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INVESTIGATION OF THE IMAGERY PREFERENCE AND EEG PATTERNS OF ELITE AND NOVICE COLLEGIATE SOCCER PLAYERS

Kate E. Marshall

To the University Council:

The Thesis committee for Kate Marshall certifies that this is the approved version of the following thesis:

INVESTIGATION OF THE IMAGERY PREFERENCE

AND EEG PATTERNS OF ELITE AND NOVICE

COLLEGIATE SOCCER PLAYERS

Yuhua Li, Ph. D., Major Professor

Mary Fry, Ph. D.

Richard Dale, Ph.D.

Accepted for the Graduate Council:

Karen D. Weddle-West, Ph.D.
Vice Provost for the Graduate Programs

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INVESTIGATION OF THE IMAGERY PREFERENCE AND EEG PATTERNS OF ELITE AND NOVICE COLLEGIATE SOCCER PLAYERS

by

Kate Marshall

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Abstract

While previous research has suggested mental imagery (MI) is beneficial to sport performances, limited studies have addressed the underlying neurological influences of MI. The current study investigated: 1) which type of MI is preferred by novice and elite soccer athletes, visual or kinesthetic and 2) if EEG patterns vary based on ability to use imagery and skill level. Thirty-eight elite soccer athletes and 17 novice players performed three simple movements physically, then mentally rehearsed the movement with eyes closed, followed by MI on six soccer scenarios. EEG data, self rating on imagery tasks, and imagery preference were recorded. Visual imagery was found to be preferred by both groups with the elite group having a higher ability to use MI. Moreover, alpha amplitude of EEG significantly decreased during MI of soccer scenarios for the elite group, not the novice, suggesting extensive soccer experience might be associated with more focused and greater concentration during MI.

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Introduction

Mental imagery has been defined as mentally creating or recreating an experience by using images and a variety of senses (Short, Afremow, & Overby, 2001). Often referred to as mental practice or mental rehearsal, it is used universally by individuals for practicing a poem or a role in a play. Mental practice of motor tasks, however, is mainly used by athletes to improve sport performances or by patients in rehabilitation settings (Dickstein & Deutsch, 2007).

It has become more and more popular for elite athletes to use mental imagery as a supplemental tool to achieve successful results. For the past four decades, the study of mental imagery has been the focus of research within psychology and motor performance labs for its benefits with motor performance skills, especially in athletes (Callow & Hardy, 2004; Dickstein & Deutsch, 2007; Feltz & Landers, 1983). Numerous studies have tested the use of mental imagery on motor skill performance and it is generally accepted in sport psychology that mental imagery training has beneficial effects on motor learning and performance (Dickstein & Deutsch, 2007; Feltz & Landers, 1983; Gregg, Hall, & Hanton, 2007; Hinshaw, 1991; Isaac & Marks, 1994; Knudstrup, Segrest, & Hurley, 2003; Ozel, Larue, & Molinaro, 2004; Short et al., 2001; Wohldmann, Healy, & Bourne, 2008).

Although mental practice research is abundantly found in literature, limited studies have used electroencephalography (EEG) to examine the neurological effects of mental imagery (Marks & Isaac, 1995). Research evidence showed that EEG recordings can be used to provide measurable evidence of cortical activities during mental imagery. Therefore, the present study attempted to examine different characteristics of EEG patterns that would be associated with individual’s ability to use imagery, as well as the influence of sport skill level. The results may help coaches and athletes better understand different neurological characteristics of mental imagery, as well as its possible benefits.

Review of the Literature

Mental imagery used as a training tool has attracted a great attention by practitioners and researchers for a long time. The use of mental imagery to produce measurable improvements in performance can be traced back to the 1800s (Hinshaw, 1991; Isaac & Marks, 1994). In 1916, Washburn (1973) proposed that mental images could affect motor behavior and that they might be coordinated with slight muscular movements during the formation of the image. The idea that mental practice could actually be used as an ergogenic aid evolved from this proposal. Throughout history, it has been used by many as a way of practicing parts in plays or when reciting a poem. Mental practice can also be used when actual practice is not an option. For example, some musicians report using mental practice when traveling because they do not have the opportunity to play instruments on airplanes and buses (Kosslyn & Moulton, 2008). Another example is for one-shot or dangerous events when actual practice may be too dangerous (Feltz & Landers, 1983). For instance, a complex and difficult surgery could be mentally rehearsed with no physical action involved. Doctors reported using mental imagery to practice for their part in a 33-hour operation to separate twins who were joined at birth (Kosslyn & Moulton, 2008). One testimony revealed that the doctors would play a videotape in their mind. Another doctor claimed to have practiced the case in her head at least 100 times. When the day came to perform the surgery came, the doctor was excited, elated, and confident.

Types of Mental Imagery

Mental imagery can be categorized into one of two types, either visual or kinesthetic. Visual imagery, also referred to as external imagery, is performed by individuals seeing themselves performing a task through the outside; as though they were looking in a mirror, or as if they had a camera strapped to their forehead. This type of imagery can be of the persons themselves, the environment, or even a combination of the two, depending on the perspective used (Dickstein & Deutsch, 2007). If it is in third-person perspective, then the image will consist of visual imagery scenes outside the person. In first-person perspective, it is related to either the person's view of the imagery contents or to its kinesthetic sensation. Kinesthetic imagery, also referred to as internal imagery, is performed by the individuals feeling their limbs and muscles move while their body does not actually move.

Previous research has compared these two types of mental imagery to examine different influences of the two types (Callow & Hardy, 2004; Dickstein & Deutsch, 2007; Féry, 2003; Glisky, Williams, & Kihlstrom, 1996; Hardy & Callow, 1999; Marks & Isaac, 1995; Neuper, Scherer, Reiner, & Pfurtscheller, 2005; Spittle & Morris, 2007). For example, Fery (2003) focused on the influence of learning a new motor task of drawing a line. He found that visual imagery was more suitable for accurately drawing the line or the task that emphasized form, whereas kinesthetic imagery was better in drawing the line when timed or for the task that emphasized timing and coordination of the two hands. Hall, Buckolz, and Fishburne (1992) examined the relationship between imagery and the acquisition of motor skills. They suggested that using kinesthetic imagery was more effective for learning closed motor skills and that visual imagery was better for learning open motor skills. Visual imagery was also better for retention of practice when environmental space was concerned and kinesthetic was better when the task involved hand accuracy performance (Dickstein & Deutsch, 2007).

