asked to perform the sequence of finger movements fluently without pauses, and without skipping any key, and to pay particular attention to keeping the interval between the individual key presses constant and the duration and velocity of each key press the same. Baseline transcranial magnetic stimulation (TMS) mapping was done of the subjects' cortical motor areas targeting the long finger flexor and extensor muscles. Subjects in the physical practice group and the mental practice group practiced the exercise independently for 2 hours daily for five days after which they had TMS mapping of the motor cortex. The CP group did not practice the exercise but had daily TMS mapping.

During the practice session, subjects in the physical practice group were encouraged to repeatedly perform the exercise on the keyboard and were free to select their own strategy. Subjects in the mental practice group were asked to sit in front of the piano and mentally visualize their fingers performing the exercise and to imagine the sound. They were not allowed to touch the piano keys or to rehearse the exercise by moving the fingers in the air. To assure that they were indeed not moving their fingers, electromyographic (EMG) activity from the long finger flexor and extensor muscles was monitored continually with the use of pairs of surface EMG electrodes taped to the skin over the belly of the muscle. The mental practice group had a single 2-hour physical practice session at the end of day 5.

Results showed that over the course of 5 days, both practice groups exhibited progressive improvement in their playing skills, as illustrated by a decrease in the number of sequence errors and a reduction in the variability (standard deviation) of the interval between key presses. Accuracy increased in all practice subjects, however, the physical practice group showed a significantly greater reduction in the number of sequence errors and a trend toward greater accuracy than did the mental practice group. The control group's performance did not improve. Concurrently with the improvement in performance, the threshold for activation of the finger flexor and extensor muscles by TMS to the contralateral scalp decreased steadily over the course of the 5 days in the physical and mental practice groups. In addition, even though the threshold decrease was taken into account, the size of the cortical representation for both muscle groups increased equally for both practice groups but did not increase for the control group.

As in the previous studies, mental practice alone led to significant fine motor skill learning but did not result in as much performance improvement as physical practice alone. However, mental practice alone led to the same plastic changes in the motor system as those occurring with the acquisition of a skill by repeated physical practice. By day 5, the changes in the cortical motor outputs to the muscles involved in the task did not differ between the physical and the mental practice groups. However, the mental practice group's performance was at the level of that occurring with only 3 days of physical practice. After a single 2-h physical practice session, the mental practice group's performance improved to the level of 5 days of physical practice.

Explanatory Theories Regarding the Effectiveness of Mental Practice

Three main theories have been suggested to explain the effectiveness of mental practice. These theories include the motivational explanation, the psychoneurological explanation, and the cognitive-symbolic explanation. Each theory is described and its relevance regarding mental practice studies in music is examined.

Motivational Theory

One of the explanations put forward as to the effectiveness of mental practice compared to no practice was the motivational explanation. This explanation, that had been suggested by Corbin (1972) and by Richardson (1967b) claimed that the difference attained between the control group and the mental practice group were attributable to the different levels of motivation between them. Corbin gave two different theories that relate to such possible motivational differences. The first theory was attributed to the actual interest raised in the mental practice group who after mentally practicing were motivated to actually try the skill at hand. The second theory related to the methodological "Hawthorne" effect in which the control group frequently received no treatment whereas the mental practice group attended practice sessions. This last explanation was specifically addressed in the analysis by Driskell, Copper, and Moran (1994) in which the type of control group was a factor. Control groups were categorized as either no contact control group defined as having received no treatment activity between initial assignment and testing, or equivalent control group which meant that they participated in some form of non-treatment activity. As previously reported, it was found that there was a trend for mental practice to be more effective in comparison with a no-contact control group than in comparison with an equivalent control group as the motivational explanation hypothesis suggests, yet this difference was not significant.

The motivational hypothesis had been taken into account in all the studies relating to music performance that used a control group, though the methods have been different. In the Ross (1985) and Coffman (1987) studies, the control groups read a motivational article on sight-reading while in the Rosenthal, Wilson, Evans, and Greenwalt (1988) study the control group practiced an unrelated musical composition. Maybe the most unique method of control was displayed in the Theiler and Lippman (1995) study in which one group alternately practiced and read excerpts on performance anxiety while another group alternately practiced physically and mentally. This condition was specifically intended to provide a baseline control for motivational and arousal variables and, as previously reported, results were significantly higher for the combined physical and mental practice group than for the control group.

Psychoneuromuscular Explanation

The second explanatory theory as to the effectiveness of mental practice was the psychoneuromuscular theory. The idea behind the psychoneuromuscular explanation was "that mental practice effects are produced by low-gain innervation of muscles that will be used during actual performance" (Feltz & Landers, 1983). This explanation related back to the beginnings of mental practice research and to the ideas suggested by Washburn (1916) that movements of slight magnitude occur when one simply images oneself performing an activity. This hypothesis was later confirmed by Jacobson (1932) and Shaw (1938) in EMG type of studies. Corbin (1972) gave two explanations as to the reasons why the low-gain innervation of muscles may be effective. The first of these explanations was described as the feedback theory in which "the innervation of the muscles involved in the skill being imagined may well be capable of providing kinesthetic feedback necessary to make adjustments in future trials, thus improving skilled motor performance" (p.102). Corbin referred to the second explanation as the connectionist theory in which the low-gain innervation of a specific muscle form a "connection" with the mental practice stimulus. Corbin stated that "repetition of the stimulus (MP) with the desired response (EMG) potential results in a strong connection between the stimulus and the response. Thus, repeated mental practice results in an improved overt performance of the task that was practiced mentally" (p.104). The psychoneuromuscular explanation was also addressed by Richardson (1967b) who pointed to certain studies as evidence that under certain conditions the process of external feedback could occur internally. Feltz and Landers (1983) were more critical towards the psychoneuromuscular explanation. Their main argument against this theory was based on the fact that although a heightened EMG activity due to mental activity was found, studies reporting this phenomenon had not been able to show that it was localized to a specific muscle area which was used during the activity. This non-localized stimulation was exemplified in the study by Shaw (1938) who found heightened activity in muscles that were not associated with the activity that was mentally practiced, including the music-related activities. Driskell, Copper, and Moran (1994) also found this explanation to be lacking on the grounds that such an explanation "suggests that the effects of mental practice would be greater for physical tasks (which would be expected to produce more muscular innervations) than for cognitive tasks" (p.489). Yet both their results and those reported by Feltz and Landers indicated that the effects of mental practice may be greater the more a task required cognitive activities.

Cognitive-Symbolic Explanation

The principle idea behind the cognitive-symbolic explanation was that mental practice effects were primarily associated with the symbolic and cognitive aspects of the task rather than the motor elements of the task. This explanation, as originally proposed by Sackett (1934), posited that mental practice facilitated those skills in which there was a symbolic control of the movements involved. Therefore mental practice in tasks, such as the various forms of maze learning where the motor part of the task was relatively small, involved mainly cognitive solutions. Thus, as Feltz and Landers (1983) pointed out,

> the symbolic or cognitive elements of an unfamiliar task can be learned from task instructions, observational learning, or initial physical performance. Mental practice of these elements fosters subjects' retention of symbolized elements and their connections more so than for subjects denied the opportunity for mental rehearsal. (p.46)

Annett (1995) elaborated on the types of task features which could be encoded and rehearsed symbolically during mental practice. These features may include a motor program or mental plan which may enable the performer to chunk information in an efficient way or which specify the order and timing of the required response.

In examining the studies relating to mental practice we can assume that no one theoretical explanation can account for all the data. Although both Feltz and Landers (1983) and Driskell, Copper, and Moran (1994) reached the conclusion that mental practice was more effective on cognitive tasks, Driskell Copper, and Moran also pointed out that for experienced subjects the type of task was less of a factor regarding the effectiveness of mental practice. This interaction between type of task and level of experience suggested that for the novice, mental practice may be helpful in rehearsing the cognitive-symbolic elements of the task whereas for the more experienced subject there may be room for both the cognitive-symbolic explanation as well as the psychoneuro-muscular explanation. To further stress the interconnection between the two explanations it is helpful to mention part of the argument made by Pascual-Leone, Dang, Cohen, Brasil-Neto, Cammarota, and Hallett (1995) in which on the one hand they agreed with the cognitive-symbolic explanation that "mental practice can be viewed as a virtual simulation of behavior by which the subject develops and 'internally' rehearses a cognitive representation of the motor act"(p.1043). Yet, on the other hand coinciding with the cognitive-symbolic approach came an element related to the psychoneuromuscular explanation which stated that:

> [M]ental simulation of movements activates some of the same central neural structures required for the performance of the actual movements. In doing so, mental practice alone seems to be sufficient to promote the modulation of neural circuits involved in the early stages of motor skill learning. (p.1043)

Music performance is undoubtedly high in cognitive and symbolic elements as well as fine motor skill ability. This may be concluded from the number of years of training required in order to attain any kind of performing ability (Ericsson, Krampe, & Tesch-Romer, 1993) as well as the amount of research regarding cognitive aspects in music performance (e.g., Dowling & Harwood, 1986; Hargreaves, 1986; Serafine, 1988). Therefore it may be presumed that, as suggested by Pascual-Leone, Dang, Cohen, Brasil-Neto, Cammarota, and Hallett (1995), various degrees of both the cognitive-symbolic explanation as well as the psychoneuromuscular explanation apply to mental practice in music performance.

The Performance of Tonal Patterns Based on Chord Progressions

Performance from a written score involves to a great extent all the elements which have been recognized as being required in sight-reading skill. These include the ability to scan ahead, recognize "chunks" or patterns, and comprehend respective rhythmic and pitch units implied in the musical notation (e.g., Hodges, 1992; Sloboda, 1988). Furthermore Sloboda (1977) pointed out that the ability to identify discernible structures was enhanced by an ability to recognize both structural markers which arise primarily out of rules of harmonic progression and physical markers such as spacing between phrases.

The performance of tonal patterns from a given chord progression is, to a certain extent, not unlike performing from notation. Elements such as scanning ahead and recognizing "chunks" or patterns are helpful. The main difference between the two types of performances lie in the notation symbols used and in the amount of information that each type of symbol conveys. Unlike regular musical notation, chord symbols do not contain information concerning note placement, rhythm, or dynamics. Therefore the main requirement when playing tonal patterns from a given chord progression is the ability to delineate from the chord symbol the correct notes to be played. The following paragraphs will address the character of chord symbols, chord progressions, and tonal patterns.

Chord Symbols

Chords are symbolized by the root note of the chord written in alphabetical letters ranging from 'A' to 'G' where each letter may receive a flat or a sharp. Due to historical reasons there are several ways of symbolizing the different types of chords. (For an in depth discussion on the nomenclature of chords and the various symbols used see Baker, 1983). Nonetheless, whatever the nomenclature used, the alphabetical letter representing the root note is usually followed by some type of abbreviation indicating the type of chord i.e. major, minor, diminished, augmented or suspended, as well as numbers indicating various seventh chords and upper extensions. For example, the letter 'C' symbolizes the chord C major which consists of the notes C, E, G. The addition of the number '7' in the chord symbol 'C7' represents a seventh chord consisting of the notes C, E, G, Bb.

Difficulty Factors in Chord progressions

There are a number of ways in which chords progress one after the other but as Baker (1983) pointed out "although there are an infinite number of ways of combining different quality chords, there are relatively few combinations in widespread use" (p.26). Of these combinations some are more common and therefore, due often to familiarity, are usually easier to execute whereas others are less familiar. Other variables that may effect difficulty level include the key in which the progression is written, and the number of chords to be performed within a bar.

Diatonic chord progressions are chord sequences that are built only on the notes of one scale and are easier to perform than chord progressions that are either chromatic or unrelated. For example, the diatonic progression of 'Emi7 - Ami7 - Dmi7 - G7 - Cmaj7' (Figure 4) which is based on the diatonic chord progression of 'III - VI - II -V - I', consists only of notes from the C major scale (no sharps or flats). This progression is relatively easier than the chromatic progression 'Emi7 - Eb7 - Dmi7 - Db7 - Cmaj7' (Figure 5) which uses substitute chords for the former diatonic progression. (Eb7 substitutes for the Am7 and Db7 substitutes for the G7).

