4-22-2011

Comparisons of Visual Versus Kinesthetic Mental Imagery in Soccer Players: An EEG Study

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COMPARISONS OF VISUAL VERSUS KINESTHETIC MENTAL IMAGERY IN SOCCER PLAYERS: AN EEG STUDY

by

Collier Shepard

A Thesis

Submitted in Partial Fulfillment of the

Requirements for the Degree of

Master of Science

Major: Health and Sport Sciences

The University of Memphis

May 2011

ABSTRACT

Shepard, James Collier. M.S. The University of Memphis. May, 2011. Comparisons of Visual Versus Kinesthetic Mental Imagery in Soccer Players: An EEG Study. Major Professor: Dr. Yuhua Li

Mental imagery has been shown to effectively increase sport performances. However, limited studies have examined the underlying neurological influence of mental practice, especially with team sports. The current study investigated whether Electroencephalogram (EEG) patterns differ based on an athlete's ability to use mental imagery, and if differences exist between the two types of mental imagery, visual versus kinesthetic, when mentally rehearsing specific soccer scenarios. Ten college elite soccer athletes and seven novices participated in this study. EEG data and self-rating were collected during mental rehearsal of three simple movements and three soccer scenarios applying either visual or kinesthetic mental imagery. Although visual mental imagery was predominantly preferred for both groups, the alpha amplitude of EEG significantly decreased during kinesthetic mental imagery of the soccer scenarios for the elite group, suggesting a deeper brain involvement than the novice group.

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Introduction

Mental practice is defined as the cognitive rehearsal of a physical skill in the absence of overt physical movements (Magill, 2007). Mental imagery is one of the most important mental processes used in mental practice for enhancing performance in competitive and rehabilitation settings (Dickstein & Deutsh, 2007; Magill, 2007; Murphy, 2005; Shoenfelt & Griffith, 2008). According to Richardson (1969), mental imagery is the existence of sensory and perceptual experiences in the absence of the stimuli that produce the genuine senses. During mental imagery an individual recreates or creates an experience by mentally producing images and a variety of senses (Short, Afremow, & Overby, 2001). It has also been suggested that mental imagery internally recreates an external experience within one's thoughts of what is, or could be (Knudstrup, Segrest, & Hurley, 2003). When individuals engage in mental imagery, they use either visual or kinesthetic mental imagery to rehearse the performance of a skill or part of a skill.

Mental practice has been shown to produce measurable differences in performance enhancement (Hinshaw, 1991; Isaac & Marks, 1994). For decades, a great amount of research within psychology and motor performance labs has studied mental practice and its benefits on motor skill enhancements, especially in sport settings (Callow & Hardy, 2004; Dickstein & Deutsch, 2007; Feltz & Landers, 1983). Murphy and colleagues (2005) found that nearly all of the athletes at an Olympic Training Center used mental practice to prepare for competition and thought it enhanced performance. It was determined that 90% of the athletes used mental imagery, while 94% of the coaches encouraged their players to use mental imagery. Besides preparing for competition, mental imagery was also used by athletes for error correction, new skill acquisition, and relaxation.

Although an extensive amount of research has been conducted on mental imagery, limited studies have examined the underlying neurological characteristics in individuals engaged in it. Particularly, there is little research using brain monitoring technique to determine whether visual mental imagery or kinesthetic mental imagery has greater influences on cortical activities for team sport players. The current study examined electroencephalography (EEG) patterns associated with athletes' abilities to use mental practice as well as different characteristics of the two types of mental imagery. The results of the study may help athletes, coaches, and sport psychologists gain a better understanding of different neurological characteristics of mental imagery, as well as its potential benefits for athletic performance.

Review of the Literature

Types of Mental Imagery

Two types of mental imagery have been commonly practiced: visual mental imagery and kinesthetic mental imagery. When an individual uses visual mental imagery, he or she either applies internal or external imagery (Magill, 2007). Internal imagery is performed when an individual images being inside his or her body performing a task as if a camera was strapped to his or her forehead (Dickstein & Deutsch, 2007; Magill, 2007). In external imagery, a person sees himself or herself from an observer's point-of-view similar to watching a movie (Callow & Roberts, 2010; Magill, 2007). Kinesthetic mental imagery is performed by the individual using internal imagery to "feel" the limbs and muscles move while visualizing the movements of a skill (Callow & Roberts, 2010; Guillot, Collet, & Dittmar, 2004).

Previous research has compared the effectiveness of the two types of mental imagery (Callow & Hardy, 2004; Callow & Roberts, 2010; Dickstein & Deutsch, 2007; Glisky, Williams, & Kihlstrom, 1996; Guillot et al., 2004; Hardy & Callow, 1999; Marks & Isaac, 1995; Neuper, Scherer, Reiner, & Pfurtscheller, 2005; Spittle & Morris, 2007; Taktek, Zinsser, & St-John, 2008). In a study looking at the influence of learning a new motor task through two experiments, Féry (2003) found that visual mental imagery may be more beneficial for tasks that stress form, whereas kinesthetic mental imagery appears to be more advantageous for tasks that emphasize coordination or timing of the hands. Participants in the first experiment were either in a kinesthetic group that guided their index and middle fingers along a form or in a visual group that visualized moving along a form. The visual group performed better than the kinesthetic group when participants were asked to draw the form. In the second experiment, subjects engaged in a task that involved coordination of both hands to control a stylus' movement of a form. The two groups in this experiment were the same as the first, and the kinesthetic group outperformed the visual group in reproducing the form with the two-handed stylus. Hall, Buckolz, and Fishburne (1992) found that kinesthetic mental imagery had a more positive effect on learning closed motor skills and visual mental imagery was more useful for learning open motor skills. Both types of mental imagery have shown efficiency in retention for motor skills and performance (Taktek et al., 2008). Visual mental imagery shows better retention for practice when environmental space is concerned, while retention for tasks involving hand accuracy is better when kinesthetic mental imagery is used (Dickstein & Deutsch, 2007).

Both types of mental imagery appear to be valuable. However, which type to use may be dependent upon the task or skill but may also depend on the individual and his or her abilities to apply the two types of mental imagery while engaged in mental practice. Some individuals may be more comfortable using one type of mental imagery even if the other may be more appropriate for certain tasks.

Mental Imagery and Skill Performance

Mental practice can utilize mental imagery to help in motor skill acquisition and even improve motor performance (Blair, Hall, & Leyshon, 1993; Callow & Hardy, 2004; Dickstein & Deutsch, 2007; Driskell, Copper, & Moran, 1994; Glisky et al., 1996; Kohl, Ellis, & Roenker, 1992; Martin & Hall, 1995; Ross, 1985). Hird, Landers, Thomas, and Horan (1991) demonstrated that mental practice can lead to skill acquisition in an experiment that combined mental practice and physical practice for a pegboard task and a rotary pursuit task. For both tasks, subjects who combined mental and physical practice performed just as well as subjects who only practiced physically. The combination of mental and physical practice produced learning effects similar to physical practice because it created a learning condition to optimize cognitive problem-solving activity (Magill, 2007).

It is hypothesized that a difference in the types of mental imagery between open and closed skills should exist. Open skills are usually dependent upon another person's actions and often involve a changing environment. On the other hand, the action of closed skills is self-paced and has a repetitious behavior (Highlen & Bennett, 1979; Lerner et al., 1996; Magill, 2007). These differences may lead to visual and kinesthetic mental imagery having different effects for open and closed skills.

The effectiveness of mental practice may be somewhat dependent on experience of a skill. During the initial stages of learning, mental practice has been shown to be ineffective, perhaps due to beginners' inability to form and practice correct images. This may be because of a lack of experience, which suggests experience of a task could lead to more effective mental practice (Hinshaw, 1991). Additionally, well-developed physical skills have also been shown to benefit from mental practice because mental practice helps keep these skills well maintained and reinforces them as well (Morris, 2004). Athletes can achieve this by regularly rehearsing these skills with the goal of retention. An example of this is seen through an American colonel's use of mental practice while he endured several years as a prisoner of war. Every day, he mentally played a round of golf by visualizing each shot. After he was freed, he shot par despite not having swung a golf club in years (Murphy, 2005). A large amount of research has shown that mental practice can improve performance in athletes (Abma, Fry, Li, & Relyea, 2002; Blair et al., 1993; Gray, 1990; Gregg, Hall, & Hanton, 2007; Lejeune, Decker, & Sanchez, 1994; Meacci & Price, 1985; Rodgers, Hall, & Buckolz, 1991; Salmon, Hall, & Haslam, 1994; Spittle & Morris, 2007; Ungerleider & Golding, 1991).