Based on the literature, it appears that both types of imagery are beneficial in learning and practicing motor performance, but which one to use is dependent upon the type of task or skill being practiced. It could also depend upon the individuals who are using it and their previous experience with the two types of imagery. Based on these different variables, individuals may be more confident using one type versus another type of mental imagery. For example, if someone is performing a task involving hand accuracy performance or coordination of the two hands, research suggests kinesthetic could be more appropriate (Dickstein & Deutsch, 2007; Féry, 2003). On the other hand if it is a task that is concerned with environmental space or involves form, visual imagery may be more appropriate (Dickstein & Deutsch, 2007; Féry, 2003; Wohldmann et al., 2008)

Mental Imagery and Motor Performance

The use of mental imagery plays an important role in motor skills learning and it has been well documented that mental imagery can significantly improve motor performance (Blair, Hall, & Leyshon, 1993; Callow & Hardy, 2004; Dickstein & Deutsch, 2007; Driskell, Copper, & Moran, 1994; Glisky et al., 1996; Martin & Hall, 1995; Woolfolk, Parrish, & Murphy, 1985). Positive effects on endurance, strength, aim, and precision are just some of these positive results (Knudstrup et al., 2003). Wohldmann et al. (2008) examined the benefits of mental practice on a typing test on undergraduate students. Seventy-two right-handed undergraduate students completed familiarization and then either mental or physical training of the typing task. A delayed test of the typing task revealed that mental practice led to less retroactive interference and more transfer than did physical practice. They concluded that physical and mental practice led to the development of different mental representations of the same task and that these different representations will give an advantage to mental practice or physical practice, in some circumstances. In this circumstance, the advantage was for mental practice.

Another research group studied the effect of mental practice on basic surgical skills with 65 second-year medical students (Sanders, Sadoski, Bramson, Wiprud, & Van Walsum, 2004). Subjects either had 3 sessions of physical practice on suturing a pig's foot, 2 sessions of physical practice and 1 session of mental imagery rehearsal, or 1 session of physical practice and 2 sessions of imagery rehearsal. Their results showed that after initial physical practice of a surgery, mental practice was equal to additional physical practice after performing a surgery on a live rabbit. Prather (1973) used 23 U.S. Air Force undergraduate pilots and investigated whether mental practice was an effective way to practice landing an airplane. The experimental group listened to tape recordings that prompted their mental practice of landing an aircraft while the control group did not receive this practice. The experimental group ratings on both procedures and ability to land were significantly higher than the ratings of the control group and it was concluded that mental practice may be an effective adjunct to the training program.

Due to variability across studies, it has been difficult to determine which specific aspects of mental imagery have the greatest improvement on performance (Glisky et al., 1996). Studies have examined different variables such as type of task, experience with task, imagery ability, experience with imagery, and type of imagery used (Glisky et al., 1996; Hinshaw, 1991). For example, it has been suggested that the higher the level of cognitive involvement in the task, the greater the benefit from mental rehearsal. Cognition has been previously defined as the act of knowing and involves studying all human activities related to knowledge (Neisser, 1967). Included in these activities are attention, creativity, memory, perception, problem solving, thinking, and the use of language. A cognitive task would then be focused primarily on spatial, temporal, or sequential aspects of the task and secondary to that process, would be the actual motor response (Hinshaw, 1991). Glisky et al. (1996) took 47 subjects who were either naturally internal or naturally external imagers, and had them perform both a cognitive/visual and a motor/kinesthetic task. Results revealed superior performance on the cognitive/visual task by the internal imagery group and greater performance of the external imagery group on the motor/kinesthetic task when compared to the control group. Wrisberg and Ragsdale (1979) researched early acquisition effects of mental imagery on skills that were both high and low in cognitive demand. The study found that mental imagery was positively correlated with cognitive demand of the task.

One study chose to research music performance because it is an activity that places high demands on fine motor coordination as well as on cognitive processes (Theiler & Lippman, 1995). They had college-level guitarists and vocalists practice one of four conditions (a) continuous physical practice; (b) mental practice alternating with physical practice; (c) mental practice with a modeled recording of the music alternating with physical practice; and (d) a motivational control activity alternating with physical practice. Most of the significant differences in performance ratings that occurred were between the mental practice conditions and the control/motivational condition and they concluded that mental practice may facilitate cognitive coding and help to create optimal levels of attentional focus and arousal.

Also, it was hypothesized by Highlen and Bennett (1983) that there should be a difference between open and closed skills since open skills are usually dependent upon another person's actions. A closed skill is performed in which the environmental surroundings remain relatively constant, where an open skill is executed in a constantly changing environment. One study attempted to examine this difference by comparing elite wrestlers to elite divers (Highlen & Bennett, 1983). Psychological factors associated with training and competition, one of which was imagery, were compared between both sports, as well as between qualifying and nonqualifying athletes within each sport. The wrestlers represented the open skilled sport, while the divers represented the closed skill sport. The use of imagery differentiated only the qualifying divers from the nonqualifying divers, but did not differentiate the two groups in wrestling nor between the divers and the wrestlers. Another study found that imagery use varied among a group of open skilled and closed skill sports (Arvinen-Barrow, Weigand, Thomas, Hemmings, & Walley, 2007). They examined cognitive specific (CS), cognitive general (CG), motivational specific (MS), motivational general-arousal (MG-A), and motivational general-mastery (MG-M) types of imagery among the two different groups. They found that athletes in open skilled sports used more MG-A and MG-M imagery; and that athletes in closed skill sports used more CS and MS imagery. Also, open skilled athletes used significantly more MG-A imagery than closed skill athletes. The researchers attempted to explain their findings by suggesting that athletes that participate in a closed skill sport seem to use more imagery when rehearsing specific sporting skills such as a golf-putt (CS) and to imagine specific goals and goal oriented behavior such as winning a trophy or medal (MS). However, athletes that participate in an open skill sport tend to use more imagery to regulate stress and arousal levels (MG-A) and for focus and self-confidence (MG-M).