Another factor that effects the relative difficulty of the chord progression is the key of the progression. For example, the key of C major is considered an easy key especially in comparison to a key such as F# major. Therefore, the chord progression in

Figure 4 which is a common harmonic progression in the key of C is relatively easier than the same type of progression in the key of F#. (A#mi7 - D#mi7 - G#mi7- C#7 - F#maj7).

The number of chords per bar is another variable that effects the relative difficulty of the task. For example, the performance of a tonal pattern played over a VI-II-V-I progression written one chord to a bar, would be easier to execute than the same

Figure 4. Diatonic progression in the key of C major.

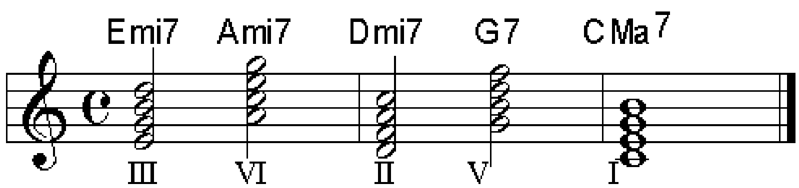
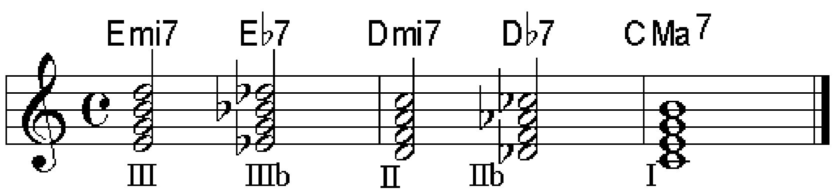


Figure 5. Chromatic progression using substitute chords.



progression written two chords per bar. The reason for this lies both in the amount of time available to the performer to scan ahead prior to executing the tonal pattern and in the number of notes that have to be performed in a bar.

Tonal Patterns

Tonal patterns, also referred to as digital patterns (Coker, 1989), scale patterns (Crook, 1991) or melodic structures (Bergonzi, 1992), are regarded by Coker (1991) as one of the basic elements of the jazz language. Coker (1991) defined tonal patterns as

cells of notes, usually numbering 4-8 notes per cell, that are structured according

> to the numerical value of each note to the root of a chord or scale. That is, 1 would be the root, 2 is the second degree of the scale (or the 9th of the chord), 3 is the third, and so on. Hence a digital pattern of 1-2-3-5 for a C Major chord (or scale) would be C-D-E-G. . . . Generally speaking, digital patterns usually occur at one rhythmic level for the entire cell (as opposed to a mixture of rhythmic values), and that level is most often the eighth-note level. (p.8)

Bergonzi (1992) described tonal patterns as “a simple and pragmatic approach to improvisation. . . . a numerical system which provide the student with an intervallic method for playing on chord changes while examining the similarities and relationships between different chords” (p.6)

Tonal patterns have been in use since the early days of jazz, but as Coker pointed out "the device was brought suddenly and sharply into notice by John Coltrane, whose brilliant solos on 'Giant Steps' and 'Countdown' made use of a number of digital patterns, each pattern occurring literally dozens of times" (Coker, 1991 p.8). Crook (1991) listed examples of tonal patterns consisting of four notes all of which incorporated the tonic triad plus one additional note. These included permutations of 1–3–5 plus either the 2, 4, 6 or 7 of the scale. The use of the seventh note together with the 1,3, and 5 of the chord within the tonal pattern means that these specific patterns are comprised of all four notes of a seventh chord. Coker (1989) even defined the specific pattern of 1-3-5-7 as change-running, which is the jazz equivalent of chord arpeggiation. Crook gave examples of tonal patterns using the tonic triad (1,3,5) plus the 7 of the scale which included, apart from the chord arpeggiation of 1-3-5-7, other permutations such as 1-5-3-7, 3-5-7-1, 5-3-1-7, 7-5-3-1, and 3-1-7-5 (Crook, 1991 p.67). This last pattern of 3-1-7-5 was selected as the required tonal pattern for this study.

The performance of tonal patterns over chord changes eliminates the obvious requirements related to notational type of reading such as scanning notes and chunking them into meaningful rhythmic or melodic patterns. When performing tonal patterns from chord symbols, a working knowledge of the chord symbols is required as well as the ability to translate the symbols into notes according to the tonal pattern that is required. This requirement should be distinguished from, for example, the ability to strum chords on a guitar which, although requires knowledge of the correct hand position for executing the chord, does not necessitate knowledge of the individual notes that comprise the chord. Also, similar to the reading requirements of regular notation, familiarity with common chord progressions that are used in the jazz literature such as V-I, or II-V-I, and the ability to scan ahead and analyze the progression in terms of key and diatonic function are necessary requirements for chunking chords into meaningful progressions.

CHAPTER 3

METHODOLOGY

The purpose of this study was to investigate the relative effectiveness of different proportions of time spent on physical and mental practice, in the context of performing a tonal pattern over harmonic progressions of different difficulty levels.

The specific questions were:

1. Were there differences on the measure of note errors between the different practice groups of physical practice, combined physical and mental practice in the proportions of 66% physical and 33% mental practice, combined physical and mental practice in the proportions of 33% physical and 66% mental practice, and mental practice?
2. Was there a difference between the easy harmonic progression and the hard harmonic progression on the measure of note errors?
3. Was there an interaction between the difficulty levels of the harmonic progression and the practice groups on the measure of note errors?

This chapter provides a description of the methodology which was used in order to answer the specific questions. This includes a description of the subjects, experimental design, equipment, stimuli materials, experimental routine, data collection and data analysis procedures. The chapter concludes with a brief description of the pilot study that was conducted prior to the main study.

Subjects for the Study

Sixty undergraduate students (7 females and 53 males) whose age ranged from 17 to 33 years of age (m= 23.6, SD=3.03), volunteered to take part in the study. Years of performance study of the subjects ranged from 1 to 20 years (m=7.5, SD=3.57) and years of improvisation study ranged from 6 months to 12 years (m=2.7, SD=2.06). Subjects' musical instruments included piano (n=21), guitar (n=12), bass (n=12), saxophone (n=10), flute (n=3), trumpet (n=1), and violin (n=1). The students were recruited from the Jerusalem Academy of Music and Dance (n=19), the Rimon School of Jazz and Contemporary music (n=30) and, the Technion Institute of Technology (n=11). All subjects had participated in a jazz improvisation course at their institution of learning. These jazz improvisation courses, regardless of the fact that they were held at different institutions in Israel, taught improvisation using methodologies that were the same or very similar to those developed by American jazz educators (e.g., Baker, 1983; Bergonzi, 1992; Coker, 1991; Crook, 1991). The knowledge acquired in such a course was deemed necessary in order to meet the demands of the proposed musical task, which required not only knowledge of chord symbols, but also the ability of translating the symbols into musical notes on the instrument. All students were familiar with chord symbols and had some experience in performing tonal patterns in relation to harmonic progressions if only at the basic level of arppegiating the four notes of the chord. Subjects read and signed an informed-consent form (Appendix C) approved by the Institutional Human Subjects Review Committee.

Experimental Design

The experimental design used in the study was a mixed design which included four independent practice groups (A) and two task levels (B) involving repeated measures. This design has been designated as the A x (B x S) design where the parenthesis indicates the repeated factor (Keppel, 1982). A pretest-posttest design was used where the pretest scores were later used as covariates for adjusting the scores on the post test. Counterbalancing of task level presentation was used to control for practice effects (Keppel, 1982). A partial blocking by instrument type was done to limit possible effects due to instument type.

Independent Variables

The study had two independent variables which included the type of practice procedure and the task level (see Table 3). The variable of practice procedure was divided into four levels that included the following: 100% physical practice (PP), alternating 66% physical practice and 33% mental practice (66:33), alternating 33% physical practice and 66% mental practice (33:66), and 100% mental practice (MP). All combined practice procedures began with mental practice. This decision was based on results by Etnier and Landers (1996) in which mental practice prior to physical practice was more effective than the same amount of time after physical practice. The second independent variable of task level was divided into two levels: easy and hard.

Table 3: Independent Variables

Task Level	Practice Procedure			
	PP	66:33	33:66	MP
Easy				
Hard				

Dependent Variables

Each performance was rated according to the number of note errors. A note error was defined as a deviation from the note associated with the prescribed tonal pattern applied to the chord change, regardless of octave placement. Note errors were scored as one point per note error with a maximum of four note error points per chord. The note error points were summed for each performance with a maximum of 64 note error points for the easy task and a maximum of 112 note error points for the hard task.

Materials

The New Real Book (Sher & Bauer, 1988) is an anthology of jazz and jazz related compositions. Although within the jazz repertoire there are compositions that are less familiar than others, none of those that appear in The New Real Book can be regarded as obscure. Nonetheless, the chord progressions used in jazz standards are very similar and most all of them use standard chord progressions with a somewhat limited amount of variations. As Baker (1983) explained

> Although there are an infinite number of ways of combining different quality chords, there are relatively few combinations in widespread use. These combinations we call formulae. . . . In addition to the widely used II V_7 formula there are other combination of chords or chord sequences which have been frequently used that they now constitute the main body of most popular and jazz compositions. . . The player will find that few tunes fit neatly into one formula or another, but rather combine two or more of them, often in modified form. (p.26-27)

Bearing this in mind, it was assumed that the source of an excerpt that included only the chord symbols without reference to the melodic line or to the lyrics of the song, would not be recognized by most improvisers. Also, transposition of the excerpt to another key would further insure relative obscurity of the source.

Since the difficulty level of any excerpt is a function of the type of progressions it contains, the keys of the progressions, and the number of chords per bar, it was decided to choose two excerpts that would differ mainly on the factor of number of chords per bar. The easy level was characterized as containing only one chord per bar whereas the hard level was characterized as containing mainly two chords per bar. Excerpts were chosen according to two criteria which included a minimum number of same chord repetitions and a maximum of two chords per bar. Chosen excerpts were transposed to different keys (an interval of a fifth from the original key) so that they differed in terms of keys and chords. This was done to minimize practice effects from one excerpt to the other.

The two excerpts of chord progressions were: (1) bars 17-32 of the song “All the things you are” (Kern, 1988) transposed from the key of Ab to the key of Eb for the easy task; (2) bars 17-32 of the song “Line for lyons” (Mulligan, 1988) transposed from the key of G to the key of D for the hard task. A practice progression of five bars in the key of C major was composed for pre- experimental practice. These bars were followed with the same progression but with the applied pattern notated. All progressions appear in appendix A.

Table 4 provides a musical analysis of the transposed excerpts and the practice progression in terms of chords per bar, number of same chord repetitions, and tonal centers. As can be seen from the compared analysis, apart from the difference between the progressions on the main factor of number of chords per bar, both the easy progression and the hard progression were equal in terms of having three key areas each. The type of progressions in each key area included mainly diatonic progressions of II-V and II-V-I characteristics.

Table 4: Musical Analysis of Excerpts

Task Level	Harmonic excerpt	Chords Per bar	Chord repetitions	Key areas
Easy	All the things	1 chord	Dma7 (2)	D,B,Eb,
Hard	Line for lyons	4 bars of 1 chord;	Emi7 (6),A7 (5),	F#mi,
		12 bars of 2 chords	F#mi7,B7 (4),Dma7 (3)	Emi, D
Practice		3 bars of 1 chord;	Cma7 (2)	C
		2 bars of 2 chords	Dmi7 (2)	

The progressions were performed in the same keys by all instruments regardless of whether they were concert key instuments or transposing instruments such as saxophone or trumpet whose notated pitch is different from their sounded pitch. The transposition of the original excerpts by an interval of a fifth assured that the excerpts did not appear in the original key for the transposing instruments which are either an interval of a second for trumpet and tenor saxophone, or an interval of a sixth for alto saxophone.