Athletes have described that using mental practice has lead to more positive effects in speed, accuracy, strength, movement dynamics, and overall performance (Dickstein & Deutsch, 2007). Murphy (2005) stated that mental practice can strengthen the brain's cognitive templates that control athletic skills. In a study by Peynircioglu, Thompson, and Tanielian (2000), mental practice produced significantly enhanced results for free throw shooting. Participants in the study were randomly assigned to one of two groups: a mental practice group and a “psych-up,” nonspecific arousal group. “Psyching-up” did not improve free throw shooting performance. However, free throw shooting performance improved in the group that engaged in mental practice.

Athletes’ abilities to mentally practice may affect performance. Robin et al. (2007) studied the effects of mental practice ability on motor improvement following mental imagery training in tennis. Skilled tennis players were divided into three groups based on whether they were good or bad imagers. Results showed that mental practice improved return shots, and good imagers improved more than poor imagers. Novices to mental practice are more likely to use external visual mental imagery and may not form a correct image, perhaps due to a lack of experience. These individuals may not visualize as vividly as good imagers and may not closely approximate the actual physical, affective, and emotional responses of the actual event. Mentally practicing with inappropriate images can result in a lack of confidence, increased anxiety, and decreased motivation (Hinshaw, 1991). Therefore, it is important to assess an individual’s experience and ability with mental practice.

Some athletes are capable of applying both visual and kinesthetic mental imagery equally well. Guillot et al. (2004) implemented a mental practice session in which gymnasts and tennis players alternated using both visual and kinesthetic mental imagery. Using a ratio of visual imagery to kinesthetic imagery (VI/KI ratio), the results showed that gymnasts had a ratio of nearly 1.0, indicating that they are equally able to employ both types of mental imagery. The tennis players, on the other hand, showed more ability to use either visual or kinesthetic mental imagery. Half of the tennis players had a ratio of over 1.0, which suggests a higher ability to use visual mental imagery. Conversely, the other half displayed a better use of kinesthetic mental imagery due to a ratio under 1.0.

It is debatable whether mental practice has a bigger impact on an athlete learning a new sport or on an elite athlete. Both novice and elite athletes use mental practice, however, elite athletes have described mental practice as being more relevant to their performances and report using mental practice more often than novices (Gregg et al., 2007). Although a majority of previous studies indicated that mental practice can be effective at all stages of learning, Mackay (1981) suggested that beginners may be ineffective in using mental practice because they are unable to form and mentally practice technically correct images due to a lack of experience. It is still unclear whether mental practice is more beneficial based on the skill level of the athlete.

The effectiveness of mental practice is partly based upon an individual's mental imagery capacity or his or her ability to employ mental practice. Participating in spatial activities may increase mental imagery capacity, and sports are considered a spatial activity (Ozel, Larue, & Molinaro, 2004). In a study by Ozel et al. (2004), athletes performed a mental rotation task significantly faster than non-athletes. This supports the idea that a link exists between sports and the ability to perform mental practice. An individual's experience with a certain skill or confidence level for performing a skill may affect mental practice. Amba et al. (2002) found that highly confident athletes tended to use mental practice more than athletes with low levels of confidence. Also, Mahoney and Avener (1977) observed that successful gymnasts tend to utilize mental practice better than less successful gymnasts. These findings suggest that athletes may be able to mentally practice more efficiently than non-athletes, and, among athletes, elite athletes are better than novices.

While athletes suggest mental practice improves their performances, Feltz and Landers (1983) proposed that it only slightly influences performance and is no more effective than actual physical practice. The research group performed a meta-analysis on over sixty related studies and observed the effect of mental practice on athletic performance. They found an overall effect size of .48, thus, concluding that mental practice only influences athletic performance only to some extent. A combination of mental practice and actual practice has shown to have the biggest effect on performance in sports and many other skills (Magill, 2007; Meacci & Price, 1985; Robin et al., 2007; Ross, 1985).

In a meta-analysis conducted by Driskell et al. (1994), the results imply that mental practice can effectively enhance performance. Mental practice allows individuals to rehearse behaviors and code them into easily remembered words and images that aid in recall. However, mental practice does not allow knowledge of results or visual and tactile feedback that actual practice offers. Thus, the group proposed that a combination of physical and mental practice may have the most positive effect on performance. Gurrero, Henrich, and Carleton (1998) tested the effects of combined mental and physical practice on field goal percentage in seven female high school varsity basketball players. The players were divided into either a physical practice group or combined physical and mental practice group and shot 150 shots from five different fixed locations for both the pretest and posttest. The combination group saw a significant improvement in field goal percentage from pretest to posttest, while the physical practice group did not improve. Also of note, participants in the combination group improved on an individual basis.

Theories of Mental Practice

Several hypotheses and theories have attempted to explain the principal mechanisms of mental practice. These include the psychoneuromuscular theory, the symbolic learning hypothesis, and the bioinformational theory (Hinshaw, 1991).

The psychoneuromuscular theory, which focuses on the possibility of “muscle memory,” states that muscles “learn” to perform functions from the formation of mental images during mental practice. Support for the theory was seen as early as 1934 when muscle activity was measured by electromyography (EMG) during mental practice. Numerous studies have investigated the relationship between EMG activity in both mental and physical practice and have revealed that EMG activity can occur during mental practice (Bird, 1984; Jacobson, 1934; Suinn, 1976). The psychoneuromuscular theory explains that since neural pathways in mental practice are similar to the neural pathways controlling muscles in actual practice, the pathways controlling the muscles can be strengthened through mental practice which may improve performance (Hinshaw, 1991).

The symbolic learning hypothesis states that success of mental practice is dependent on and varies with the cognitive components of the task at hand. If the task is motor related, mental practice should have little effect on the success of the task. If the task is more cognitive in nature, mental practice can have an effect on the task’s success. Performance on a handgrip task did not improve when subjects used mental practice to prepare for the task, but, in the same study, free-throw shooting, a more cognitive task, improved in subjects who mentally practiced shooting free throws (Peynircioglu et al., 2000). Symbolic learning also hypothesizes that the early stages of both physical and cognitive learning should exhibit a much larger effect of mental practice than later stages. (Hinshaw, 1991)

A more recent theory is the bioinformational theory, which explains mental practice through a network of stimulus/response channels. All behaviors, covert and overt, construct specific and distinctive networks of interconnected channels in the brain. Every time a behavior is repeated, the corresponding network is activated. This theory proposes that an overt behavior's network is replicated and reproduced internally in the form of an image. Success of mental imagery depends on the involved networks being activated while simultaneously inhibiting responses of contraindication (Hinshaw, 1991).

Through a transfer of training effect, mental practice may influence performance. A generalized practice effect may also exist (Hodes, 1991). Hodes discovered that instructional methods utilizing high mental imagery resulted in increased transfer of training. This is possibly a result of better learning of the procedural information, which may occur because the novel behaviors are recalled more easily after being mentally practiced clearly. As new skills are mentally practiced repetitively, new behavioral patterns may become embedded into one's memory like what might happen with repetitive physical practice (Kellner, 1979). Both the increased transfer of training due to mental practice and the generalized practice effect may contribute to improved performance.

Mental Imagery and Electroencephalogram (EEG)

The reliability of the construction of images has become a focal point of research in mental imagery (Intons-Peterson, 1983). No direct way exists to measure when images have or have not been created, so in an effort to make up for this, researchers apply scientific measures to provide evidence of brain and muscle activity during mental practice. EEG offers a convenient, non-invasive way to measure cortical activity during mental practice and can provide recordings of a subject's alpha waves that are reliable, predictable, and visible (Marks & Isaac, 1995). More importantly, the alpha band is linked to an individual's mental effort for performing cognitive tasks and is the dominant frequency found in EEG for human adults (Klimesch, 1999; Stecklow, 2010).

Marks and Isaac (1995) investigated topographical distribution of EEG in visual and kinesthetic mental imagery of four different tasks. In the experiment, subjects were put into either a vivid or non-vivid imager group and performed four tasks that were either visual or kinesthetic mental imagery tasks. Subjects were put into the two groups based on their Vividness of Visual Imagery Questionnaire (VVIQ) and Vividness of Movement Imagery Questionnaire (VMIQ) scores. For the first task, subjects imagined a friend or relative and how they looked, walked, and dressed. The second task involved mentally imaging standing, walking, running, and jumping. For the last two tasks, subjects mentally and physically performed touching the thumb to the four fingers of their dominant hand and making a fist with their dominant hand. EEG data for five frequency bands was collected during both visual and kinesthetic mental imagery of the tasks for both groups. The frequency bands included delta, theta, alpha, beta 1, and beta 2. The EEG data revealed significant effects for both frequency and location of cortical waves in the alpha band in visual and kinesthetic mental imagery in the two groups. Consistently different responses for vivid and non-vivid imagers were seen only in the alpha band. The results from this experiment indicate that alpha waves are the most valid measure of cortical activity for EEG recordings.