Experience of the task plays a role in the effectiveness of mental imagery as well. Mental imagery has been shown to be ineffective in the initial stages of learning a skill, suggesting that perhaps subjects are unable to form and practice technically correct images due to lack of experience (Hinshaw, 1991). Individual differences become extremely important when researching the efficacy of imagery, especially prior experience with forms of visualization. Robin et al. (2007) examined how imagery ability could affect motor improvement following motor imagery training in tennis. Skilled tennis players were divided into three groups dependent upon if they were good or bad imagers. Results showed that mental imagery improved tennis return, and that this improvement was better in good imagers than in poor imagers. If one is a novice at mental imagery they are more likely to use an external perspective and may not form a correct image, due to lack of experience (Hinshaw, 1991). The image may also not be as vivid and will not closely approximate the actual physical, affective, and emotional responses to the actual event.

Inappropriate imagery can be a powerful enemy if the image is incorrect in its content. One study compared positive and negative imagery to a control group in students (Woolfolk et al., 1985). The students were instructed to putt a golf ball in a hole and were then separated into one of three groups. The positive imagery group was told to imagine the ball rolling right into the cup, the negative imagery group was told to imagine the ball rolling and narrowly missing the cup, and the control group did not use imagery at all. The positive imagery group improved their putting scores by 30.4%, whereas the control group only improved by 9.9%. The negative imagery group, however, reduced their putting scores by 21.2%, showing that the content of imagery during mental practice can affect later behavior. Visualization of negative images has been shown to result in lack of confidence, increased anxiety, and decreased motivation to practice or perform (Hinshaw, 1991). Therefore, it is important to assess an individual's experience and ability with mental imagery.

Mental Imagery and Sport Performance

A great amount of research in the literature has focused on sport performance enhancements (Abma, Fry, Li, & Relyea, 2002; Blair et al., 1993; Gray, 1990; Gregg et al., 2007; Lejeune, Decker, & Sanchez, 1994; Rodgers, Hall, & Buckolz, 1991; Salmon, Hall, & Haslam, 1994; Spittle & Morris, 2007; Ungerleider & Golding, 1991). Athletes who have applied mental imagery in the sports context have reported positive effects in speed, performance accuracy, muscle strength, movement dynamics, and motor skill performance (Dickstein & Deutsch, 2007). Rodgers et al. (1991) examined the effects of an imagery training program on imagery ability, imagery use, and figure skating performance. Twenty-nine skaters were assigned to either an imagery or verbalization training group, while another 11 skaters served as a control group. Subjects had two 15-minute sessions per week for 12 weeks. The imagery group would imagine different skating movements and the verbal group would describe to themselves out loud these movements. The imagery group improved in visual movement imagery ability and in terms of performance, both the imagery and verbalization groups attempted and passed more skating tests than would normally be expected.

Research has also been conducted to focus on mental imagery benefits in competitive sports. One researcher interviewed 63 of the world's top athletes and reported that 80% relied on imagery to enhance their performance (Hemery, 1988). Murphy, Jowdy, and Durtschi (1990) interviewed athletes in training at a U.S. Olympic Training Center and found that 90% of Olympic athletes use mental imagery and that 97% of them considered it to be beneficial. Ungerleider and Golding (1991) reported that mental practice may be associated with more successful track and field performance when they examined elite track and field athletes from Olympic trials. Another study implemented a mental skills program for serving for an intercollegiate volleyball team. End-of-season reported use of imagery was significantly correlated with good serve percentage (Shoenfelt & Griffith, 2008).

Athletes commonly use mental imagery in practice to facilitate training results as well. Performance accuracy and response speed were tested on soccer players that had been exposed to bi-weekly imagery sessions of soccer tasks (Blair et al., 1993). Twenty-two skilled and 22 novice soccer players were equally and randomly assigned to either a control or an experimental group. The experimental group was given an imagery training program consisting of both visual and kinesthetic imagery, and in which both internal and external imagery perspectives were included. The results showed significant improvements in response time of completing the soccer task for both skilled and novice players in the imagery group when compared to the control group.

The question of whether imagery has more of an effect on the athlete learning a new sport or the elite level athlete is debatable. Previous studies have reported that both novice and elite performers use imagery; however athletes at the elite level have reported that imagery is more relevant to their performance, and report using imagery more often than novice athletes (Gregg et al., 2007). The majority of previous research also indicates that mental imagery can be effective at all stages, although several studies have reported mental practice was ineffective in the initial stages of learning. Noel (1980) investigated the effect of visuo-motor behavioral rehearsal (VMBR) training on 14 male tennis players. Half of the participants were trained in relaxation and then given a relaxation and visualization audiocassette tape to use on a daily basis prior to a tournament while the other half received no VMBR training. Results found VMBR to be significantly more effective for highly skilled tennis players. In Highlen and Bennett's (1983) study, they compared qualifying or successful divers to nonqualifying or nonsuccessful divers on a 5 variable imagery scale to compare imagery use in training, 1 hour before competition, before a dive, control of imagery and vividness of imagery. The qualifying divers reported greater control of their imagery, which was also more vivid, and that they employed more imagery in training, 1 hour before competition, and immediately before a dive compared to nonqualifying divers. Arvinen-Barrow et al. (2007) also found greater imagery use by elite athletes than novices in their study across many sports including rugby, martial arts, golf, and figure skating. Mackay (1981) proposed a theoretical explanation for why novices are unable to achieve these same benefits. The author suggested that beginners are perhaps unable to form and practice technically correct images due to lack of experience. Which type of athlete benefits more from the use of imagery is still not clear.