To maintain simplicity of chord symbols, only the symbols of seventh chords as they appeared in the musical editor's forward of "The New Real Book" (Sher & Bauer, 1988) were used within the excerpts. For this reason, chords that were not seventh chords were replaced by seventh chords in a manner that maintained their harmonic function. For example chords such as C6 whose function was either I or IV were replaced by Cma7 (see Figure 6). Upper extensions such as 9, 11, and 13 and their alterations (b9, #9, #11, b13) were also omitted and replaced by their functional seventh chord. For example chords such as C13 whose function was V (dominant) was replaced by C7 (see Figure 7). It should be noted that the extensions and alterations that appear in "The New Real Book" (Sher & Bauer, 1988) were added by the musical editor in a manner which was explained in the foreword to the book and were not an integral part of the original songs.

Figure 6. C6 chord is replaced by a Cma7 chord.

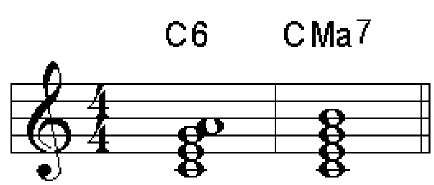
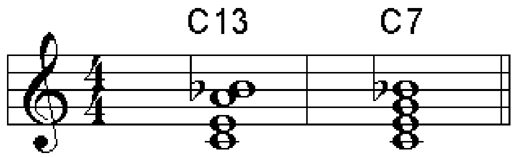


Figure 7. C13 chord is replaced by a C7 chord.



Tasks

Subjects were required to perform a tonal pattern on the excerpted 16 measure chord progression with a metronome sounding at the speed of 70 beats per minute (bpm). Each subject was then given three minutes to perform the required practice routine without a metronome, after which the required tonal pattern was again performed with the metronome. This procedure was done twice: once on the relatively easier progression and once on the harder progression. Order of excerpt was randomly assigned in such a manner that half of the group performed first on the harder progression and the other half performed first on the easier progression. The tonal pattern to be performed was taken from a list of patterns given by Crook (1991). The specific pattern that was chosen included only notes of the chord in the order of 3-1-7-5. Two rhythmic patterns were used depending on the number of chords in a bar. Figure 8 shows an example of one chord per bar as it appeared in the excerpt and as it should be performed melodically and rhythmically. Figure 9 shows an example of the melodic and rhythmic execution of two chords per bar.

Figure 8. Presentation of one chord per bar and its rhythmic and melodic solution.

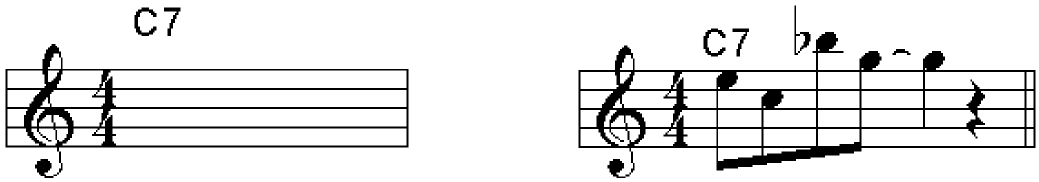


Figure 9. Presentation of two chords per bar and their rhythmic and melodic solution.

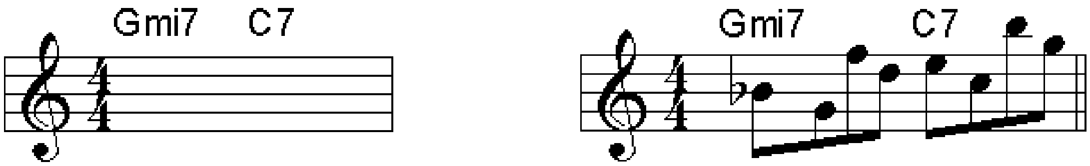


Figure 10 shows an excerpt of the first four bars of the second harmonic progression as presented to the subjects. Figure 11 shows the same harmonic progression and its notation as it should be performed by the subject. The complete progressions as well as the notated applied pattern are presented in appendix A.

Figure 10. First four bars of the second progression as seen by the subjects.

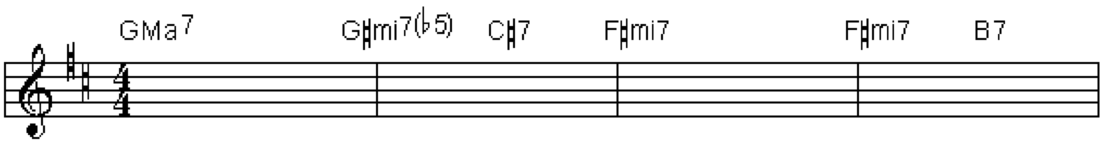
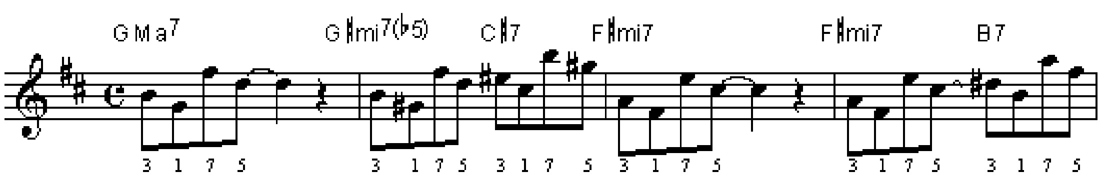


Figure 11. Notation of the first four bars of the second progression.



Experimental Routine

Sixty subjects were assigned to 1 of 4 practice groups while partially blocked for the type of instrument on which they performed. The practice procedure of the four groups were:

100% Physical practice (PP): Subjects practiced physically for a total of 3 minutes.

Combined practice of 66% physical and:33% mental (66:33): Subjects alternated between half a minute of mental practice and one minute of physical practice for a total of 3 minutes.

Combined practice of 33% physical and:66% mental (33:66): Subjects alternated between one minute of mental practice and half a minute of physical practice for a total of 3 minutes.

100% Mental practice (MP): Subjects practiced mentally for a total of 3 minutes.

A restricted random assignment of subjects to practice procedure was used in the study which has been described by Keppel (1982) as sampling without replacement:

> When human subjects are appearing in the laboratory at their own convenience, i.e., at a time that they choose, a typical approach is to make the random assignments so that any given treatment selected is not run again until all of the other treatments are represented once. (p.16)

The partial blocking for type of instrument was also achieved according to this assignment procedure, whereby the practice group assigned to each subject depended on the block of practice groups available, and the musical instrument of the subject. For example, if the first subject of the group of 4 subjects performed on piano, and the mental practice group had the least number of piano players, then that subject was placed into the mental practice group. The same criteria for group selection was done with the next 2 subjects. The last of the 4 subjects was placed into the practice group that remained regardless of the instrument of performance. After every block of 4 subjects task order presentation was altered and the assignment procedure was repeated. In order to keep track of which instruments had performed in which groups, the musical instrument of each subject was noted on the instrument by group form (Appendix C).

The musical instruments were categorized into two groups of either harmonic classification which included piano and guitar, or melodic classification which included bass, saxophone, flute, trumpet, and violin. The resulting distribution of the instrument categories across the groups was such that each practice group included at least 33% of one type of instrumental category as can be seen in Tables 5 and 6. Since gender differences were not of interest, the 7 female subjects were dispersed amongst all practice groups with a minimum of 1 subject in the combined 66:33 and mental practice groups, and a maximum of 3 subjects in the physical practice group.

Table 5: Distribution of Harmonic Instruments in Terms of Numbers and Percentages Amongst Practice Groups

Harmonic	Practice Groups							
Instruments	PP		66:33		33:66		MP	
Piano	4	26%	5	33%	7	46%	5	33%
Guitar	2	13%	5	33%	3	20%	2	13%
Total	6	40%	10	66%	10	66%	7	46%

Table 6: Distribution of Melodic Instruments in Terms of Numbers and Percentages Amongst Practice Groups

Melodic	Practice Groups							
Instruments	PP		66:33		33:66		MP	
Bass	4	26%	4	26%	1	6%	3	20%
Saxophone	3	20%	1	6%	2	13%	4	26%
Flute	1	6%	0	0%	2	13%	0	0%
Trumpet	0	0%	0	0%	0	0%	1	6%
Violin	1	6%	0	0%	0	0%	0	0%
Total	9	60%	5	33%	5	33%	8	53%

Before the beginning of the assignment procedure each subject signed a consent form and filled out a subject form listing the following details: age, gender, musical instrument, number of years of study on the instrument, number of years of jazz improvisation study (Appendix C). Each subject was numbered and that number was noted on the subject table (Appendix C).

Following this preliminary part, each subject was given written instructions as to the required task:

> You are about to be handed two pages of music which include only chord notation. Your task is to play the four notes of each chord i.e. root (1), third (3), fifth (5) and seventh (7) in the following order: 3-1-7-5. . . .Upon receiving the first music page, you are to play the required pattern with the metronome. You will then be given 3 minutes to practice in a manner that will be described later, after which you will again perform the required pattern with the metronome.

These proceedings will be similarly repeated for the second music page. (Appendix B)

Examples of the required tonal pattern are included in the task instructions as can be seen in Appendix B.

The 5 bar practice progression was then presented and the subject was required to practice applying the tonal pattern to the progression with a metronome at the speed of 70 beats per minute. Only after the subject could perform the pattern proficiently on his instrument (i.e. play the correct notes in time with the metronome) was he be allowed to continue with the experiment. This progression therefore served two functions: (a) to familiarize subjects with the task's tonal pattern, and (b) to assess whether the subject has the minimum technical and theoretical knowledge to participate in the study. Nine subjects who could not perform the practice progression after a two minute practice period were replaced.

After performance of the practice progression, the subject was presented with his or her particular practice instructions. For example the instructions for the combined practice of 66% physical practice wth 33% mental practice group were:

> Upon receiving the music you are to perform the prescribed pattern with the metronome. After performing you will practice for a period of 3 minutes alternating between a half minute period of mental practice and a one minute period of physical practice. During the mental practice period you are to mentally play the prescribed pattern, all the while imagining your hand movements and mentally hearing the notes, yet, without moving your fingers, touching or looking at your musical instrument. You will be notified by the tester as to when you are to change from each type of practice. Following your practice session you will again perform the required pattern with the metronome. All performances will be recorded. Please notify the tester when you are ready to begin. (Appendix B).

Instructions for all groups appear in Appendix B. After reading and understanding the instructions, each subject was presented with the harmonic progression and was required to perform the tonal pattern on the progression with a metronome at the speed of 70 beats per minute. This performance was recorded as the pretest. Following the pretest the subject practiced for 3 minutes according to the prescribed practice regimen. Timing was performed by the researcher and each subject was notified when to change between mental and physical practice. During mental practice, subjects were not allowed to touch their instruments. At this time the music score for pianists was placed on a music stand facing away from their instrument so that the piano keys would not be visible. Following the practice regimen the subjects performed the required tonal pattern as a posttest. Each subject repeated this procedure for each harmonic progression level. A Secco digital metronome (model DM-200) was used during the pre- and posttest. During the 3 minute practice period the metronome was turned off. All tests were conducted by the researcher. The tests were performed in practice rooms that were made available to the researcher by the institutions from which the subjects came. These practice rooms were equipped with a piano, music stands, a guitar amplifier and a bass amplifier.

A presentation of the timeline of the experimental routine for subjects receiving the easy task first is given in Figure 12 and for subjects receiving the hard task first is given in Figure 13 where (O) represents testing and (X) represents application of treatment.

Figure 12. Timeline of experimental routine for subjects receiving the easy task first.