The activation of mental imagery has been shown to occur both at the cortical level and in the musculature being imaged during mental practice. The musculature is activated in a way similar to muscles being used during physical movement, which supports the psychoneuromuscular theory (Knudstrup et al., 2003). Cerebral blood flow, EMG activity, and cortical motor evoked potentials have shown that the neuromotor pathways being used for mental practice are actually being used as if physical activity was taking place, and metabolic activity of neurons is increased during mental practice to levels similar to the activity actually being performed (Bakker, Boshker, & Chung, 1996). Suinn (1972) investigated EMG activity in downhill skiers and found that during mental practice, the roughest sections of the course had the highest muscular activity, which is similar to actual skiing.

In a related study, Beisteiner, Höllinger, Lindinger, Lang, and Berthoz (1995) recorded direct current (DC) potentials in subjects mentally imaging or physically performing a series of hand movements. DC potentials display changes that occur from excitatory synaptic activity in the cortex and have been recorded during mental imagery and in motor activity. Subjects in this study participated in two experiments in which they memorized a sequence displayed on a computer monitor and then either physically performed or mentally imaged the sequence with either a hand or both index fingers. In the first experiment, subjects were put into four conditions: moving a joystick with their right hand, mentally imaging moving their right hand, moving their left hand, or mentally imaging moving their left hand. The second experiment put subjects into three conditions that included moving the index fingers of both hands simultaneously, mentally imaging moving both fingers simultaneously, and a control group that mentally imaged a picture illuminating with five positions. The results of both experiments showed that the primary motor cortex is active during mental imagery. Also, activation of the primary sensory hand area in the cortex during mental imagery was seen in the first experiment and the sensorimotor hand area in the cortex was activated in the second experiment during mental imagery. These findings are consistent with previous research that states that mental imagery provokes both sensory and motor activity.

Whether patterns of alpha activity from EEG recordings during kinesthetic and visual mental imagery differ has been investigated. Davidson & Schwartz (1977) studied sensorimotor and occipital EEG patterning during kinesthetic and visual mental imagery. In this study, subjects were presented with stimuli from a small flashing light and an audio speaker that produced a tapping sensation in the arm. Subjects then either used visual mental imagery to imagine the flashing light, kinesthetic mental imagery to imagine the tapping sensation, or a combination of the two to imagine the two stimuli simultaneously. Occipital and sensorimotor alpha activities were observed to have different patterning during kinesthetic and visual mental imagery. Greater relative occipital activation occurred during visual mental imagery. The results suggest that image generation is associated with activation of the occipital region, which is usually involved in perceptual processing. Differences were seen in occipital alpha waves between visual and kinesthetic visual imagery, but no differences were noticed in the sensorimotor alpha waves. Although differences were seen in the alpha waves of visual and kinesthetic mental imagery, this study did not investigate the two types of mental imagery on a sport-related task.

Marks, Uemura, Tatsuno, and Imamura (1985) investigated which side of the brain to use for EEG recordings. Topographical maps for six vivid imagers and six non-vivid imagers were recorded for four visual and kinesthetic mental imagery tasks. The results of the imagery map of vivid imagers had widespread cortical activation in the left occipital and parietal cortex, which is contrary to the hypothesis that mental imagery could be associated with spatial thinking and a specialization of the right hemisphere. Non-vivid imagers showed a right hemisphere focus that appeared to be in the frontal lobe.

A recent study by Stecklow, Infantosi, and Cagy (2010) observed the alpha band peak in the parietal and occipital lobes of volleyball players engaged in mental practice of spiking a volleyball. Subjects were divided into two groups depending on whether they were elite volleyball players, the “athletes,” or players with no prior volleyball experience, “non-athletes.” Prior to testing, all subjects took the Revised Movement Imagery Questionnaire (MIQ-R) and were shown a video of an expert spiking a volleyball several times from several different camera angles. EEG signals from occipital and parietal lobes for visual and kinesthetic mental imagery were recorded for both “athletes” and “non-athletes” engaged in mentally practicing a volleyball spike. Although no difference was noticed between the “athletes” and “non-athletes” for the MIQ-R, a significant difference was found in the EEG recordings for the ability of “athletes” to mentally image a volleyball spike with more clarity than the “non-athletes.” The “athletes” were able to employ kinesthetic mental imagery more easily than visual mental imagery. These findings suggest that cortical activation depends on the type of mental imagery used. While this study found a difference between the abilities of elite and non-elite athletes to use mental imagery, the non-elite athletes had never played volleyball and never physically performed spiking before mentally practicing a spike.

Movement Imagery Questionnaire

The Movement Imagery Questionnaire (MIQ) is a questionnaire designed to reveal the ease or difficulty with which a subject is able to use mental imagery (Dickstein & Deutch, 2007). The MIQ rates subjects’ ability to mentally image eighteen predefined arm, leg, or whole body movements on a 7-point Likert scale (Hall & Martin, 1997). When using the MIQ, subjects are asked to physically perform each movement and then, following physical performance of each, mentally practice them. Subjects then score each movement based on the Likert scale. Each movement is rated twice for mental imagery: once for visual and once for kinesthetic mental imagery. Previous studies have found the MIQ to be a reliable test for mental imagery. After a one-week interval, Hall, Pongrac, and Buckholz (1985) obtained a test-retest coefficient of .83. They also had internal consistency coefficients of .87 for the visual mental imagery subscale and .91 for the kinesthetic mental imagery subscale. Similar results (visual mental imagery subscale = .89; kinesthetic mental imagery subscale = .88) were seen in a study by Atienza, Balaguer, and Garcia-Merita (1994).

A shorter version of the MIQ was developed and is known as the Movement Imagery Questionnaire-Revised (MIQ-R) (Hall & Martin, 1997). In an effort to shorten the MIQ, this questionnaire removed items that subjects often did not answer and eliminated items that produced redundant information. A significant correlation of .77 was found on the visual mental imagery scores and the kinesthetic mental imagery scores when the MIQ and MIQ-R were compared. In this study, fifty subjects either took the MIQ or the MIQ-R and then engaged in a mental manipulation task for ten minutes. Following the mental manipulation task, subjects were given the questionnaire that they did not take previously. The significance of the correlation of the two questionnaires implies that the MIQ-R is an adequate revision of the MIQ and can be used to gauge visual and kinesthetic movement imagery ability.

Summary

Previous research has provided empirical evidence that mental practice can be beneficial for athletic performance as combined with physical practice. While a large amount of concentrated studies reported that mental practice can improve motor skill performance, there is limited research on neurological characteristics underlying mental imagery of team sport skills. A recent study by Marshall (2010) investigated whether EEG patterns varied among soccer players of different skill levels and which type of mental imagery was preferred among the soccer players. It was found that the soccer players preferred to use visual mental imagery over kinesthetic imagery, and the more experienced soccer players had a higher ability to use mental imagery than less experienced soccer players according to the EEG data. However, this study allowed participants to choose which type of mental imagery they used for the soccer scenarios and did not compare whether one type was more effective for the scenarios. The current study examined whether EEG patterns vary based on an athlete’s ability to engage in mental practice and if a difference in EEG patterns exists between visual mental imagery and kinesthetic mental imagery during mental practice of different soccer specific tasks. It is hypothesized that elite soccer players would have higher mental imagery ability than novice players and would have alpha levels that are significantly different than the novices for both types of mental imagery for the soccer specific tasks.

Methods

Participants

Seventeen college students were recruited to participate in the study (age range from 18-39). The subjects were assigned to two groups. The control group was comprised of students participating in a soccer class offered by the university (N = 7, Males = 2, Females = 5). The experience of these subjects was limited to participation in the soccer class of general education program and/or recreational play. For this study, these participants were considered novice soccer players. The elite athlete group consisted of current players on the university's NCAA Division I soccer team (N = 10, Males = 4, Females = 6). All participants signed a consent form (Appendix A) approved by the University of Memphis IRB before participating in the study.

Equipment

A MP35 data acquisition unit consisting of a fully-shielded multi-strand (red, white, and black) electrode lead set cable was used to record alpha activity during mental practice sessions. Blue Sensor™ silver/silver chloride, wet-gel electrodes (Model SE-00-S) were used (Biopac Systems, Inc.; Goleta, CA). The Biopac Student Lab System Software PC 3.7.0 was used to record and analyze the data. An audio recording of directions played by a CD player led subjects through the procedure (see Appendix B).

Design and Procedure

The two groups of participants followed the same testing protocol which included two tests: 1) a physical practice and mental practice using both visual and kinesthetic mental imagery on three simple movements; and 2) a mental practice on the three simple movements and three soccer scenarios using both visual and kinesthetic mental imagery with an EEG recording. Prior to testing participant filled out a mental imagery questionnaire (Appendix B) to determine his or her experience with using mental imagery, the number of years for playing soccer, and level of soccer participation. An audio recording of a script was played (Appendix C) so that each subject followed the exact same directions.