Effectiveness of a mental imagery program is partially based upon individuals' mental imagery capacity or their ability to implement mental imagery. It has been suggested that engaging in spatial activities increases this capacity and that sport may be considered a spatial activity (Ozel et al., 2004). In Ozel et al.'s (2004) study, the results showed that athletes performed a mental rotation task significantly faster than nonathletes. This supports the suggestion that there is a link between sport and the ability to perform mental image transformations. Mental imagery effectiveness can also be due to an individual's experience with the certain skill being performed or their confidence level of performing the skill. It has been proposed that novices do not have the muscle patterns primed to perform the skill compared to someone with more experience (Hinshaw, 1991). Abma et al. (2002) found that athletes who were highly confident tended to use imagery more than athletes with low levels of confidence. Mahoney and Avener (1977) found that successful gymnasts were better at using imagery than those who were less successful. The gymnasts who were less successful were more likely to allow their anxiety to reach panic levels which decreased their performance. For these reasons, athletes or an elite group may be able to better perform mental imagery practice than non-athletes or a novice group, especially if the image is within their sporting event.

Feltz and Landers (1983) conducted a meta-analysis that included over 60 related studies and examined the effect of imagery on athletic performance. They revealed an overall effect size of .48. It was concluded that mental practice influenced performance only somewhat, and had no more of an effect than real practice. It was also noted that the type of skill, type of subjects used, and other conditions can moderate this influence.

Related literature has suggested that the combination of mental imagery and physical practice is the most efficient method to improving performance compared to physical or mental imagery practice alone (Robin et al., 2007). Another meta-analysis was conducted on 35 studies by Driskell et al. (1994) that included 100 studies. Results of this analysis indicated that mental imagery is an effective means for enhancing performance. Specifically, mental practice offers the opportunity to rehearse behaviors and to code behaviors into easily remembered words and images to aid recall. However, it does not offer direct knowledge of results or visual and tactile feedback that physical practice can offer. They proposed that a positive effect on performance may best be achieved with using both physical and mental practice. Yue and Cole (1992), however, performed a study comparing an isometric finger exercise to mental practice of the same exercise. Their results showed that mental practice improved muscle strength by 22%, which was comparable to the 30% increase by the isometric exercises, while a control group only increased their muscle strength by 3.7%. By repeatedly engaging the motor control processes responsible for the specific finger movement during the mental practice, subjects were able to work on those processes and increase actual muscle strength (Kosslyn & Moulton, 2008).

Theories of Mental Imagery

Several hypotheses and theories have been proposed to explain the underlying mechanisms of mental imagery. They are the psychoneuromuscular theory, symbolic learning hypothesis, and bioinformational theory (Hinshaw, 1991).

1. The psychoneuromuscular theory stems directly from the early work on mental imagery from the late 1800s. Focusing on the possibility of "muscle memory", the theory explains that during the formation of a mental image the muscles "learn" to perform the functions pictured in the mind. In 1934, electromyographic activity was found to coincide with using imagery and helped to support this theory. Numerous studies have

since explored this relationship between EMG activity in imagery and physical practice and have determined that EMG activity is associated with using imagery (Bird, 1984; Jacobson, 1934; Suinn, 1972, 1976). Suinn (1972), for example, examined downhill skiers and found that during imagery sessions, the roughest sections of the course had the highest muscular activity, similar to actual skiing. This theory explains that since the neural pathways are similar to those of actual practice, neural pathways controlling the muscles of an action are strengthened through imagery of the action and can therefore improve performance (Hinshaw, 1991).

2. According to the symbolic learning hypothesis, the success of mental practice is dependent on and variable with the cognitive components of the task included. If the task is motor related, imagery practice should have little effect. If the task is more cognitive, imagery practice will have a better effect. Symbolic learning also hypothesizes that the early stages of both physical and thus cognitive learning should exhibit a much larger effect of imagery than the later stages. (Hinshaw, 1991)

3. A more recent theory is the bioinformational theory, which attempts to explain imagery through a network of stimulus/response channels. Every behavior, either covert or overt, creates a specific and unique network of interconnected channels in the brain. Each time a behavior is repeated, there is activation of the corresponding network. The theory explains that an overt behavior’s network is copied and internally reproduced in the form of an image. Whether imagery is successful or not depends on the activation of the networks involved while simultaneously inhibiting contraindicatory responses. (Hinshaw, 1991)

4. Mental imagery may affect performance through a transfer of training effect and a generalized practice effect has also been suggested (Hodes, 1991). Hodes found that instructional methods that used high imagery resulted in increased transfer of training through greater learning of procedural information. Perhaps this occurs because the new behaviors are recalled more easily after they have been clearly visualized or practiced mentally. As new skills or behaviors are repeatedly rehearsed mentally, new behavioral patterns may be embedded in one's memory, similar to what might occur with physical practice (Kellner, 1979). The increased transfer of training due to mental imagery and the generalized practice effect may both contribute toward improved performance.

A close functional relationship between imagined and executed movements has been suggested by previous studies. For instance, Beisteiner, Höllinger, Lindinger, Lang, and Berthoz (1995) conducted a study on 46 subjects using unilateral and bilateral hand movements. The main result was that with unilateral performance, the side of the performing hand (right or left) had localized effects in recordings over the sensorimotor hand area. It has also been determined that imagined and executed movements have similar durations and similar effects on parameters such as heart rate and respiratory rate.

It has been suggested that visual mental imagery may use the same mechanisms that are used in visual perception (Kosslyn & Moulton, 2008). In a study using functional magnetic imaging (fMRI) to assess brain activity, it was examined that two thirds of all brain areas activated during either visual imagery or visual perception were activated in common (Kosslyn & Moulton, 2008). Yet another study had subjects perform the same task in visual perception (with the visual stimuli) and during imagery (with closed eyes) (Ganis, Thompson, & Kosslyn, 2004). Results revealed that almost 90% of the same neural areas were activated. Kosslyn, Thompson, Wraga, and Alpert (2001) examined that different types of imagery could also affect different which areas of the brain were activated (Kosslyn et al., 2001). For example, they instructed two groups of subjects to mentally rotate an object. One group was told to mentally rotate the object by physically twisting the stimulus with their hands, while the other group was told to imagine the object being rotated by an electric motor. Both groups' behavioral data indicated that the participants mentally rotated the object, but only the first group had primary motor cortex activation.