Instructions	Easy Task first			Hard Task second			Total
	(O)	(X)	(O)	(O)	(X)	(O)	
7 minutes	1 minute	3 minute	1 minute	1 minute	3 minute	1 minute	17
	Pretest	Practice	Postest	Pretest	Practice	Postest	minutes

Figure 13. Timeline of experimental routine for subjects receiving the hard task first.

Instructions	Hard Task first			Easy Task second			Total
	(O)	(X)	(O)	(O)	(X)	(O)	
7 minutes	1 minute	3 minute	1 minute	1 minute	3 minute	1 minute	17
	Pretest	Practice	Postest	Pretest	Practice	Postest	minutes

Data Collection Procedure

Performances were recorded using a Panasonic mini cassette recorder model RQ-L319. Pretests and posttests were recorded randomly on different cassettes in such a manner that no posttest was recorded immediately after its pretest. Each performance was identified by a number assigned from a random number table. These numbers were recorded on the audio tape before performance and registered on the subject table (Appendix C).

Note errors were independently scored by two judges who were both proffesional musicians and music teachers. Both judges had been trained in scoring during the pilot study. To insure that any differences between conditions were not attributed to scoring bias, judges were not knowledgeable as to whether the performance being judged was a pretest or posttest. Each judge had a copy of the chord changes with the correct tonal pattern notated (Appendix A) and were allowed to review a performance as many times as they deemed necessary. The judges were instructed to circle each incorrect note. To accommodate for performances of those subjects who performed on transposing instruments such as saxophone or trumpet, judges also had a transposed copy of the sounded pitch of these instruments with which to score the performance (Appendix A). Intejudge reliability using the formula of agreements divided by agreements plus disagreemnts was performed on 20% of the studies resulting in a reliability coefficient of $\underline{r} = .92$.

The test was checked for face validity by the researcher. Test reliability was determined using the split half method. Each test was divided into first and second half, each half containing 8 bars. Pretest results of each half were correlated using the Pearson product-moment correlation. The estimated test reliability coefficient was then obtained using the Spearman-Brown formula. Estimated test reliability that was calculated using pretest results of the18 subjects from the pilot study was for the easy task $\underline{r} = 0.76$ and for the hard task $\underline{r} = 0.91$. The reliability that was calculated using pretest results of the 60 subjects in the current study were almost identical with $\underline{r} = 0.75$ for the easy task and $\underline{r} = 0.91$ for the hard task. This similarity of results may be attributed to the fact that the pilot study subjects were similar to the study subjects in years of performance study which ranged from 1 to 16 years (m=6.9, SD= 3.71), and years of improvisation study which ranged from 6 months to 8 years (m=2.5, SD=1.83). However the two subject groups did differ in age which for the pilot study subjects was higher and ranged from 18 to 59 years (m=28.8, SD = 9.92) and in music instrumentation which but for one melodic instrument, consisted entirely of the harmonic instruments piano (n=15) and guitar (n=2).

Data Analysis Procedure

The first step was to report descriptive statistics which included correlations between the subject variables of years of performance study and years of improvisation study with the dependent variable of note errors. The second step included the examination of the distribution curves of the dependent variables. These were found to be positively skewed. To rectify the distribution curves a power transformation was needed for, as Newton and Rudestam (1999) pointed out, the power transformation "is particularly helpful in reducing skew, condensing outliers, and conditioning the distribution to approximate a normal curve" (p.174). The power transformation that was chosen was a logarithmic transformation. As Winer (1971) explained "the logarithmic transformation is particularly effective in normalizing distributions which have positive skewness" and the specific logarithmic transformation of $X' = \log(X + 1)$ is used "to avoid values of X close to zero" (p.400). Therefore this power transformation was used on both pretest and posttest results.

The next step included a 4 X 2 (Practice Group X Task Level Posttest) ANCOVA with repeated measures on the last factor using the pretest scores as covariables. This was followed by a post hoc comparison between the adjusted means of each practice group on the two tasks using a paired sample t test.

Pilot Study

Prior to the actual experiment, the researcher conducted a pilot study to refine the experimental procedures and instructions, practice scoring the performances, and elicit reactions to the experimental conditions. The pilot study research design was in essence the same as that proposed for the main experiment although it included two more groups. One of these practiced alternately 50% mentally and 50% physically and the other was a control group which practiced on an unrelated chord progression. Eighteen subjects participated in the pilot study and were randomly assigned to one of the six practice groups. All subjects of the pilot study read and signed an informed consent form approved by the Institutional Human Subjects Review Committee. Each subject followed the required practice procedure and was then allowed to comment on the difficulty of the excerpts, and the clarity of the instructions. Decisions regarding the metronome speed for performance, and the muting of the metronome during the practice session were established after the performance of the sixth subject. Each performance was scored by the same judges as in the main study. A square root transformation was used to reduce positive skewness of pretest and posttest scores and to condense the distribution to approxiamate a normal curve.

In order to validate that both tasks differed in difficulty level, a paired t test was done on the pretest means. A significant difference, $t(17) = -5.43$, at the $p < .001$ level between the pretest means of both tasks indicated that both tasks did indeed differ in difficulty level. The ANCOVA revealed no main or interaction effects probably due to the limited number of subjects in the pilot study.

CHAPTER 4

RESULTS

This chapter reports the results of the data gathered during the experimental procedures. Following correlations between subject variables and dependent variables the dependent variables before and after the logarithmic transformation are presented graphically, using a histogram with a superimposed normal curve. A statistical ANCOVA of the dependent variables is followed by two post hoc comparisons of adjusted means as well as the calculation of pre- to posttest effect sizes.

The Pearson product-moment correlation between subject variables and the dependent variables (Table 7) shows that only years of performance study were significantly correlated with the dependent variable of note errors on the hard task.

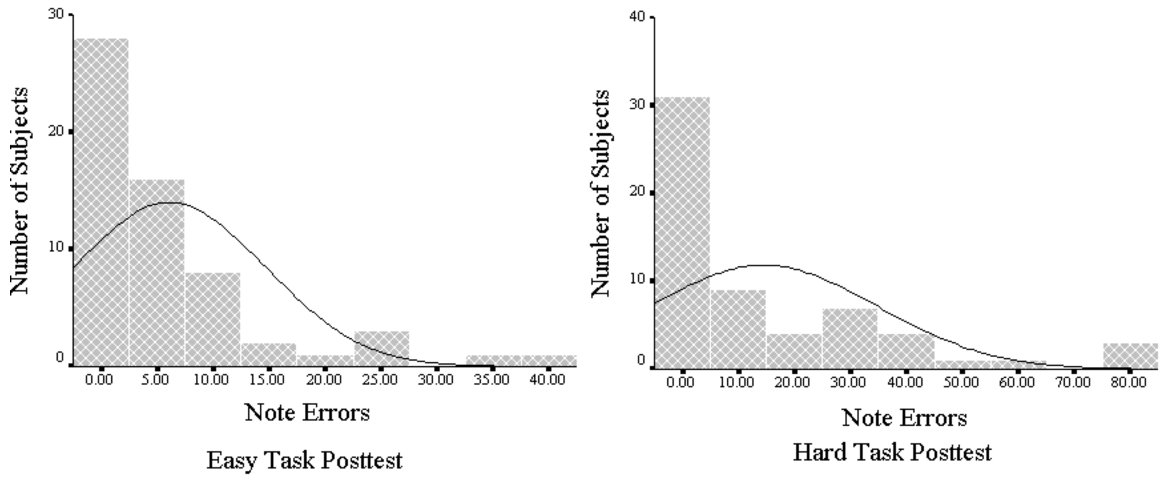
Table 7: Pearson Correlations Between Subject and Dependent Variables

Subject Variable	Dependent Variable	
	Note Errors	
	Easy	Hard
Age	-.051	-.199
Years of Performance Study	-.156	-.260*
Years of Improvisation Study	-.202	-.092

*p<.05;

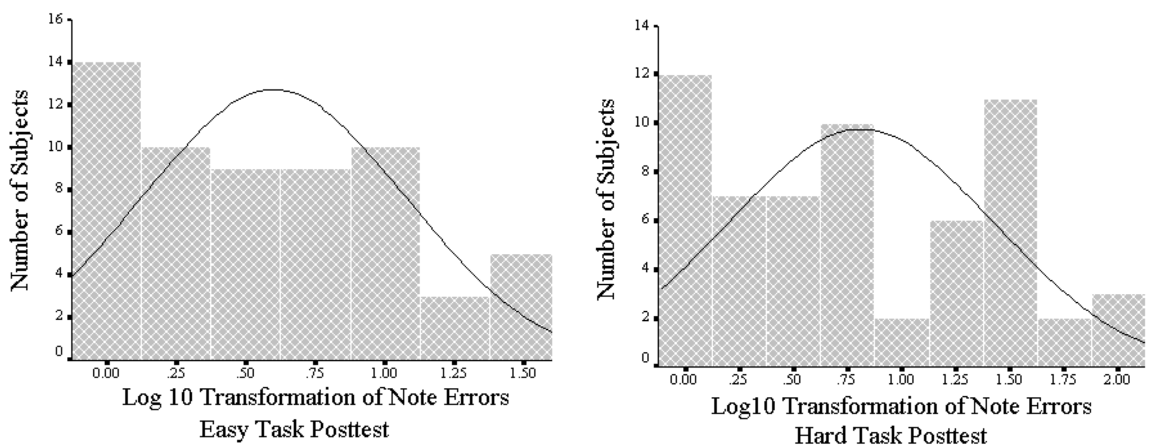
As shown in Figure 14, distributions of the dependent variable revealed a positive skew of the superimposed normal curves and large deviations.

Figure 14. Histograms and distribution curves of posttest note errors for the two tasks.



The normalizing effect of the logarithmic transformation on the dependent variable may be seen in Figure 15. Henceforth all statistical analyses were done on the logarithmic transformation of the pre- and posttests.

Figure 15. Histograms and distribution curves of the log10 transformation of note errors.



Data Analysis

The means and standard deviations of the pre- and posttest scores for each practice group on each task are shown in Table 8. A graphic presentation of the mean pre- and posttest scores on each task as a function of practice group is given in Figure 16. As can be seen, all pretest means on the easy task were lower than pretest means on the hard task. This was expected due to the different difficulty levels of the task.

Table 8: Pre- and Posttest Mean Performance Scores and Standard Deviations for Each Practice Group on the Two Tasks

	Easy Level Task				Hard Level Task			
	Pretest		Posttest		Pretest		Posttest	
Group	M	SD	M	SD	M	SD	M	SD
Physical Practice	1.02	0.32	0.71	0.49	1.40	0.35	0.69	0.55
66:33 combined	0.86	0.44	0.62	0.45	1.46	0.39	0.88	0.66
33:66 combined	0.96	0.42	0.57	0.44	1.26	0.41	0.85	0.61
Mental Practice	0.74	0.58	0.49	0.51	1.14	0.62	0.81	0.66

A 4 X 2 (Practice Group X Task Level Posttest) ANCOVA with repeated measures on the last factor, using the pretest on each task as a covariate (Table 9), revealed a significant main effect for the task level factor, $F(1,54) = 6.61$, $p<.013$, and a significant interaction effect, $F(3,54) = 3.65$, $p<.018$. No significant main effect was found for the practice group factor $F(3,54) = 2.30$. These results answered all research questions: (1) there were no statistically significant differences between the practice

Figure 16. Hard task scores and easy task scores as a function of practice procedure and pre- to posttest performance.