Subjects were tested individually. The procedure was explained to them and they were given the purpose of the study before the first test.

Physical and mental practice on simple movements. Subjects listened to a tape that led them through the Movement Imagery Questionnaire-Revised (MIQ-R). This consisted of three general movements to perform both physically and mentally: a knee raise, a toe touch, and a lateral arm movement. After performing the movements, subjects were asked to mentally practice each movement by either "feeling" (kinesthetic mental imagery) or "seeing" (visual mental imagery) it. For visual mental imagery, subjects used external imagery and saw themselves perform each movement as if they were a spectator watching their performance. Each movement was presented twice so subjects had the opportunity to employ both types of mental imagery. When a movement was presented, subjects were asked to repeatedly perform it mentally until asked to stop. After completing each of the general movement tasks, subjects rated the ease or difficulty with which they were able to mentally practice each movement on a Likert scale of 1 to 7 (Appendix D).

Mental practice on simple movements and soccer scenarios with EEG recording. For the second test, three electrodes were placed on each subject's temporal lobe, parietal lobe, and ear lobe (Figure 1). A 10 second calibration was obtained while subjects were seated with their eyes closed. A baseline period followed consisting of 10 seconds in which subjects closed their eyes, 10 seconds with their eyes open, and another 10 seconds of their eyes being closed.

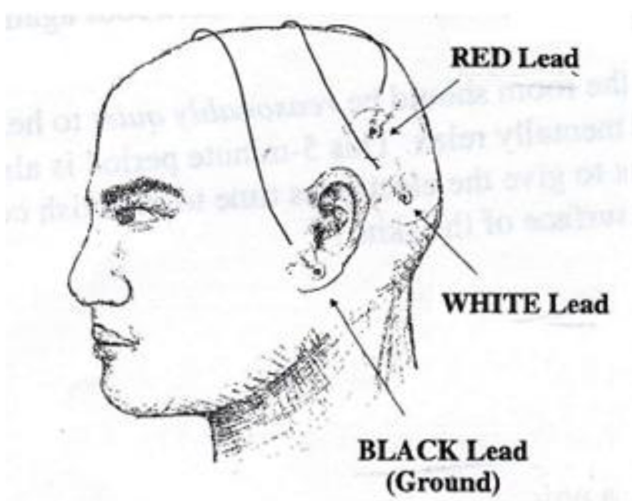

Figure 1. Electrode Placement During EEG Recording

Following baseline, subjects were presented with the simple movements from the previous test and asked to mentally practice each one. Each movement was presented twice so subjects had the opportunity to employ both types of mental imagery. After given a movement to perform and type of mental imagery to use, subjects were asked to mentally perform a movement over and over again until told to stop. Subjects were asked to verbally rate their experiences after mentally practicing, which lasted fifteen seconds for each movement, and the same Likert scale used for the MIQ-R was used.

Three soccer scenarios that included penalty kick shooting, trapping, and a through pass were then described to subjects. After each description, subjects were instructed to mentally practice the scenario over and over again until told to stop by using either visual or kinesthetic mental imagery. Once again, subjects employed external imagery when asked to use visual mental imagery. Each scenario was presented twice so subjects were able to use both types of mental imagery for all of the scenarios. Subjects used visual mental imagery for each scenario first and then used kinesthetic mental imagery. Subjects were asked to verbally rate their experiences after mentally practicing each scenario. Mental rehearsal lasted fifteen seconds for each scenario, and the same Likert scale used for collecting self-rating data (Appendix E). After mental practice was completed, subjects were asked which form of mental imagery they preferred to use, either visual or kinesthetic. Figure 2 shows a timeline of the EEG reading.

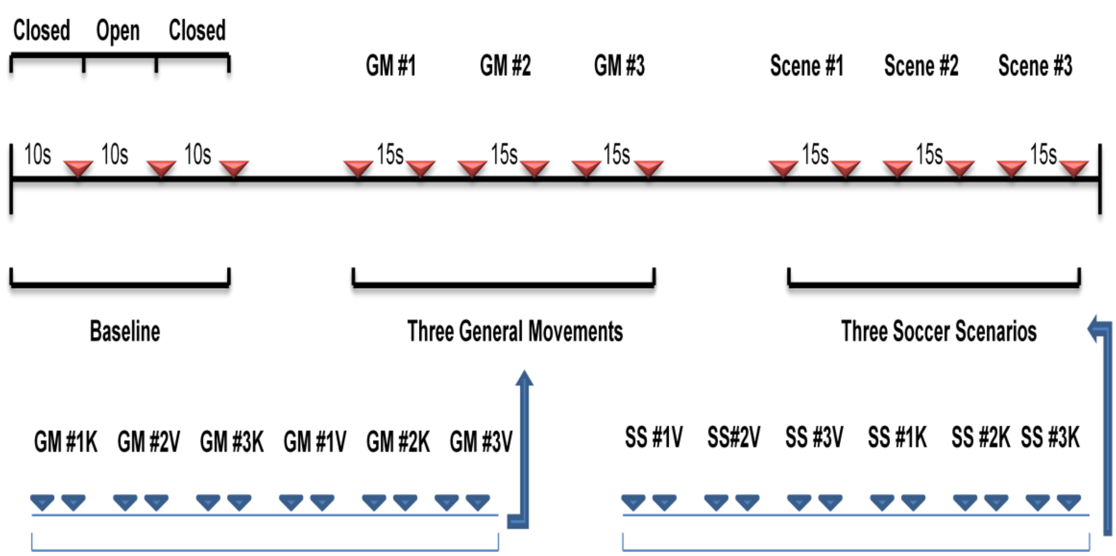

Figure 2. Timeline for EEG Reading

EEG data was acquired during mental practice through the three electrodes. As the alpha wave was being recorded, markers were placed throughout the mental practice session to separate the periods of mental imagery from the rest of the time. The BioPac data acquisition system, MP35, was used to attain EEG, alpha wave, and alpha-RMS data (Figure 3). The BioPac programming analyzed data of the alpha waves.

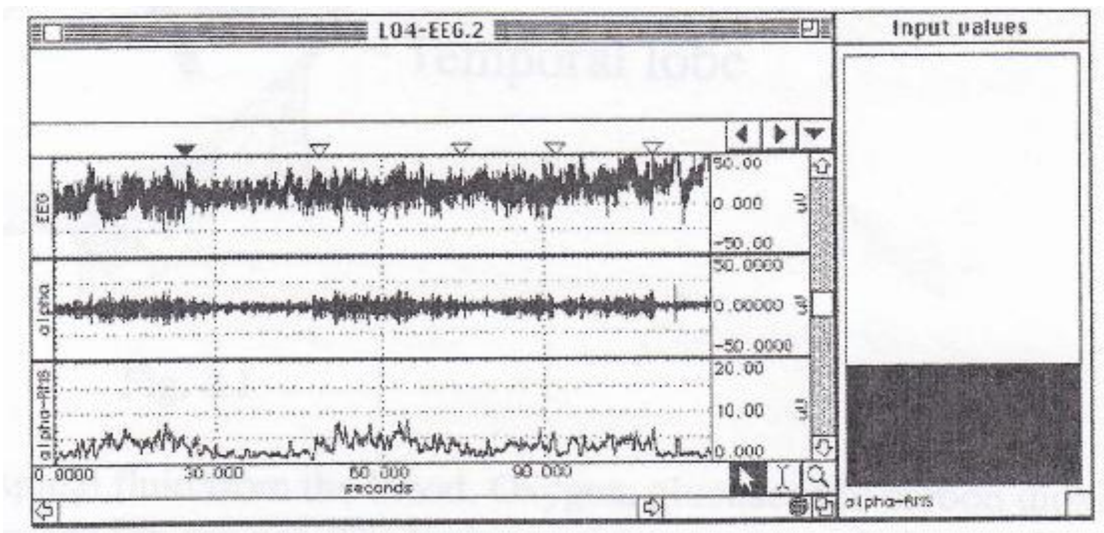

Figure 3. Screen Shot of BioPac EEG Recording

Data Analysis

Descriptive statistics were calculated to obtain the means and standard deviations of the two groups for self-rating and EEG data. A 2 (group) X 6 (test: GM_V, GM_K, GM_{EEGV}, GM_{EEGK}, SS_{EEGV}, SS_{EEGK}) ANOVA repeated on the second factor was performed on the self rating scores, while a 2 (group) X 4 (test: GM_V, GM_K, SS_V, SS_K) ANCOVA on the second factor was performed on the EEG data to compare the differences in alpha patterns between the groups and tests, as well as the interaction between the two factors.

Results

Characteristics of subjects from both control and study groups, including age, gender, and mental imagery preference, are presented in Table 1. It shows that above 76% of the participants indicated their preference of using visual mental imagery during the mental rehearsal of the soccer scenarios, with 71% in the control and 80% in the study.