Electroencephalogram (EEG) and Imagery

Mental imagery is an imagined rehearsal of a motor act without any overt movement (Beisteiner et al., 1995). During mental rehearsal, you realize the ability to simulate a movement within its temporal and spatial sequencing and by doing so, you produce images of sensation which would arise during execution. The process is associated with cognitive operations which should produce measurable changes in the levels of cortical activities. Modern technology, such as computerized brain image, allows us to observe those changes and understand better neurological characteristics and underlying mechanisms of the impact on the brain.

An important issue concerned in imagery research is the reliability of the construction of images (Intons-Peterson, 1983). There is no way to directly and definitively measure when images have or have not been created. To alleviate this problem, researchers have applied scientific measures to provide evidence of brain (EEG) and muscle (EMG) activities during imagery. One such measure, the electroencephalogram (EEG), provides a convenient non-invasive measure of cortical activation and is widely used (Marks & Isaac, 1995). An EEG recording can provide a reliable, predictable and visible recording of a subject's alpha waves during mental rehearsal (Marks & Isaac, 1995). Mental imagery of certain tasks can produce replicable EEG patterns in primary sensory and motor areas (Beisteiner et al., 1995; Pfurtscheller & Neuper, 1997).

It has been shown that mental imagery induced activations occur at the cortical level and in the musculature that is imagined being used, similar to what happens when they are actually being used (Knudstrup et al., 2003). EMG activity, cerebral blood flow, and cortical motor evoked potentials have shown that neuromotor pathways that are only imagined being used during mental imagery are actually being used and that metabolic activity of the neurons being involved is increased during mental imagery as if the activity were actually being performed (Bakker, Boschker, & Chung, 1996).

Breitling, Guenther, and Rondont (1986) studied the brain electrical activity of right-handed normal subjects while they performed motor tasks that were of increasing difficulty. Subjects listened to a recording which took them through a period of relaxation, a simple movement of pressing their right index finger against a sponge, a repetitive movement of making a fist, a programmed movement of touching the thumb to other fingers, and then an imagery session of the programmed movement. The results showed a decrease in the alpha amplitude in the motor execution cortical areas when subjects imagined finger movements as well as when they physically performed the movements when compared to baseline. They concluded that the same motor control areas that are used during the physical task were also used when the task was imagined.

Alpha wave is the dominant frequency in the human scalp EEG of adults and reflects cognitive and memory performance in particular (Klimesch, 1999). Davidson and Schwartz (1977) examined modality-specific EEG patterning during self-generation kinesthetic and visual imagery (Davidson & Schwartz, 1977). Twenty subjects imagined a flashing light, a tapping sensation on the right forearm, and then both the flashing light and tapping sensation together. EEG was recorded from the left occipital and left sensorimotor regions. Different patterns of occipital and sensory motor alpha activities were observed during kinesthetic imagery versus visual imagery. Specifically, there was greater relative occipital activation that occurred during kinesthetic imagery when compared to visual imagery. The authors suggested that image generation might be associated with activation of the occipital region normally involved in perceptual processing.

Another study found suppression of the alpha wave during their EEG recordings when using imagery. Costello and McGregor (1957) had twenty subjects imagine a car, diagram, bus scene and a wheel during a normal relaxed condition and then during a drowsy state. They attributed the suppression of the alpha rhythm found during imagery to two factors. First, that suppression was a result of the vividness of the image, the more vivid the image the greater the suppression of the alpha wave. The second factor was to what extent higher order thought processes were involved, the less they are involved the greater the suppression of the alpha wave.

Which side of the brain to use during mental imagery has also been investigated by using EEG recordings in the literature. Marks, Uemura, Tatsuno, and Imamura (1985) investigated topographical maps of six vivid imagers and six non-vivid imagers when they were conducting visual imagery and calculation tasks. The imagery map generated for vivid imagers had widespread cortical activation in the left occipital and parietal cortex, evidence contrary to the hypothesis that imagery could be associated with spatial thinking and a specialization of the right hemisphere. It was actually non-vivid imagers who indicated a right hemisphere focus which appeared to be frontal.

Overall, there is limited research on cortical activities associated with mental imagery rehearsal. Moreover, little study has been conducted to examine neurological characteristics of mental imagery using elite team-sport athletes. Further research is needed to provide empirical evidence supporting previous findings and understand the processing of mental imagery.

Movement Imagery Questionnaire

The Movement Imagery Questionnaire (MIQ) was developed to examine subjects' perception of how easy or difficult using imagery is (Dickstein & Deutch, 2007). The MIQ is based on subject's ratings of the ease of imaging 18 predefined arm, leg or whole body movements on a 7-point Likert scale (Hall & Martin, 1997). Subjects are asked to perform each movement and then use imagery, before scoring each movement. Movement imagery is rated twice, once for visual and once for kinesthetic. It has been used in many previous studies and was found to be a reliable test for imagery research. Hall et al. (1985) reported a test-retest coefficient of .83 for a 1-week interval. They also found internal consistency coefficients of .87 for the visual subscale and .91 for the kinesthetic subscale. Atienza, Balaguer, and Garcia-Merita (1994) reported similar internal consistencies (visual subscale = .89; kinesthetic subscale = .88).

The Movement Imagery Questionnaire-Revised (MIQ-R) is a shorter version of the same test developed by Hall and Martin (1997). The goal was to reduce the length of the MIQ by removing items subjects often failed to answer, and eliminating items that provided redundant information. Fifty subjects were presented with either the MIQ or the MIQ-R. After completing this first questionnaire, subjects were engaged in a mental manipulation task for 10 minutes that acted as a distracter. The subjects were given the second questionnaire of either the MIQ or the MIQ-R, depending which one they had completed first. Half of the subjects completed the MIQ first, while the other half were first given the MIQ-R. When the two questionnaires were compared, a significant correlation of .77 was found on the visual scores as well as with the kinesthetic scores. Their results suggest that the MIQ-R is an acceptable revision of the MIQ and can be employed to assess visual and kinesthetic movement imagery ability.