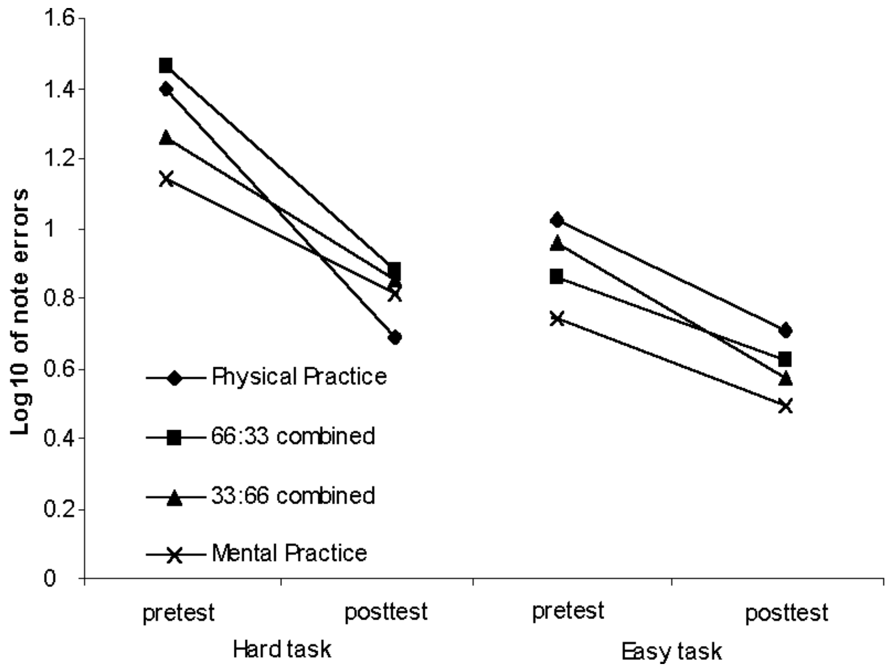


Table 9: Summary of 4 X 2 (Practice Group X Task Level Posttests) ANCOVA With Repeated Measures on the Last Factor

Source (adj.)	SS	df	MS	F
Between Subjects				
Practice Group	0.83	3	0.28	2.30
Subjects w/ practice group	6.54	54	0.12	
Within Subjects				
Task Level	0.49	1	0.496	6.61*
Task Level X Practice Group	0.82	3	0.27	3.65*
Task Level x (subj. w/ groups)	4.05	54	0.07	

*p<.05

groups; (2) a statistically significant difference was found between the easy harmonic progression and the hard harmonic progression in that performance on the easy progression was better than performance on the hard progression; (3) a statistically significant interaction effect was found between the difficulty levels of the harmonic progression and the practice groups.

Post Hoc Analysis

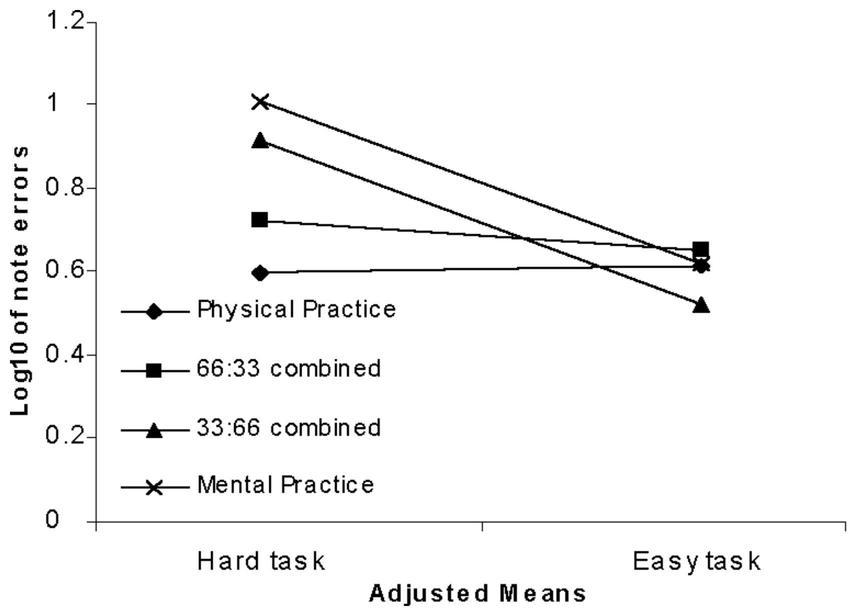
First t-Test

Since the posttest means do not take into account pretest differences between subjects, the adjusted posttest means and standard deviations for each group on each task were calculated and are presented in Table 10. Figure 17 presents the adjusted posttest means as a function of practice groups by task level.

Table 10: Means and Standard Deviations of Adjusted Posttest Means For Each Practice Group On Each Task

	Easy Level Task		Hard Level Task	
Group	M	SD	M	SD
Physical Practice	0.61	0.26	0.60	0.39
66:33 combined	0.65	0.36	0.72	0.44
33:66 combined	0.51	0.34	0.91	0.46
Mental Practice	0.61	0.47	1.00	0.69

Figure 17. Adjusted posttest means as a function of practice groups by task.



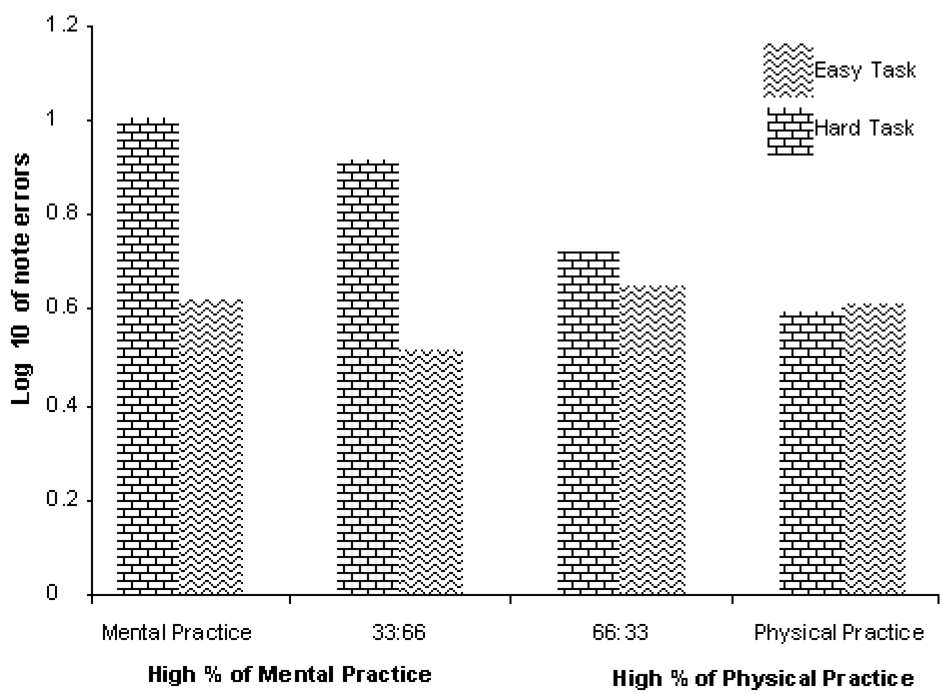
In order to examine the interaction effect, a post hoc comparison between the adjusted means of each practice group on the two tasks was done using the paired sample t-test (Table 11). Results of the t-test revealed that the task level effect was significant only for the 33:66 practice group, t(14)=-3.65, and for the mental practice group, t(14)=-3.53, both at the p=.003 level. No significant differences of task level effect were found for the physical practice and the 66:33 combined practice groups. These results suggested that for the 33:66 combined practice group and the mental practice group, both groups that had the higher percentage of mental practice, the performance on the easy harmonic progression was significantly better than on the hard harmonic progression. However for the 66:33 combined practice group and the physical practice group, both groups that had the higher percentage of physical practice, performance on both harmonic progressions were not significantly different (Figure 18).

Table 11: Post Hoc Comparison of Adjusted Posttest Means of Each Group on the Two Tasks Using the Paired Sample T-Test

Practice Group	Adj. Mean Easy	Adj. Mean Hard	Mean Difference	SD	95% Confidence interval Lower	95% Confidence interval Upper	T	df
PP	0.61	0.60	0.01	0.31	-0.16	0.18	0.15	14
66:33	0.65	0.72	-0.07	0.52	-0.36	0.22	-0.52	14
33:66	0.51	0.91	-0.39	0.41	-0.62	-0.16	-3.65**	14
MP	0.61	1.00	-0.38	0.42	-0.62	-0.15	-3.53**	14

**p<.005

Figure 18. Adjusted means as a function of tasks by practice group.



Second t-Test

There was a similarity between the behaviors of the mental practice group and the 33:66 combined practice group as well as a similarity between the physical practice group and the 66:33 combined practice group. Therefore a comparison between the combined adjusted scores of each of the two groups on the two tasks was conducted after collapsing the four practice groups into two new practice groups. One was higher in physical practice percentage and included the physical practice and the combined 66:33 practice groups (HPP), and one was higher in mental practice percentage and included the mental practice and the combined 33:66 practice groups (HMP). The means and standard deviations of the adjusted posttest means for these practice groups is given in Table 12 and graphed in Figure 19.

Table 12: Means and Standard Deviations of Adjusted Posttest Means For the New Practice Groups On Each Task

	Easy Level Task		Hard Level Task	
Group	M	SD	M	SD
High Physical Practice	0.63	0.31	0.66	0.41
High Mental Practice	0.56	0.41	0.96	0.58

The t-test analysis of the adjusted means of the two new groups on each task, as shown in Table 13, revealed significant differences between the groups on the hard task, $t(58)=-2.30$, at the $p=.02$ level. No significant differences were found between these two new groups on the easy task. This finding suggests that performance of the higher physical practice group on the hard task was significantly better than that of the higher mental practice group (Figure 20).

Figure 19. Adjusted posttest means as a function of new practice groups by task.

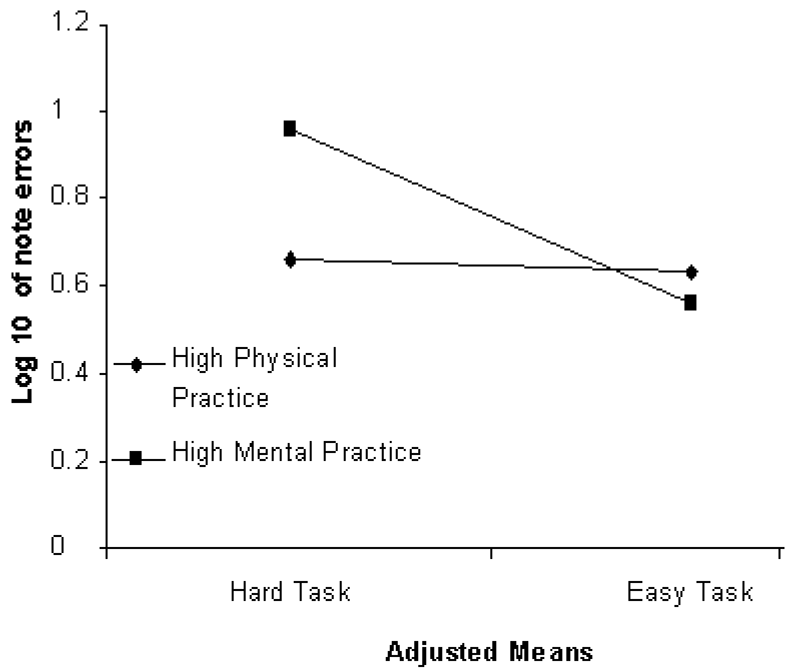


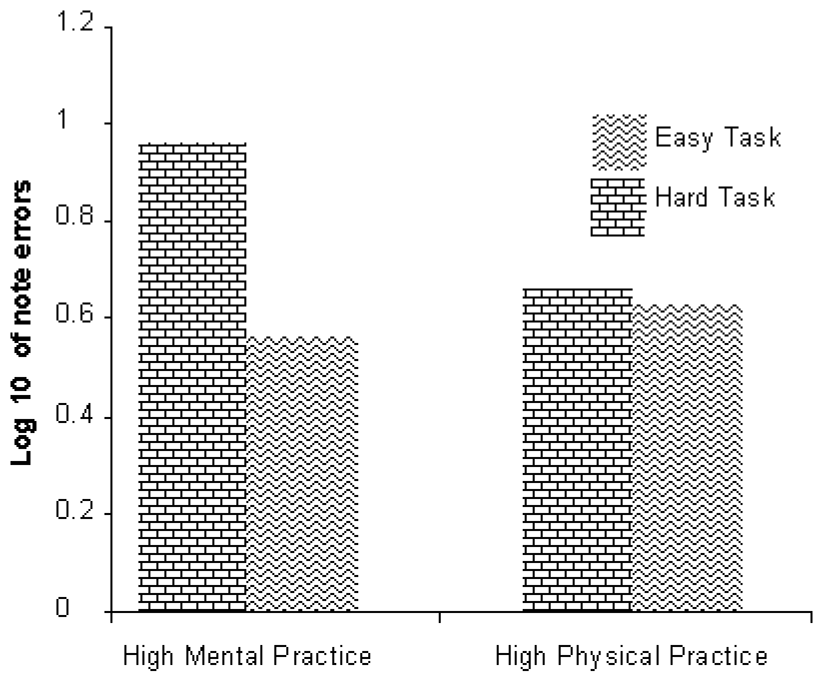
Table 13: Post Hoc Comparison of Adjusted Means of the Two Newly Formed Groups on Each Task Using the Independent Samples T-Test