Table 1

Subject Characteristics of Control and Study Groups

Group	N	Age	Gender	MI Preference
Control (Novice)	7	24.3* (6.99)	Male = 2 Female = 5	Visual = 5 (71%) Kinesthetic = 2 (29%)
Study (Elite)	10	21.1 (2.38)	Male = 4 Female = 6	Visual = 8 (80%) Kinesthetic = 2 (20%)

*Mean (Standard Deviation)

Table 2 presents the group means and standard deviations of self-rating score over six test conditions (i.e., either visual or kinesthetic mental imagery on general movement only, general movement with EEG recording and soccer scenario with EEG recording). The higher value indicates the easier of the mental rehearsal task an individual perceived. The results of a 2(Group) X 6(Test) ANOVA revealed a significant Test effect, $F(5,75) = 6.84$, $p = .001$, suggesting all participants rated significantly different between the six different test conditions. The follow-up test revealed that both groups rated significantly higher on the easiness scale of mental imagery task in visual imagery rehearsal than kinesthetic mental imagery on three test conditions, mental rehearsal of general movement only, general movement with EEG recording, and soccer scenarios. There was no group difference, nor was the interaction of Group and Test.

Table 2

Means and Standard Deviations of Self-Ratings for Mental Imagery of General Movements and Soccer Scenarios for Control versus Study Groups

Group	General Movements		General Movements (EEG)		Soccer Scenarios	
	Visual	Kinesthetic	Visual	Kinesthetic	Visual	Kinesthetic
Control (*N* = 7)	6.33* (.88)	5.48 (.92)	6.24 (.79)	5.33 (1.33)	5.86 (1.29)	5.24 (1.37)
Study (*N* = 10)	6.13 (.83)	5.47 (1.39)	6.07 (.90)	5.03 (1.27)	5.93 (.73)	5.03 (1.35)

*****Mean (Standard Deviation)

Table 3 presents the group means and standard deviations of EEG activities level (alpha amplitude) over the baseline and four test conditions (i.e., either visual or kinesthetic imagery on general movement and soccer scenario). The results of an independent t-test on the baseline data showed that there was no significant difference between the two groups, $t(15) = 1.05$, $p = .31$. This suggests that both control and elite group had a similar baseline level of EEG activity based on recording, although control group showed a relatively higher value (3.77) than the elite group at the baseline (3.11).

Table 3

Means and Standard Deviations of Alpha Activity for Baseline and Mental Imagery of General Movements and Soccer Scenarios for Control versus Study Groups

Group	Closed Eyes1	Open Eyes	Closed Eyes2	General Movements		Soccer Scenarios	
				Visual	Kinesthetic	Visual	Kinesthetic
Control (N = 7)	3.67* (1.28)	1.98 (.57)	3.77 (1.28)	3.33 (1.23)	3.31 (1.20)	3.18 (.49)	3.44 (1.39)
Study (N = 10)	2.95 (1.15)	2.23 (.57)	3.11 (1.34)	2.82 (1.10)	2.90 (1.07)	2.78 (.34)	2.58 (.68)

*Mean (Standard Deviation)

In general, EEG level has a noticeable variability among individuals, including gender difference. Therefore, an analysis of covariance was used with the baseline as the covariate to get a more accurate assessment. The results of a 2 (Group) X 4 (Test) ANCOVA revealed a significant test effect, $F(3, 42) = 3.76$, $p = .018$. Moreover, a significant interaction between Group and Test was found, $F(3, 42) = 4.34$, $p = .009$. The follow-up test showed that the alpha amplitude significantly decreased during the rehearsal of kinesthetic imagery of soccer scenarios for the elite group, but this was not the case for the control group, which showed almost no changes compared with the rest of the test conditions (Figure 4).

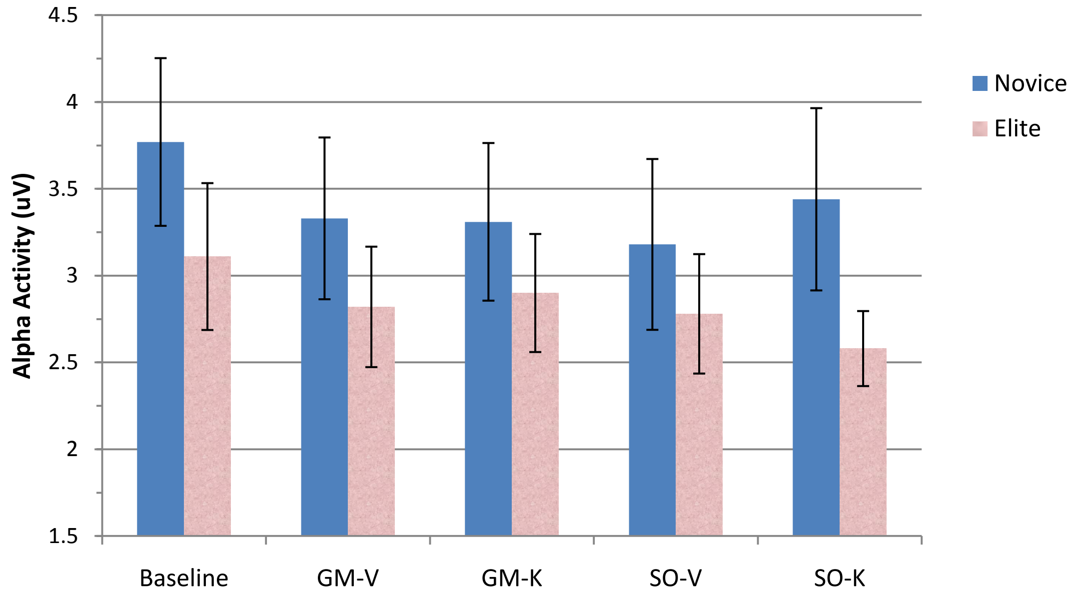

Figure 4. Mean Alpha Amplitude Scores Recorded During the Baseline and Four Different Test Conditions for the Two Groups.

Discussion

Mental imagery is very popular among many individuals in order to enhance their motor skills. It has become increasingly popular among athletes to improve sport performances. However, limited studies were conducted on the neurological impact of mental rehearsal. The current study examined the characteristics of EEG patterns associated with the imagery abilities of novice and elite soccer players by using different types of mental imagery during mental rehearsal of simple movements and selected soccer scenarios. Previous research (Mackay, 1981; Ozel et al., 2004; Stecklow et al., 2010) suggested that elite athletes might be able to use mental imagery more effectively than novices, and the EEG activity of elite athletes would be significantly different than beginners. In order to extend our understanding on the influence of different types of mental rehearsal on the brain, the current study investigated EEG patterns for both visual and kinesthetic mental imagery of general movements and different scenarios that could occur in a team sport.

First, it was found that a majority of participants in both groups favored visual versus kinesthetic mental imagery when mentally rehearsing the soccer scenarios. The previous study by Marshall (2010) also found that a majority of the participants preferred to use visual mental imagery for soccer scenarios. Nearly all of the participants in the current study indicated a preference for visual mental imagery when using mental practice for any sport or skill in the mental imagery questionnaire prior to testing, and all but one subject preferred to use visual mental imagery for the soccer scenarios. These subjects likely preferred visual mental imagery over kinesthetic for the soccer scenarios because they were more familiar with and preferred using visual mental imagery prior to the study. Also, less than half of the novice players had previously used any type of mental practice. Visual mental imagery was likely easier for the novices with no previous experience with mental practice to employ than kinesthetic mental imagery, which would explain their higher preference for using visual mental imagery during the soccer scenarios.

Marshall (2010) has reported that elite athletes should be better able to mentally practice the soccer scenarios than the novices and, thus, rate the soccer scenarios higher. The author suggested that elite athletes might be more capable of mentally rehearsing the soccer scenarios with greater attention to detail of performing the skills and the surrounding environment. Yet, no difference was seen in the current self-rating reports for elite soccer players and novices. This could be related to the fact that all of the soccer scenarios selected for the present study were simplistic and required basic soccer skills that novices should be familiar with. For example, the three scenarios included in the study were a penalty kick, a trap, and a through pass. The previous study (Marshal, 2010) used additional soccer scenarios that were more complicated than the three used in this study and required skills that novices may not be as familiar with as the three used in the current study. These three scenarios included receiving a pass and turning, a 50/50 ball, and jumping and heading. This may lead to significant lower rating scores for the novice players compared with the elite players.

Previous research (Marshall, 2010) has also found differences between elite and novice athletes on self-rating for the MIQ-R. The author speculated that elite athletes rated higher on general movements than novices because they had more experience using mental imagery and felt more confident using both visual and kinesthetic mental imagery than the novices. However, it was not the case based on the present study. The finding for the MIQ-R agrees with Stecklow et al. (2007). In that study, no differences were found between athletes and non-athletes for the MIQ-R given prior to a volleyball task. The authors suggested that there was no difference because the MIQ-R has movements that are unfamiliar to both groups. Another possible explanation may be that the general movements of the MIQ-R are simple movements, therefore, athletes and non-athletes may perceive the mental rehearsal of these tasks at a similar level.