Summary

A great amount of research has been conducted to provide solid evidence that mental imagery does have some ergogenic effect over no practice. EEG recording has been introduced to measure cortical activities during mental imagery. While previous research has found that mental imagery can be successful in improving motor skill performance, limited studies focused on neurological measurements using elite athletes, which would be practically meaningful and valuable to coaches and athletes themselves. The present experiment attempted to examine: 1) whether one specific type of motor imagery, visual or kinesthetic, is preferred by soccer players and 2) if EEG patterns vary based on an individual's ability to use imagery and skill level. It was hypothesized that elite soccer athletes will have higher imagery ability than the novices and the alpha activity pattern and would be different than their counterparts.

Methods

Subjects

A total of 55 college students were recruited to participate in the study (age range from 18-35 years). They were categorized into one of the following two groups. The control group consisted of students participating in a soccer class offered by the university general education program. Their soccer experience was limited to participation in the class and possibly some recreational play (N = 17, Males = 15, Females = 2). For this study, they were considered novice soccer players. The study group consisted of student athletes who currently play on the university's NCAA Division I soccer team (N = 38, Males = 17, Females = 21). For this study, they were considered elite soccer players. All subjects signed a consent form (Appendix A) approved by the IRB of the University of Memphis before participating in the study.

Equipment

In order to record the alpha activity during the mental imagery sessions of the subjects, the MP35 data acquisition unit, consisting of a fully-shielded multi-strand (red, white, and black) electrode lead set cable, and Blue Sensor™ silver/silver chloride, wet-gel electrodes (Model SE-00-S) was 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 was used to lead the subjects through the procedure (see Appendix B) and a CD player was also used in this study.

Design

The two groups of subjects followed the same test protocol which included a single session with two phases: 1) mental imagery on six simple movements and 2) mental imagery on six soccer scenarios with an EEG recording. An audio recording of a script was used (Appendix B) so that each subject would follow the exact same directions. The MIQ-R (Appendix C) was used to assess individuals' self reported perception of easiness in visual and kinesthetic imagery of movement during the first test phase for the general movements. A questionnaire (Appendix D) was used for the verbal report of the soccer scenarios and which style of imagery they chose to use, either visual or kinesthetic, during the soccer scenarios.

Procedure

Subjects were tested individually. They were explained the procedure and given the purpose of the study before the following two testing phases.

Test 1 – PHYSICAL AND MENTAL REHEARSALON SIMPLE MOVEMENTS

Subjects listened to a tape that led them through the MIQ-R which consisted of 3 general movements to slowly perform including a knee raise, a toe touch, and a lateral arm movement. After performing the movement the subjects were asked to perform a mental task to either "feel" or "see" the movement just performed. Each movement was presented twice so the subjects had the opportunity to both "feel" and "see" each. "Feel" involved using kinesthetic imagery to feel their limbs and muscles perform the movement while their body does not actually move. "See" involved using visual imagery to see themselves perform the movement through the outside. After each pair of movement and mental tasks, the subjects were asked to rate the ease or difficulty with which they were able to do the mental task.

Test 2 – MENTAL REHEARSAL ON SIMPLE MOVMENTS AND SOCCER SCENARIOS WITH EEG RECORDING

After the MIQ-R was completed, the subjects were asked to sit down and the three electrodes were placed on the subjects' temporal lobe, parietal lobe, and ear lobe (Figure 1). They were asked to sit still and keep their eyes closed. A 10 second calibration was obtained, followed by a baseline period. The baseline period consisted of 10 seconds with their eyes closed, 10 seconds with their eyes open, and then another 10 seconds of eyes closed. The subjects' eyes remained closed throughout the rest of the procedure.

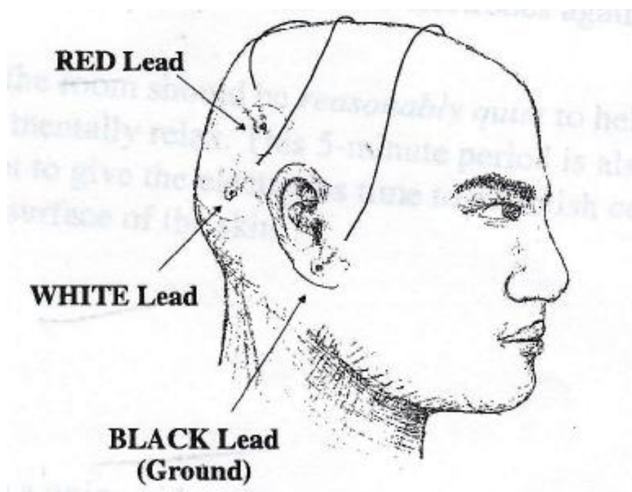

Figure 1. Electrode Placement Locations Used in the Experiment

The subjects were then described the six soccer scenarios including penalty kick shooting, trapping, a through pass, receiving a pass and turning, a 50/50 ball, and jumping and heading. After describing the scenario, the subjects were instructed to repeat the image in their head over and over again until they were told to stop and asked to verbally rate their experience, similar to the general movements performed in Test 1. The imagery lasted 15 seconds with all descriptions and the same 1-7 scale as previously mentioned with the MIQ-R was used. After the six soccer scenarios were completed, the subjects were asked which form of mental imagery they chose to use, either visual or kinesthetic.

EEG data was obtained during the mental imagery by placing one electrode each on the subjects' temporal and parietal lobes as well as a ground lead on the ear lobe, for a total of three electrodes. As the alpha wave was being recorded, markers were placed throughout the imagery session so the periods of mental visions were separated from the rest of the time. BioPac data acquisition system, MP35 was used to obtain the EEG data. BioPac programming was also used for data analysis of the alpha waves as well.

Data Analysis

EEG, alpha wave, and alpha-RMS were recorded during baseline as well as imagery sessions using the Biopac data acquisition system (Figure 2).