Task Difficulty	Adjusted Mean Difference	Standard Error	95% Confidence interval Lower	Upper	T	df
Easy	0.06	0.09	-0.12	0.25	0.66	58
Hard	-0.30	0.13	-0.56	-0.03	-2.30*	58

*$p < .05$

As a result of this second post hoc comparison it may be concluded that the performance of the physical and combined 66:33 practice groups on both the easy and hard harmonic progressions were not significantly different from each other and were just as good as the performance of all groups on the easy progression.

Figure 20. Adjusted posttest means as a function of tasks by new practice groups.



Pre- to Posttest Effect Size

One final descriptive statistic of pre- to posttest effect size was calculated. The pre- to posttest effect size, or as defined by Becker (1988) the standardized mean change, represents the average change from pretest to posttest in standard-deviation units. Effect sizes of the practice groups on each task (Table 14) were calculated as the difference between mean pretest and mean posttest divided by the pretest standard deviation. As can be seen from the results, for the hard task, the higher the percentage of physical practice, the larger was the effect size. Physical practice had the largest effect size (ES = 2.03) followed by the 66:33 combined physical and mental practice group (ES = 1.49) and the

33:66 combined physical and mental practice group (ES= 1.00). Mental practice had the smallest effect size (ES=0.53). Examination of practice group effect sizes on the easy task also revealed an overall similar pattern. Physical practice had the largest effect size (ES=0.96) and mental practice had the smallest effect size (ES=0.43). However, contrary to the pattern found for the hard task, on the easy task the effect size of the 33:66 combined physical and mental practice group (ES=0.93) was larger than that of the 66:33 combined physical and mental practice group (ES=0.55).

Table 14: Effect Sizes of Pre- to Posttest For Each Practice Group on Each Task

Group	Easy Task	Hard Task
Physical Practice	0.96	2.03
66:33 combined	0.55	1.49
33:66 combined	0.93	1.00
Mental practice	0.43	0.53

CHAPTER 5

SUMMARY CONCLUSIONS AND DISCUSSION

This chapter begins with a summary of the study including a restatement of the purpose and research questions, the methodology used, and the findings. This is followed by a conclusions section in which the findings are examined in context of the related literature. Finally a discussion regarding various issues of the study is presented.

Summary

The purpose of this study was to investigate the relative effectiveness of different proportions of time spent on physical and mental practice, in the context of performing a tonal pattern over harmonic progressions of different difficulty levels. Three specific research questions were posed:

1. Were there differences on the measure of note errors between the different practice groups of physical practice, combined physical and mental practice in the proportions of 66% physical and 33% mental practice, combined physical and mental practice in the proportions of 33% physical and 66% mental practice, and mental practice?
2. Was there a difference between the easy harmonic progression and the hard harmonic progression on the measure of note errors?
3. Was there an interaction between the difficulty levels of the harmonic

progression and the practice groups on the measure of note errors?

Sixty undergraduate students who had participated in a jazz improvisation course, volunteered to take part in the study. Using a sampling without replacement procedure (Keppel, 1982), the subjects were assigned into four independent practice groups, partially blocked for musical instruments. The four practice groups included a physical practice group, a mental practice group and two combined physical and mental practice groups. The two combined practice groups alternated between mental and physical practice in the proportions of 66% physical and 33% mental practice for one group, and in the proportions of 33% physical and 66% mental practice for the other group.

Subjects were tested on the performance of a tonal pattern on both an easy and a hard harmonic progression. Presentation of the two difficulty levels of the harmonic progressions were counterbalanced to control for practice effects. Each subject performed a pretest followed by a 3 minute practice session according to the required practice routine. A posttest was performed immedeately following the practice session. All pre- and posttests were recorded and later scored according to number of note errors.

Subject variables of age, years of performance study, and years of improvisation study were examined for possible correlations with the dependent variable of note errors. It was found that only the subject variable of years of performance study was significantly correlated with the dependent variable of note errors.

A logarithmic transformation of note error results (Winer, 1971) was used to rectify the distribution curves. All statistical procedures were carried out on the resulting logarithmic trasnformations. An ANCOVA was done using pretest scores as covariates, followed by post hoc comparison between the adjusted means of each practice group on the two tasks using paired sample t tests.

Findings of the study revealed that: (a) there were no differences between the different practice groups on the measure of note errors, (b) there was a significant difference between the easy harmonic progression and the hard harmonic progression on the measure of note errors such that performance on the easy progression was significantly better than performance on the hard progression, and (c) there was a significant interaction between harmonic difficulty level and the practice groups. Post hoc comparisons between the adjusted means of each practice group on the two tasks revealed that for the 33:66 combined practice group and the mental practice group, both groups that had the higher percentage of mental practice, the performance on the easy harmonic progression was significantly better than on the hard harmonic progression. However for the 66:33 combined practice group and the physical practice group, both groups that had the higher percentage of physical practice, performance on both harmonic progressions was not significantly different.

In a second post hoc analysis, the four groups were collapsed into two groups: one high in percentage of physical practice that included both the physical and the combined 66:33 groups, and the other high in percentage of mental practice that included the mental and the combined 33:66 practice groups. Results of these post hoc comparisons revealed that there was no significant differences between the two groups on the easy task, yet there was a significant difference between the two groups on the hard task. The group that was high in percentage of physical practice performed significantly better on the hard task than the group that was high in percentage of mental practice.

One final descriptive statistic, the pre- to posttest effect sizes which represented the average change from pretest to posttest in standard deviation units (Becker, 1988), were calculated for each practice group on each task. Results revealed a similar effect size pattern for both tasks. For the hard task, the higher the percentage of physical practice within the practice group, the larger was the effect size. For the easy task the same overall pattern occurred though with a difference for the combined practice groups. The effect size of the combined 33:66 practice group was larger than that of the combined 66:33 practice group.

Conclusions

In light of the reveiwed literature, the findings of this study partially confirm previous findings and partially add new information. Feltz, Landers and Becker (1986) calculated and compared pre- to posttest effect sizes of physical, mental, and combined physical and mental practice. The overall tendency of these three practice procedures was such that physical practice had the largest overall mean effect size followed by that of the combined physical and mental practice. Mental practice had the smallest overall effect size. The effect sizes of the practice groups in this study were of the same pattern.

Hird, Landers, Thomas and Horan (1991) compared different proportions of combined physical and mental practice. Results of posttest effect sizes showed a linear trend in which the higher the proportion of physical practice, the larger was the posttest effect sizes of the groups. Mental practice had the least posttest effect size and physical practice had the largest posttest effect size. Regarding the combined practice groups, the higher the proportion of physical practice, the larger the posttest effect size of that group. As discussed earlier, this trend was not apparent when pre- to posttest effect sizes were calculated apparently due to large standard deviation differences between pretest and posttest. Effect sizes of the combined practice groups within this study were different for the two tasks. For the hard task, the higher the percentage of physical practice, the larger was the effect size. The 66:33 combined physical and mental practice group had a larger effect size than the 33:66 combined physical and mental practice group. However, for the easy task the effect size of the 33:66 combined physical and mental practice group was larger than that of the 66:33 combined physical and mental practice group.

These findings concerning effect sizes should not be mistakenly interpreted as findings of significant differences between groups. On the contrary, all that they reflected was a certain consistency in effect size pattern between practice groups found in the studies of Feltz, Landers and Becker (1986) and Hird, Landers, Thomas and Horan (1991) with those found in this study.

Research studies in mental practice related to music performance have found both non significant and significant findings between practice groups. Studies by Coffman (1981), Rosenthal, Wilson, Evans, and Greenwalt (1988), and Theiler and Lippman (1995) have reported no significant differences between practice groups on the measure of note errors. Results of this study have also shown no significant differences between the four practice groups.

Significant differences between practice groups (disregarding control groups or groups with added interventions such as simulated movement or modeling) have been reported in two studies. Ross (1985) found significant differences between the combined physical and mental practice group and the mental practice group, and Lim and Lippman (1991) reported significant differences between the physical and the mental practice groups.

As a post hoc procedure, this study collapsed the four practice groups into two practice groups based on containing either a higher percentage of physical practice or a higher percentage of mental practice. Although, as stated previously, no significant differences were found between the four practice groups, post hoc comparisons between the two new groups suggested that for the hard task there was a significant difference between the two. For the easy task there was no significant difference between the two groups.

The issue of varying levels of task difficulty and their interaction with practice procedures has not been addressed in mental practice studies. However the Rubin-Rabson (1941) study was perhaps the only study that did do a post hoc analysis regarding the effectiveness of the various practice methods according to the difficulty of the experimental materials. She found that for the easy and medium pieces there was a tendency toward superiority for the combined physical and mental practice method, whereas for the difficult pieces the physical practice method was the most effective. The results of the current study seemed in part to confirm Rubin-Rabson’s (1941) post hoc findings, in that there was a significant interaction effect between task difficulty and practice procedure. The interaction results of this study suggested that subjects who used practice procedures with a higher percentage of mental practice performed significantly better on the easy task than on the hard task. Subjects who used the practice procedures with a higher percentage of physical practice performed as well on both tasks, as did subjects of all practice groups on the easy task.

Discussion

This study introduced several features that had not been examined in mental practice research. These include the type of a musical task and its execution at two different difficulty levels. Also the examination of various combinations of mental and physical practice was a relatively unresearched field and had not been addressed within music performance.

Mental practice research in music performance to date has been concerned with the learning and memorizing of written music (Coffman, 1987; Lim & Lippman, 1991; Rosenthal, Wilson, Evans, & Greenwalt, 1988; Ross, 1985; Rubin-Rabson, 1941; Theiler & Lippman, 1995). The use in this study of a different type of musical task, the performance of a tonal pattern over chord changes, expanded even further the spectrum of musical tasks that may be applied to mental practice research. Within this genre, the performance of a specific tonal pattern was but one of many possible musical exercises that may be used (e.g., Bergonzi, 1992; Coker, 1991; Crook, 1991).

Three subject variables that included age, years of performance study, and years of improvisation study, were examined for significant correlation with the dependent variable of note errors. Only years of performance study correlated significantly with the dependent variable in that the more years of study the less the amount of performed note errors. The fact that number of years of improvisation study did not yield significant correlation was somewhat surprising. From questions of subjects while filling out the subject form, it was apparent that there was a difference in the number of years of study of improvisation and the number of years that musical improvising had been performed with or without prior formal training. It is suggested that future studies examine whether the total number of improvisation years may not have a higher correlation with the dependent variable.