The main findings were that elite athletes had a significantly lower EEG pattern compared to novices when mentally rehearsing soccer specific scenarios by using kinesthetic mental imagery. However, no such a difference was observed for visual imagery. Specifically, the alpha activity level changes significantly from the baseline for the elite group when asked to use kinesthetic imagery, however, not much change was found for the control group. This significant decrease in the alpha amplitude of kinesthetic mental imagery suggests that the elite athletes may have greater mental effort when using kinesthetic mental imagery than when using visual mental imagery.

First, this higher level of mental effort is likely due to the participants being more familiar and well established with the skills required for the soccer scenarios. This was expected because these are skills that elite soccer players are superior to the control group, whereas the general movements are not. The psychoneuromuscular theory suggests that the neural pathways for the activation of the musculature in actual practice are similar to the neural pathways in mental practice (Hinshaw, 1991). This could explain the higher level of concentration for the soccer scenarios than the general movements because the neural pathways for mental practice could be strengthened by the greater amount of actual practice for the soccer scenarios compared to the general movements.

Previous studies have proposed visual mental imagery to be more effective than kinesthetic mental imagery for open skills such as soccer (Hall et al., 1992; Highlen & Bennett, 1993). However, the results for this study suggest that players were more alert during kinesthetic mental imagery than visual mental imagery for the three soccer scenarios presented. It should be pointed out that these three soccer scenarios have repetitive practice tasks because no defensive pressure was on the individual performing the scenario. These findings of the current study agree with the research of Stecklow et al. (2010). In this study, volleyball players employed kinesthetic mental imagery more effectively than visual mental imagery for spiking a volleyball with no defensive pressure. These volleyball players also showed more cortical areas with habituation during kinesthetic mental imagery, which suggests that kinesthetic mental imagery may be better than visual mental imagery for skills of repetitive nature. Participants were more alert when employing kinesthetic mental imagery for skills that were repetitive in nature because those neural pathways for the muscles are activated to a level similar to as if the subjects were actually performing the movement, which is supported by the psychoneuromusclar theory (Hinshaw, 1991).

Another explanation for the elite soccer players concentrating more during kinesthetic mental imagery might be because the soccer scenarios required the subjects to concentrate on foot accuracy. Previous studies (Beisteiner et al., 1995; Féry, 2003) have found that kinesthetic mental imagery is better for skills that require limb movement and accuracy. Beisteiner et al. (1995) demonstrated that kinesthetic mental imagery activated the sensorimotor hand area more than visual mental imagery when subjects mentally rehearsed moving a joystick in response to a target sequence and moving the index finger of both hands simultaneously according to a sequence. Féry (2003) also found that kinesthetic mental imagery was more effective than visual mental imagery for a task that involved accuracy of both hands to guide the movement of a stylus. The author suggested that kinesthetic mental imagery may be more beneficial for motor tasks that require great motor control and accuracy. It is possible that kinesthetic mental imagery is better for the soccer scenarios in this study due to their requirement of motor control of the entire body and foot movement and accuracy, which is similar to hand movement and accuracy.

Ironically, while all participants in the study, regardless of soccer play level differences, reported visual imagery was a favorite format over kinesthetic imagery that they chose to use during mental rehearsal, it appears that kinesthetic imagery has a greater influence on brain involvement. Specifically, several previous studies (Beisteiner et al., 1995; Féry, 2003; Stecklow et al., 2010) have advocated that kinesthetic mental imagery is more beneficial for skills that are repetitious, require limb movement accuracy, and involve great motor control. In addition to EEG, direct current (DC) potentials and functional magnetic resonance imaging (fMRI) have detected ipsilateral activity of the motor cortex when individuals mentally rehearse manual motor sequence tasks, and kinesthetic mental imagery has been proposed to be more beneficial for such tasks (Beisteiner et al., 1995).

A noticeable shortcoming of the present study is the small sample size used in the current study and no gender differences have been made. Also, subjects were instructed to use third person point of view for the soccer scenarios, but a few subjects (5 out of 17) reported using first person point of view instead. It was well known that many factors can influence of mental status, such as the time of the testing day, the gender difference in mental states, various previous experiences, etc. The limited sample, plus greater variability within groups could decrease the statistical power of the study. However, the results of this study can be beneficial for athletes, coaches, and sport psychologists because it suggests that kinesthetic mental imagery may have greater impact on mental status and be more effective than visual mental imagery for certain sport skills.

Conclusion and Future Research

The results of the current study found that alpha amplitude for elite athletes was significantly decreased during kinesthetic mental imagery than visual mental imagery when sports skills are mentally rehearsed in a situation where there is no defensive pressure on the individual. The findings support previous research that elite athletes may concentrate more while using mental imagery compared to novices while mentally rehearsing sport specific scenarios by using kinesthetic mental imagery, which is considered more effective than visual mental imagery in certain sport specific skills (Stecklow et al., 2010). Athletes should be encouraged more and trained more on kinesthetic imagery during mental rehearsal to achieve optimum results.

Future research should use relatively more complicated soccer scenarios where defensive pressure is applied to the individual. Showing a video of the soccer scenarios instead of using audio may improve the subjects' abilities to employ mental imagery while mentally rehearsing the soccer scenarios. In addition, further investigations may combine EEG with EMG to determine differences in force production when using visual versus kinesthetic mental imagery, which would allow us to better understand the underlying mechanisms of the process of mental imagery.

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Appendix A

INFORMED CONSENT FORM

The University of Memphis

Title of Investigation: Alpha pattern differences between visual and kinesthetic mental imagery in elite soccer players

Principal Investigators: Collier Shepard, Graduate student
Yuhua Li, Associate Professor
Department of Health & Sport Sciences
Tel: (901) 678-2311

The purpose of this research project is to examine if there will be a different electroencephalography (EEG) pattern between visual mental imagery versus kinesthetic mental imagery during mental practice. EEG measures cortical activities during mental practice. In the study, you will listen to a tape that leads you through three general movements and mentally practicing these movements using either visual or kinesthetic mental imagery. You will then rate the ease or difficulty with which you were able to produce the mental images. Then, you will be led through three situations in a soccer match scenario and asked to mentally practice performing the soccer tasks, as well as making a verbal rating as to how difficult or easy it was for you to imagine the given situation. Surface EEG data will be collected during mental practice for both general movements and soccer specific tasks.

Minimal risks of your participation would include little discomfort such as skin irritation when 3 sensors will be placed on your head. The University of Memphis is not responsible for any compensation to the subject for injury, damages, or expenses of any type. For any questions or concerns with research-related injury, you may contact Dr. Yuhua Li, one of the principle investigators, at 678-2311.

Potential benefits of your participation would be that you will be provided with the information regarding your general tendency in mental imagery characteristics, visual or kinesthetic, and which type of mental imagery is more effective. The information may be applicable to a practical setting, such as that you may select the type of imagery that would be better suitable to envision yourself by seeing or feeling the given task during mental practice.

All information gathered during your participation will be confidential within the limit allowed by law. The results of this study will be submitted for the publication, but no reports of the results will contain information, which could be used to identify you. For research-related questions you may contact the principal investigators. For the problems or questions regarding subjects' rights, you may contact the chair of the Institutional Review Board (IRB), Susie Hayes, Research Support Services. Tel: 678-2533.

Your permission to participate in this study is absolutely voluntary. You are free to deny consent or stop the test at any point, if you so desire. You can do that without penalty and your decision will not affect future relations with the university or the researchers.

"I have read and understand the explanation provided to me and voluntarily agree to participate in this study".

_____________________________ _____________________________
Signature of Subject Date

_____________________________ _____________________________
Subject's Name (print) Date of Birth

_____________________________ _____________________________
Signature of Investigator Date

Appendix B

Mental Imagery Questionnaire

Name: ______________________________ Date _________________________

Weight (lb): ____________________ Height (in): ___________________

Gender: M _______ F_________

1. How long have you practiced soccer and at what level?

__________ Years

at College Team _____, or College PE class _______, or College Recreational level ____;

at High School Team ______;

at Middle School Team ______;

Or other __________________________.

2. What position do you or did you play the most?

____

3. Have you used mental practice before?

______ Yes ______ No

If yes, how often?

A. Very frequently B. Moderately C. Occasionally D. Not at all

4. Do you prefer to use visual or kinesthetic mental imagery?

A. Very much B. Moderately C. Somewhat D. Slightly E. Not at all

5. Please list any other mental practice methods that you have used during the past 12 months:

____

____

Thank you!