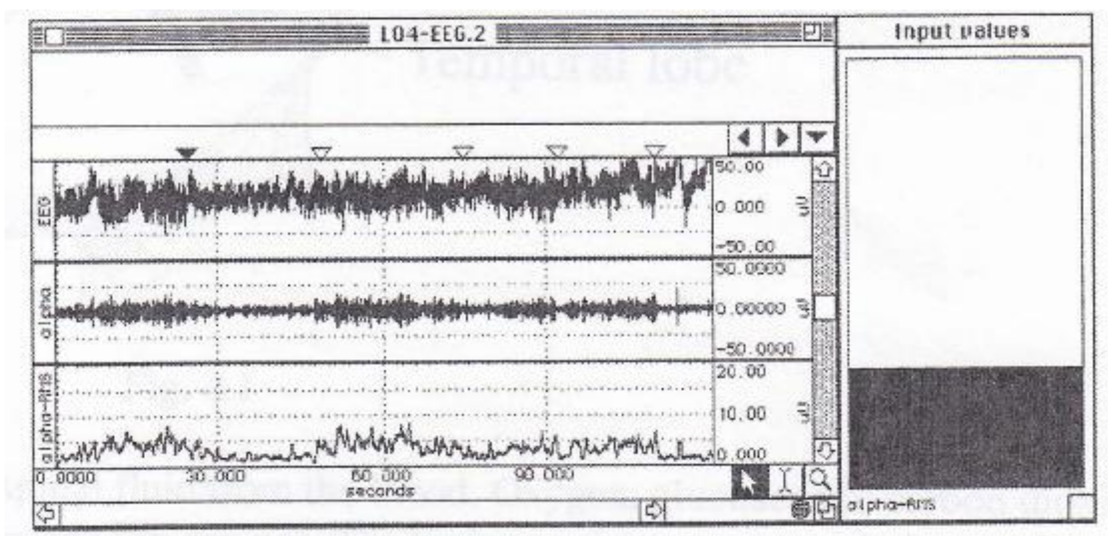

Figure 2. EEG Recording with Alpha Wave Shown on Window Display

Area and standard deviation were measured for each wave. Area was computed as the total area among the waveform and the straight line that was drawn between the endpoints marking each imagery session. Standard deviation was a measure of the variability of data points. The data represents amplitudes of the brain rhythms. The advantage of using the standard deviation measurement was that extreme values or artifacts did not unduly influence the measurement.

Descriptive statistics were calculated to compare the differences between the two groups for mental imagery on both general and soccer specific movements for self-rating data and EEG data for the soccer movements. The soccer scenarios were divided into simple and complex movements. The simple movements included penalty kick shooting, trapping, and a through pass. The complex movements included receiving a pass and turning, a 50/50 ball, and jumping and heading. A 2 (group) X 3 (test: GM, SS_S, SS_C) ANOVA repeated on the second factor was performed on self rating scores and EEG.

Results

Subject's characteristics for both the control and study groups, including gender and age, were summarized and are presented in Table 1.

Table 1
Demographic Information of Participants in Control and Study Groups

Group	N	Age	Gender
Control (Novice)	17	22* (2.67)	Male = 15 Female = 2
Study (Elite)	38	21 (3.37)	Male = 17 Female = 21

*Mean (Standard Deviation)

The descriptive statistics for self-rating data regarding mental rehearsal on the general movements, and the simple and complex soccer scenarios are presented in Table

2. The results of a 2(group) X 3(test: general, scenario1, scenario2) ANOVA showed a significant group effect, $F_{(1,53)} = 9.644$, $p < .01$, and a test effect, $F_{(1,53)} = 13.964$, $p < .01$. The soccer team players reported higher scores in easiness of mental imagery rehearsal during all test conditions (i.e., general movements and soccer scenarios) than the novice subjects. Moreover, the follow-up test showed that self-rating scores were significantly higher in rehearsing soccer scenarios than general movements for all subjects. No significant interaction was found from the data.

Table 2
Means and Standard Deviations of Self Ratings on Mental Imagery of General Movements and Soccer Scenarios for Two Groups

Group	General Movements		Soccer Scenarios	
	Kinesthetic	Visual	Simple (1-3)	Complex (4-6)
Control N = 17	5.00* (1.70)	5.39 (1.55)	5.88 (0.97)	5.96 (1.11)
Study N = 38	5.46 (1.25)	6.03 (1.25)	6.56 (0.62)	6.18 (0.96)

*Mean (Standard Deviation)

Alpha wave measures were recorded and are presented in Table 3. Average score and Area score are given for the alpha wave. Alpha amplitude is presented in Figure 3.

Table 3

Means and Standard Deviations of EEG Recordings on Mental Imagery in Soccer Scenarios for the Two Groups

Group	Alpha Activity	Closed Eyes	Soccer Scenarios Simple (1-3)	Soccer Scenarios Complex (4-6)
Novice (N = 17)	Average Score	3.10* (1.61)	2.96 (1.27)	2.89 (1.25)
	Area Score	54.68 (32.99)	52.29 (23.78)	50.45 (22.13)
Elite (N = 38)	Average Score	3.64 (1.58)	3.08 (1.33)	3.16 (1.49)
	Area Score	77.40 (98.75)	55.15 (25.14)	57.89 (30.47)

*Mean (Standard deviation)