Within the area of task difficulty, this study had limited itself to the performance of a tonal pattern on harmonic progressions of two levels: easy and hard. The resulting interaction pattern suggested that as the difficulty of the task became harder so did the differences between the practice groups become larger. This was even more apparent when post hoc comparisons were done between the two newly formed practice groups: one high in percentage of physical practice and one high in percentage of mental practice. Whereas for the easy task there was no significant difference between the two groups, for the hard task there was a significant difference between the two. Future studies should examine at least three difficulty levels in order to determine whether this pattern continues in a linear fashion or not. If indeed this pattern continues, it may be speculated that significant differences between the four original practice groups will occur when tasks are at the more difficult end of the spectrum. Also, future research has to examine whether the type of musical task itself, which was high both in cognitive and motor elements, contributed to the resulting interaction pattern. Other tasks, both in areas of music such as the learning and memorizing of written music, and in areas outside of music, have to be examined to see whether this interaction pattern is consistent in all fields.

The ability to manipulate elements of a task so as to change the difficulty level is almost limitless. This study examined two levels of task difficulty by manipulating the amount of chords per excerpt. Other possibilities of manipulation for example could have included changing the required tonal pattern, changing the metronome speed and changing all of these at once. The manipulation of task elements in order to change the task difficulty may easily be applied to other areas of mental practice research. For example dart throwing tasks may be manipulated by distancing throwers closer and further away from the dartboard. Also the dartboard itself may use circles of different diameters whereby the dartboard used in the easier task would have a larger center ring diameter than the dartboard used in the harder task. Such manipulations of task difficulty levels would help in determining if the interaction that was found is both consistent in musical tasks and in tasks outside of music performance.

The findings of this study, that combinations of physical and mental practice of differing proportions are effected differentially by task difficulty, should also be addressed in future research. Even those studies that include only one combined practice group should be more specific in reporting the proportions of each practice type. As has already been shown, mental practice studies related to music performance have not reported these proportions and they have not been consistent. For example, Ross (1985) used a combined practice group of 66% physical practice and 33% mental practice whereas Coffman (1987) and Theiler and Lippman (1995) used a combined practice group of 50% physical practice and 50% mental practice.

Hird, Landers, Thomas and Horan (1991) pointed out that perhaps one of the biggest drawbacks of mental practice research was that “it is common in research studies to instruct subjects to use mental practice without teaching them how to use it” (p.292). The unfamiliarity with mental practice may be exemplified by the concluding remarks by Lim and Lippman (1991) that “all subjects regretted not having been made aware of mental practice earlier in their musical training, asserting that a combination of practice skills is important and that all practice skills should be taught early” (p.29). Even within this study several subjects were literarily astonished at the possibility that they could practice mentally, let alone actually succeed in improving their performance after such a practice session. In a certain respect, the comparison between mental practice and combinations of mental and physical practice with that of physical practice in a music performance task, is almost like comparing a newly learned practice technique of mental or combined physical and mental practice with that of a thoroughly ingrained practice technique of physical practice.

Maybe a future direction in mental practice research should be not only a comparison of the different practice techniques, but also a comparison between subjects who had been trained to practice mentally, or in combinations of physical and mental practice with those who had not. A difference between these two groups in favor of the trained subjects would mean that mental practice as a practice technique can be improved. If this were the case, then maybe the interaction that was found in the current study between the different practice procedures would not apply to those who are adept in the skill of mental practice.

The mental practice procedures that were used in this study were built based on findings of previous research in order to achieve the highest possible practice outcome. The limited time of three minutes (mental practice group), two minutes (combined 33:66 practice) and one minute (combined 66:33 practice) have been found to be the optimum time for cognitive type tasks (e.g., Etnier & Landers, 1996; Feltz & Landers, 1983). Also, mental practice prior to physical practice, as performed by the combined practice groups, has been found to be more effective than mental practice after physical practice (Etnier & Landers, 1996).

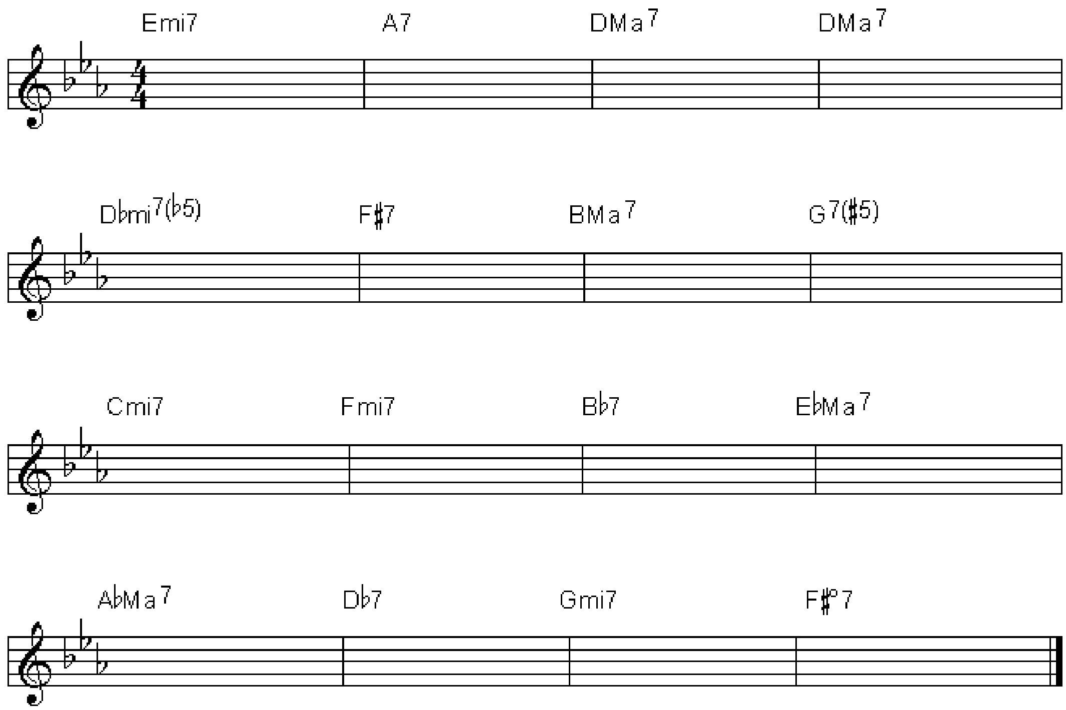
The fact that these practice procedures have to a certain extent been as effective as the physical practice procedure suggests that music pedagogues introduce these methods to their students. Presenting both beginning music students as well as advanced music students with the opportunity of experimenting with mental practice would be consistent with Hallam's (1995) conclusions that music students be presented with a range of learning strategies. Thus they may explore and develop their preferred approach to practicing.

The possibilities of incorporating mental practice into the music lesson are almost endless. This is true both of the private studio lesson and of the class band lesson. Mental practice tasks may range from practicing new pieces that have not yet been rehearsed to pieces that have been rehearsed and that are in the process of being learned. Results of this study suggest that mentally practicing easy pieces would be as beneficial as physically practicing. Therefore, to instill within music students a sense of accomplishment whilst practicing mentally, it would seem that at the beginning stages of applying mental practice easy pieces should be used. Once music students begin to feel comfortable with mental practice, harder pieces could be attempted. Findings of this study suggested that even within harder tasks certain combinations of mental and physical practice (combined 66:33) were preferable to other combinations (combined 33:66). Therefore allowing the students the opportunity of combining mental and physical practice, and acknowledging the effect this type of practice procedure has on their performance is yet another way of exposing these practice methods to the students. The optimal mental practice period used in this study was of a short time length ranging from one to three minutes. The inclusion of such a practice period within the music lesson would be hardly noticeable, but could have the potential of paying large dividends toward improving the effectiveness of practice habits.

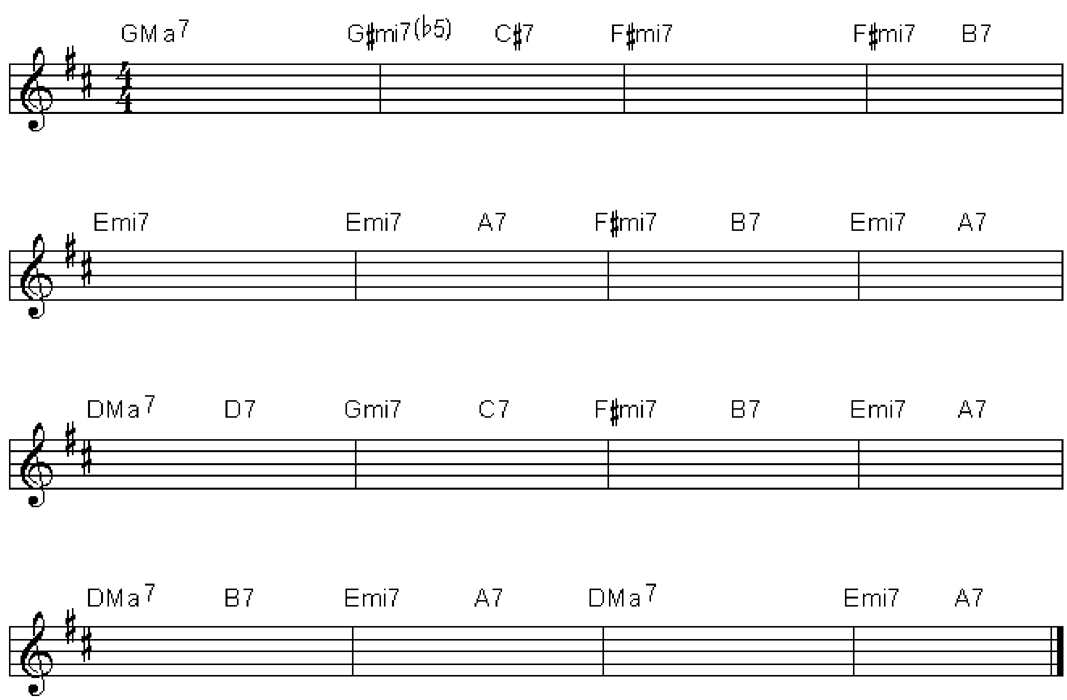
APPENDIX A

HARMONIC PROGRESSIONS AND THEIR MELODIC SOLUTIONS

Harmonic progression 1 (as presented to the subjects)



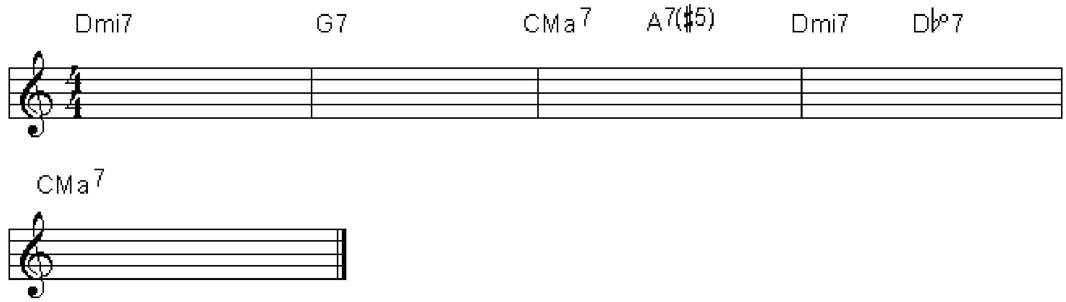
Harmonic progression 2 (as presented to the subjects)