Appendix C

Imagery Tape - Verbatim

"General Task Introduction: I am going to present you with six general movements for you to make. After each movement, I will ask you to try and imagine making the movement again by either seeing yourself, or feeling yourself perform these tasks. When I say 'see', I want you to try to imagine seeing yourself as though you had a camera on the top of your forehead looking out, or you may try to see yourself as though you have stepped out of your body looking back, watching yourself from the outside. When I say 'feel', I want you to try to imagine feeling your muscles and limbs making the movement as it is just performed without actually doing it. When I say 'starting position', please follow along and perform the action as it is described. I will then say 'mental task', this is where you will close your eyes and begin your imagery as instructed. I will walk you through this process, so please just follow along"

"Please stand up and give yourself enough room to make some big movements. Place your rating scale on the table in front of you with a writing utensil. Let's begin…"

"Movement #1:
Starting Position – Stand with your feet and legs together and your arms at your sides. Slowly, raise your right knee as high as possible so that you are standing on your left leg with your right leg bent at the knee. Now, lower your right leg so that you are again standing on two feet.
Mental Task – Please close your eyes and assume the starting position. I want you to attempt to ***feel*** *yourself making the movement just performed without actually doing it. Please repeat this imagery scene until time is finished."*

{15 Second Pause}

"Now, please rate the ease or difficulty with which you were able to do this mental task."

{10 Second Pause}

"Movement #2:
Starting Position – Stand with your feet and legs together and your arms at your sides. Slowly, extend the arm of your non-dominant hand straight out to your side, so that it is parallel to the ground, palm down. Slowly move your arm forward until it is directly in front of your body, still parallel to the ground. Keep your arm extended during the entire movement. You may drop your arm down to your side.
Mental Task – Please close your eyes and assume the starting position. I want you to attempt to ***see*** *yourself making the movement just performed with as clear and vivid a visual image as possible. Please repeat this imagery scene over and over until time is finished."*

{15 Second Pause}

"Now, please rate the ease or difficulty with which you were able to do this mental task."

{10 Second Pause}

"Movement #3:
Starting Position – Stand with your feet and legs together and your arms at your sides. Slowly, extend your arms fully above your head, bend forward at the waist and try and touch your toes with your fingertips. Slowly return to the starting position, standing erect with your arms extended above your head. You may now drop your arms down to your sides.
*Mental Task – Please close your eyes and assume the starting position. Attempt to **feel** yourself making the movement just performed without actually doing it. Please repeat this imagery scene over and over until time is finished.*

{15 Second Pause}

"Now, rate the ease or difficulty with which you were able to do this mental task."

{10 Second Pause}

"Movement #4:
Starting Position – Stand with your feet and legs together, and your arms at your sides. Slowly raise your right knee as high as possible so that you are standing on your left leg, with your right leg bent at the knee. Now, slowly lower your right leg so that you are again standing on two feet.
*Mental Task – Please close your eyes and assume the starting position. Attempt to **see** yourself making the movement just performed with as clear and vivid a visual image as possible. Please repeat this imagery scene over and over until time is finished."*

{15 Second Pause}

"Now rate the ease or difficulty with which you were able to do this mental task."

{10 Second Pause}

"Movement #5:
Starting Position – Stand with your feet and legs together and your arms at your sides. Slowly, extend the arm of your non-dominant hand straight out to your side so that it is parallel to the ground, palm down. Move your arm forward, slowly, until it is directly in front of your body still parallel to the ground. Keep your arm extended during the entire movement. You may now drop your arm down to your side.
*Mental Task – Please close your eyes and assume the starting position. Attempt to **feel** yourself making the movement just performed without actually doing it. Please repeat this imagery scene over and over until time is finished."*

{15 Second Pause}
"Now rate the ease or difficulty with which you were able to do this mental task."

{10 Second Pause}

"Movement #6:
Starting Position – Stand with your feet and legs together and your arms at your sides. Slowly, extend your arms fully above your head. Bend forward at the waist and try and touch your toes with your fingertips. Now, return to the starting position, standing erect with your arms extended above your head. You may drop your arms down to your sides.
Mental Task – Please close your eyes and assume the starting position. Attempt to ***see*** *yourself making the movement just performed with as clear and vivid a visual image as possible. Please repeat this imagery scene over and over until time is finished."*

{15 Second Pause}

"Now rate the ease or difficulty with which you were able to do this mental task."

{10 Second Pause}

"Stop the tape and apply electrodes"

{Apply 3 electrodes according to Lab Manual. Open EEG program and click on new subject. Have subject sit in chair, relaxed with their eyes closed. Play tape when ready}

"Now that the electrodes have been applied, please try to sit very still with your eyes closed. Try to move your facial muscles as little as possible during the process. We will first run a 5 second calibration followed by a baseline reading, which will require you to open and re-close your eyes. I will then present you with the three general movements you just performed. Please try and imagine them as I say them to you. You may use visual or kinesthetic imagery, which ever came easier to you. Once I have given you a moment to imagine the scene, I will ask you to verbally rate the ease or difficulty with which you were able to imagine the given situation. Again, please try to stay relaxed and keep your eyes closed the entire time. The rating scale for the general movements will be very similar to your previous ranking. 1=Very Hard to Imagine, 2=Hard to Imagine, 3=Somewhat Hard to Imagine, 4=Neutral, 5=Somewhat Easy to Imagine, 6=Easy to Imagine, 7=Very Easy to Imagine. Now please close your eyes, and let's begin."

"For the calibration period, please sit very still with your eyes closed. Run calibration."

{Calibrate-10 Second Pause}

"Prepare to run the Baseline"

{Redo Calibration if necessary – otherwise, go to Record page}

“For this baseline reading, your eyes will remain closed for the first ten seconds. At ten seconds, we will ask you to open your eyes, after another ten seconds, we will ask you to close your eyes again. Total baseline period is thirty seconds. Let’s begin.

“Close your eyes.”
“Run Baseline.”
{Hit Record: Baseline}

{10 Second Pause}

“Open your eyes.”
{Marker - F9}

{10 Second Pause}

“Close your eyes.”
{Marker - F9}

{10 Second Pause}

{Marker - F9}
“End Baseline”
“Now that the baseline period is complete, please follow along for the general movements.”

{Keep EEG Rolling}

“Please stay relaxed and keep your eyes closed.”

“General Task Introduction: I am going to present you with six general movements. After each movement, I will ask you to try and imagine making the movement again by either seeing yourself, or feeling yourself perform these tasks.”

“Movement #1:
Starting Position – Stand with your feet and legs together and your arms at your sides. Slowly, raise your right knee as high as possible so that you are standing on your left leg with your right leg bent at the knee. Now, lower your right leg so that you are again standing on two feet.
Mental Task –I want you to attempt to ***feel*** *yourself making the movement without actually doing it. Please repeat this imagery scene over and over until time is finished.”*
{Marker - F9}

{15 Second Pause}

{Marker - F9}
"Now, please verbally rate the ease or difficulty with which you were able to do this mental task. 1=Very Hard to Imagine, 2=Hard to Imagine, 3=Somewhat Hard to Imagine, 4=Neutral, 5=Somewhat Easy to Imagine, 6=Easy to Imagine, 7=Very Easy to Imagine."

{10 Second Pause}

"Movement #2:
Starting Position – Stand with your feet and legs together and your arms at your sides. Slowly, extend the arm of your non-dominant hand straight out to your side, so that it is parallel to the ground, palm down. Slowly move your arm forward until it is directly in front of your body, still parallel to the ground. Keep your arm extended during the entire movement. You may drop your arm down to your side.
Mental Task – I want you to attempt to ***see*** *yourself making the movement with as clear and vivid a visual image as possible. Please repeat this imagery scene over and over until time is finished."*
{Marker - F9}

{15 Second Pause}

{Marker - F9}
"Now, please verbally rate the ease or difficulty with which you were able to do this mental task. 1 being very hard to imagine, 7 being very easy to imagine."

{10 Second Pause}

"Movement #3:
Starting Position – Stand with your feet and legs together and your arms at your sides. Slowly, extend your arms fully above your head, bend forward at the waist and try and touch your toes with your fingertips. Slowly return to the starting position, standing erect with your arms extended above your head. You may now drop your arms down to your sides.
Mental Task – Attempt to ***feel*** *yourself making the movement without actually doing it. Please repeat this imagery scene over and over until time is finished.*
{Marker - F9}

{15 Second Pause}

{Marker - F9}
"Now, verbally rate the ease or difficulty with which you were able to do this mental task."

{10 Second Pause}

"Movement #4:
Starting Position – Stand with your feet and legs together, and your arms at your sides. Slowly raise your right knee as high as possible so that you are standing on your left leg, with your right leg bent at the knee. Now, slowly lower your right leg so that you are again standing on two feet.
Mental Task – Attempt to ***see*** *yourself making the movement just performed with as clear and vivid a visual image as possible. Please repeat this imagery scene over and over until time is finished."*
{Marker - F9}

{15 Second Pause}

{Marker - F9}
"Now verbally rate the ease or difficulty with which you were able to do this mental task."

{10 Second Pause}

"Movement #5:
Starting Position – Stand with your feet and legs together and your arms at your sides. Slowly, extend the arm of your non-dominant hand straight out to your side so that it is parallel to the ground, palm down. Move your arm forward, slowly, until it is directly in front of your body still parallel to the ground. Keep your arm extended during the entire movement. You may now drop your arm down to your side.
Mental Task – Attempt to ***feel*** *yourself making the movement without actually doing it. Please repeat this imagery scene over and over until time is finished."*
{Marker - F9}

{15 Second Pause}

{Marker - F9}
"Now verbally rate the ease or difficulty with which you were able to do this mental task."

{10 Second Pause}

"Movement #6:
Starting Position – Stand with your feet and legs together and your arms at your sides. Slowly, extend your arms fully above your head. Bend forward at the waist and try and touch your toes with your fingertips. Now, return to the starting position, standing erect with your arms extended above your head. You may drop your arms down to your sides.
Mental Task – Attempt to ***see*** *yourself making the movement with as clear and vivid a visual image as possible. Please repeat this imagery scene over and over until time is finished."*
{Marker - F9}

{15 Second Pause}

{Marker - F9}
"Now rate the ease or difficulty with which you were able to do this mental task."

{10 Second Pause}

"I am now going to present you with six soccer-specific scenarios for you to imagine. You will be asked to use visual or kinesthetic mental imagery. Once I have given you a moment to mentally rehearse the scene, I will ask you to verbally rate the ease or difficulty with which you were able to imagine the given situation. Please stay relaxed and keep your eyes closed. Let's begin."

"Scenario #1: Penalty Kick Shooting - Imagine standing about three yards behind the ball on the 18-yard-line, facing the goal, getting ready to shoot a PK. Two to three steps forward and you strike the ball to the corner of the goal. The ball rolls with a topspin, barely skimming the grass and hits the side netting.
Mental Task – I want you to attempt to ***see*** *yourself making the movement with as clear and vivid a visual image as possible. Please repeat this imagery scene over and over until time is finished."*

{Marker - F9}

{15 Second Pause}

{Marker - F9}
"Now please verbally rate the ease or difficulty with which you were able to imagine this scenario. 1 being very hard to imagine, 7 being very easy to imagine."

{10 Second Pause}

"Scenario #2: Trapping – Imagine watching the ball floating toward you. With no pressure around you, the ball falls to your feet and a simple trap is made placing the ball a half a step in front of you.
Mental Task – I want you to attempt to ***see*** *yourself making the movement with as clear and vivid a visual image as possible. Please repeat this imagery scene over and over until time is finished."*

{Marker - F9}

{15 Second Pause}

{Marker - F9}

"Now please verbally rate the ease or difficulty with which you were able to imagine this scenario. 1 being very hard to imagine, 7 being very easy to imagine."

{10 Second Pause}

"Scenario #3: Through Pass – Imagine the ball at your feet. Out of your peripheral vision, a teammate is making a run down the flank. You notice a small seam between defenders; you set yourself up, and strike the ball directly through the defense to lead your teammates run.
Mental Task – I want you to attempt to ***see*** *yourself making the movement with as clear and vivid a visual image as possible. Please repeat this imagery scene over and over until time is finished."*

{Marker - F9}

{15 Second Pause}

{Marker - F9}
"Please verbally rate the ease or difficulty with which you were able to imagine this scenario."

{10 Second Pause}

"Scenario #4: Penalty Kick Shooting - Imagine standing about three yards behind the ball on the 18-yard-line, facing the goal, getting ready to shoot a PK. Two to three steps forward and you strike the ball to the corner of the goal. The ball rolls with a topspin, barely skimming the grass and hits the side netting.
Mental Task –I want you to attempt to ***feel*** *yourself making the movement without actually doing it. Please repeat this image over and over again in your head until I say to stop and ask you to verbally rate your experience."*

{Marker - F9}

{15 Second Pause}

{Marker - F9}
"Please verbally rate the ease or difficulty with which you were able to imagine this scenario."

{10 Second Pause}

"Scenario #5: Trapping – Imagine watching the ball floating toward you. With no pressure around you, the ball falls to your feet and a simple trap is made placing the ball a half a step in front of you.

Mental Task –I want you to attempt to ***feel*** *yourself making the movement without actually doing it. Please repeat this image over and over again in your head until I say to stop and ask you to verbally rate your experience."*

{Marker - F9}

{15 Second Pause}

{Marker - F9}
"Please verbally rate the ease or difficulty with which you were able to imagine this *scenario."*

{10 Second Pause}

"Scenario #6: Through Pass – Imagine the ball at your feet. Out of your peripheral vision, a teammate is making a run down the flank. You notice a small seam between defenders; you set yourself up, and strike the ball directly through the defense to lead your teammates run.
Mental Task –I want you to attempt to ***feel*** *yourself making the movement without actually doing it. Please repeat this image over and over again in your head until I say to stop and ask you to verbally rate your experience."*

{Marker - F9}

{15 Second Pause}

{Marker - F9}
"Now, please verbally rate the ease or difficulty with which you were able to imagine *this scenario."*

{End of Tape}

Appendix D

Name: ________________________
Date: ________________
Gender: M F

Rating Scale – General Tasks

Movement #1 – FEEL

1	2	3	4	5	6	7
Very Hard to Feel	Hard to Feel	Somewhat Hard to Feel	Neutral	Somewhat Easy to Feel	Easy to Feel	Very Easy to Feel

Movement #2 – SEE

1	2	3	4	5	6	7
Very Hard to See	Hard to See	Somewhat Hard to See	Neutral	Somewhat Easy to See	Easy to See	Very Easy to See

Movement #3 - FEEL

1	2	3	4	5	6	7
Very Hard to Feel	Hard to Feel	Somewhat Hard to Feel	Neutral	Somewhat Easy to Feel	Easy to Feel	Very Easy to Feel

Movement #4 – SEE

1	2	3	4	5	6	7
Very Hard to See	Hard to See	Somewhat Hard to See	Neutral	Somewhat Easy to See	Easy to See	Very Easy to See

Movement #5 – FEEL

1	2	3	4	5	6	7
Very Hard to Feel	Hard to Feel	Somewhat Hard to Feel	Neutral	Somewhat Easy to Feel	Easy to Feel	Very Easy to Feel

Movement #6 – SEE

1	2	3	4	5	6	7
Very Hard to See	Hard to See	Somewhat Hard to See	Neutral	Somewhat Easy to See	Easy to See	Very Easy to See

Appendix E

Name: ______________________

Date: ____________

Primary Soccer Position:_______________

Gender: M F

EEG Rating Scale
Soccer Scenarios

1	2	3	4	5	6	7
Very Hard to Imagine	Hard to Imagine	Somewhat Hard to Imagine	Neutral	Somewhat Easy to Imagine	Easy to Imagine	Very Easy to Imagine

SOCCER SCENARIO	Type of Imagery		RATING	
Knee Raise	1)KMI	4)VMI		
Lateral Arm Movement	2)VMI	5)KMI		
Toe Touch	3)KMI	6)VMI		
Penalty Kick Shooting	1)VMI	4)KMI		
Trapping	2)VMI	5)KMI		
Through Pass	3)VMI	6)KMI		

*Self – Report:

Ask subject which style of imagery they preferred for the soccer scenes, seeing (visual) or feeling (kinesthetic)? *Circle Answer.*

Kinesthetic **Visual**

When using visual mental imagery, how did you see yourself?

When using kinesthetic mental imagery, how did you feel yourself?

THE UNIVERSITY OF MEMPHIS

Institutional Review Board

To: James Collier Shepard
Health and Sport Sciences
From: Chair, Institutional Review Board
For the Protection of Human Subjects
irb@memphis.edu
Subject: Alpha pattern differences between visual and kinesthetic mental imagery in elite soccer players (020111-162)
Approval Date: February 18, 2011

This is to notify you of the board approval of the above referenced protocol. This project was reviewed in accordance with all applicable statuses and regulations as well as ethical principles.

Approval of this project is given with the following obligations:

1. At the end of one year from the approval date, an approved renewal must be in effect to continue the project. If approval is not obtained, the human consent form is no longer valid and accrual of new subjects must stop.
2. When the project is finished or terminated, the attached form must be completed and sent to the board.
3. No change may be made in the approved protocol without board approval, except where necessary to eliminate apparent immediate hazards or threats to subjects. Such changes must be reported promptly to the board to obtain approval.
4. The stamped, approved human subjects consent form must be used. Photocopies of the form may be made.

This approval expires one year from the date above, and must be renewed prior to that date if the study is ongoing.

____

Chair or Designee, Institutional Review Board
The University of Memphis