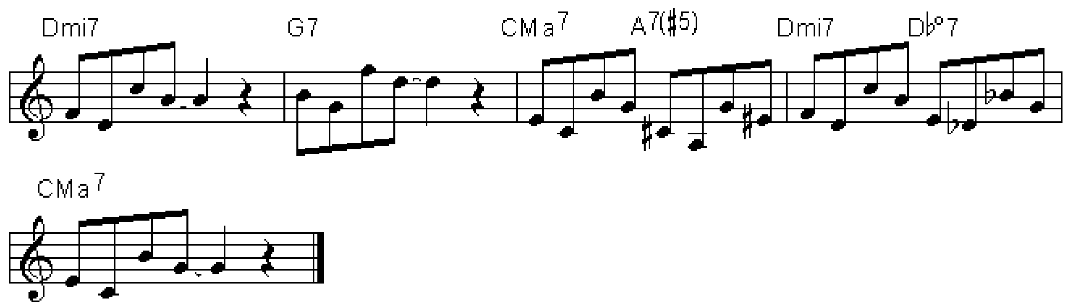
Melodic solution of harmonic progression 1 in concert key (used by judges for scoring)

Melodic solution to harmonic progression 2 (used by judges for scoring)

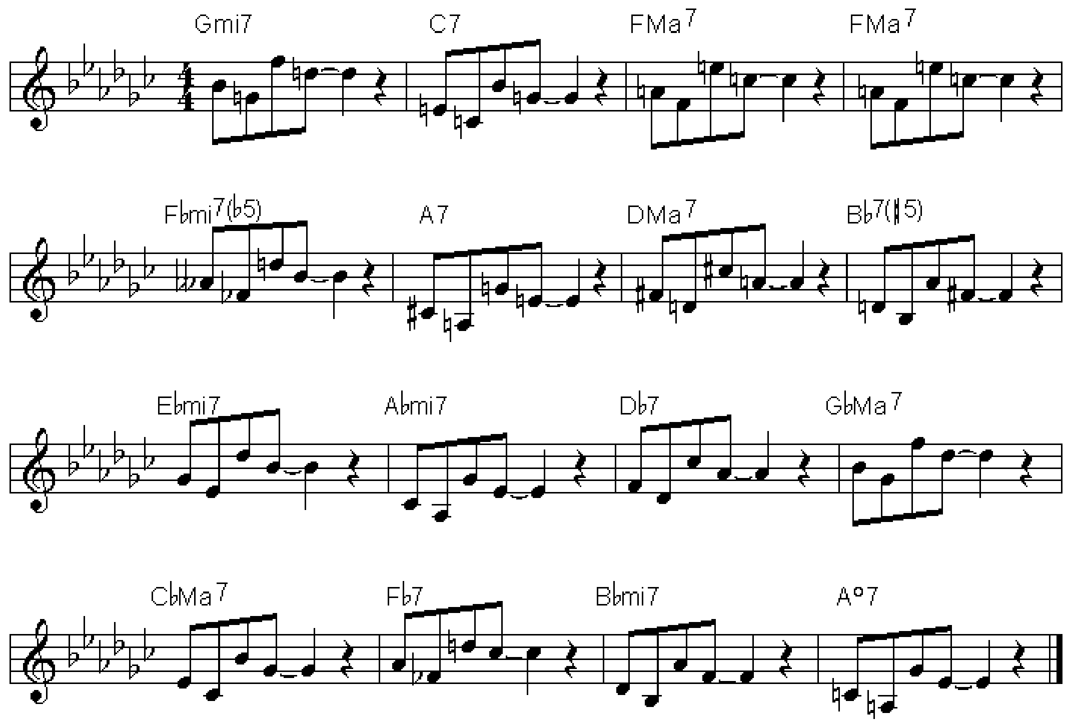
Practice progression (presented to subjects prior to testing)



Melodic solution of practice progression (presented to subjects together with the practice progression)

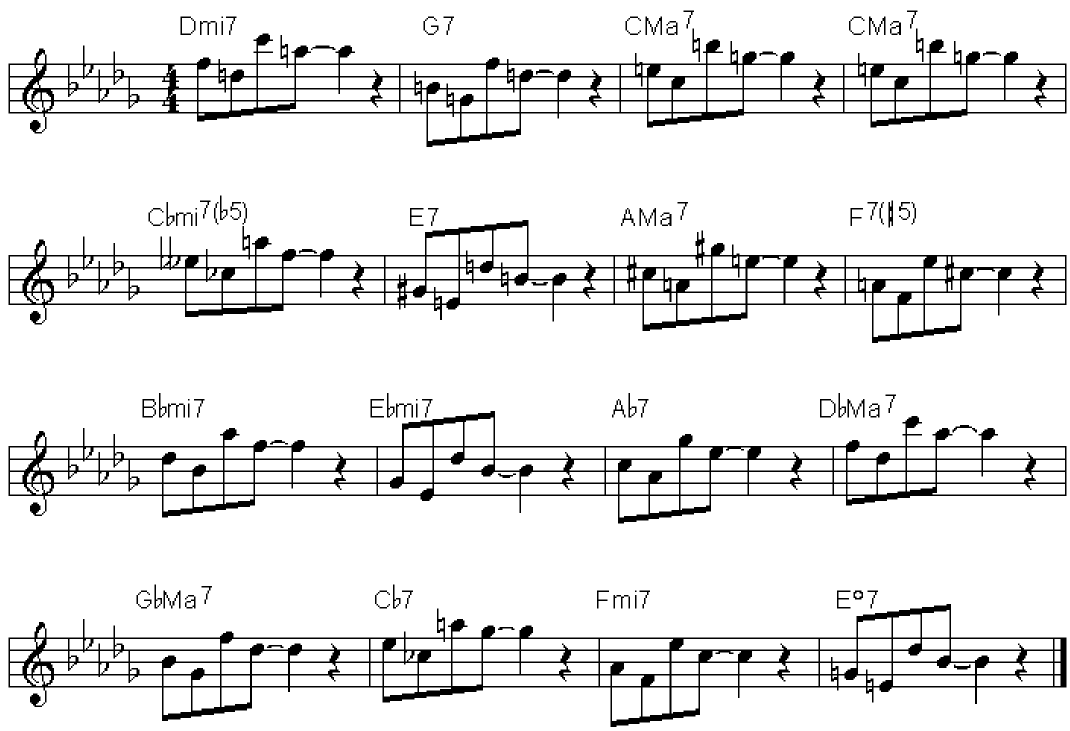


Melodic solution of harmonic progression 1 in Eb transposition (alto saxophone)



Melodic solution of harmonic progression 2 in Eb transposition (alto saxophone)

Melodic solution of harmonic progression 1 in Bb transposition (trumpet and tenor sax)



Melodic solution of harmonic progression 2 in Bb transposition (trumpet and tenor sax)

APPENDIX B

TASK INSTRUCTIONS

Task instructions

You are about to be handed two pages of music which include only chord notation. Your task is to play the four notes of each chord i.e. root (1), third (3), fifth (5) and seventh (7) in the following order: 3-1-7-5. Figure 1 illustrates a notated example of one chord per bar as it will appear in the music and its melodic and rhythmic solution.

Figure 1. One chord per bar and its solution.

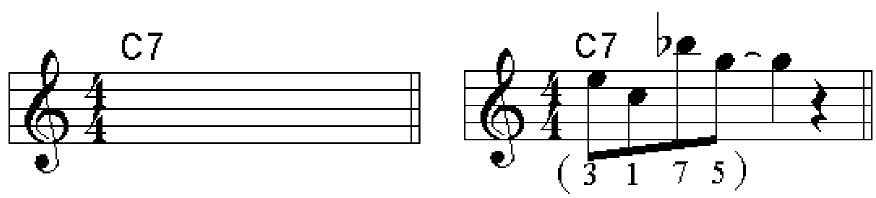
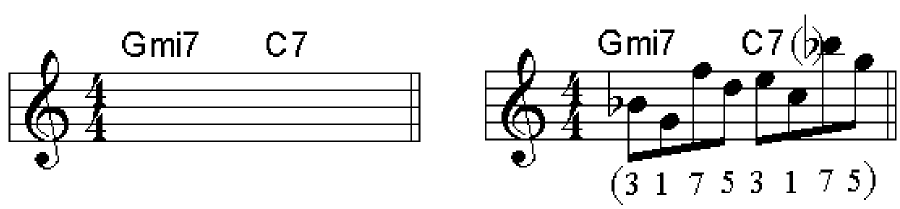


Figure 2 illustrates the notation of two chords per bar and its solution.

Figure 2. Two chords per bar and their solution.



Upon receiving the first music page, you are to play the required pattern with the metronome. You will then be given 3 minutes to practice in a manner that will be described later, after which you will again perform the required pattern with the metronome. These proceedings will be similarly repeated for the second music page.

If you have any questions please ask now. In order to familiarize you with the required pattern and the metronome speed, you have two minutes to practice the five bar progression which appears at the top of the following page. At the bottom of the page appears the correct solution of the progression. Your contimuation in the study depends on your ability to perform correctly on this progression.

Practice Instructions

Physical Practice group

Upon receiving the music you are to perform the prescribed pattern with the metronome. After performing you will practice playing for a period of 3 minutes.

Following your practice session you will again perform the required pattern with the metronome. All performances will be recorded.

Please notify the tester when you are ready to begin.

Mental practice group

Upon receiving the music you are to perform the prescribed pattern with the metronome. After performing you will mentally practice playing for a period of 3 minutes. During the mental practice period you are to mentally play the prescribed pattern, all the while imagining your hand movements and mentally hearing the notes, yet, without moving your fingers, touching or looking at your musical instrument.

Following your practice session you will again perform the required pattern with the metronome. All performances will be recorded.

Please notify the tester when you are ready to begin.

Combination practice group of 66% PP and 33% MP

Upon receiving the music you are to perform the prescribed pattern with the metronome. After performing you will practice for a period of 3 minutes alternating between a half minute period of mental practice and a one minute period of physical practice. During the mental practice period you are to mentally play the prescribed pattern, all the while imagining your hand movements and mentally hearing the notes, yet, without moving your fingers, touching or looking at your musical instrument. You will be notified by the tester as to when you are to change from each type of practice.

Following your practice session you will again perform the required pattern with the metronome. All performances will be recorded.

Please notify the tester when you are ready to begin.

Combination practice group of 33% PP and 66% MP

Upon receiving the music you are to perform the prescribed pattern with the metronome. After performing you will practice for a period of 3 minutes alternating between a one minute period of mental practice and a half minute period of physical practice. During the mental practice period you are to mentally play the prescribed pattern, all the while imagining your hand movements and mentally hearing the notes, yet, without moving your fingers, touching or looking at your musical instrument. You will be notified by the tester as to when you are to change from each type of practice.

Following your practice session you will again perform the required pattern with the metronome. All performances will be recorded.

Please notify the tester when you are ready to begin.

APPENDIX C
FORMS AND TABLES

Consent form

Dan Cahn

Doctoral Student in the department of Music Education,

University of North Texas

I, (fill in full name) ______________________________________ agree to participate in a study concerning practice methods in music performance. This study requires from me to perform a musical task and to practice this task upon my instrument in a prescribed fashion. The experiment itself will last approximately 20 minutes. Performances will be recorded for later analysis but, to preserve confidentiality, I will not be identified by name. Analysis results of performances will be reported only as group results.
I understand that there is no personal risk or discomfort directly involved with this research and that I am free to withdraw from the experiment at any time without prejudice or penalty.

Date: Signature of Subject

Date: Investigator.

This project has been reviewed by the University of North Texas Committee for the Protection of Human Subjects (phone: (940) 565-3940).

Copy of this form is provided to the subject.

Subject Form

Before beginning the experiment kindly fill in the following information.

Age:

Gender: Male/ Female

Musical Instrument:

Number of years of study:

Number of years in improvisation study:

Instrument by Group Table

	PP		33:66		66:33		MP	
	Easy	Hard	Easy	Hard	Easy	Hard	Easy	Hard
Piano								
Guitar								
Saxophone								
Flute								
Bass								
Trumpet								
violin								

Example of Subject Table

Subject Number	Music instrument	Practice group	First task performed	Easy Pretest	Easy Posttest	Hard Pretest	Hard Posttest
1							
2							
3							
4							
5							
6							
7							
8							
9							
10							
11							
12							
13							
14							
15							
16							

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