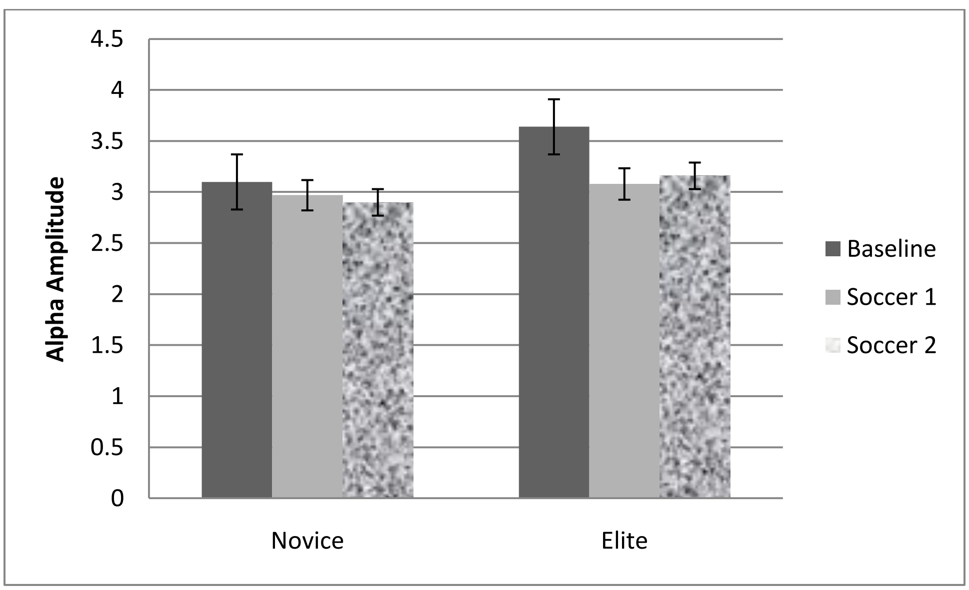

Figure 3. Mean Alpha Amplitude Scores Recorded During the Baseline and Soccer Scenarios for the Two Groups.

For baseline EEG activity, the results of a 2(group) X 2(test: closed-eye1 vs. closed-eye2) with repeated measures on the second factor, showed no significant main effect and interaction in the analysis for both closed-eye periods. During mental imagery rehearsal, the results of a 2(group) X 3(test: close1, scenario1, scenario2) ANOVA based on average alpha scores revealed a significant test effect, $F_{(1, 53)} = 15.7$, $p < .01$, and an interaction, $F_{(1, 53)} = 5.8$, $p < .05$. The follow-up test showed that the average alpha level significantly decreased during mental imagery rehearsal in more soccer scenarios than the two rest periods for the elite group; however, this was not the case for the novice group. The analysis based on alpha area scores showed no significant findings, although the similar tendency was identified.

No significant gender effect was found among the elite group.

Discussion

The current study investigated which type of motor imagery was preferred by novice and elite soccer athletes and if their EEG patterns would vary based on their ability to use imagery and sport skill level. Based on previous research (Costello & McGregor, 1957; Gregg et al., 2007; Highlen & Bennett, 1979; Ungerleider & Golding, 1991), it was hypothesized that elite soccer players would have a higher imagery skill than the novices and that alpha activity for the elite group would be significantly different from the novice. First, it was found that visual imagery was preferred over kinesthetic imagery by all subjects with no regard to the level of soccer experience. There were 88% of the novice soccer players and 81% of the elite soccer athletes who indicated that they preferred visual imagery. In both the elite and novice soccer groups, the majority of subjects chose to use visual imagery over kinesthetic imagery when they were asked to mentally rehearse six soccer scenarios. This finding goes along with the previous suggestion by Hall et al. (1992) that visual imagery may be better for an open skill versus a closed skill. The explanation coincides with the current results given that soccer is an open-skill sport, meaning that athletes' movement responses are dependent upon opponents' actions and executed in a constantly changing environment (Highlen & Bennett, 1983). The findings were also parallel with Dickstein and Deutsch's (2007) theory that visual mental imagery is better for retention of practice when environmental space is concerned. Although visual imagery was preferred among both groups, kinesthetic imagery could still possibly have a beneficial effect on soccer athletes and should not be ruled out as a helpful form of practice.

One main finding was that the elite soccer group rated significantly higher than the novice soccer group on the self-rating scale over all scenarios, including mental imagery on both general movements and soccer scenarios. Past research has only looked at single movements and individual sports, but not team sport activities. The current investigation was the first to look at simple and complex soccer movements. It was interesting that the expert soccer players self reported higher ratings than the novice level players with not only the soccer scenarios, but also with the general movements. A possible explanation might be that the elite soccer group has had more prior experience using imagery, and therefore felt more confident using it no matter what type of scenario or movement was presented to them. As previously explained in the related literature, the novice is more likely to use an external perspective and may or may not form a "correct" image (Hinshaw, 1991). The incorrect images would have made the imagery tasks more difficult for the novice players compared with the experienced soccer athletes. The simple body movements that subjects were asked to engage in mental rehearsal were not the movements that individuals normally perform during an ordinary life situation. Therefore, the novice soccer players could have rated lower because they were not forming images correctly for the movements and scenarios if they are not familiar with those movements, or they are just not good at them.

According to Lang's (2007) description of the bioinformational theory, mental practice would activate learned muscular-neural networks in experienced subjects. Novices do not have the necessary network prototypes from which to facilitate learning and thus cannot perform mental practice with the ease that experienced subjects can. This explains the reason why the elite soccer group rated higher than the novice soccer group in all of the imagery sessions.

The data showed that both novice soccer players and elite soccer athletes rated higher for the soccer scenarios than with the general movements. This suggests that the subjects were more confident using imagery with the soccer scenarios than with the general movements. Relatively speaking, the subjects were more familiar with the soccer scenarios than with those simple body movements which are not regularly performed movements. During mental practice, movements are being governed by information that has been stored in one's implicit memory (Kosslyn & Moulton, 2008). Moulton and Kosslyn believe the primary function of mental imagery is to allow one to generate predictions based on past experience (Moulton & Kosslyn, 2009). If the subjects are not as familiar performing the general movements, such as the lateral arm movement, they will not be as comfortable using mental imagery to perform them. They may perhaps be more familiar performing penalty kicks, through passes, or any of the other soccer scenarios that were presented. Trying to use mental imagery on a skill that subjects have no or little prior physical experience with could be more difficult than a skill they have vast experience performing.

Another main finding was that there was a significant interaction between Test and Group in the EEG activity data. Specifically, the elite soccer group had a significant decrease in their alpha amplitude during the soccer scenario imagery compared with the baseline period; however, there was not much change for the novice group. The lower amplitude of the alpha wave indicates a higher alert level, suggesting that the elite athletes were more focused and highly active during the mental rehearsal on the soccer scenarios. This data supports the findings that the elite athletes rated higher in the self reporting than the novice soccer group, suggesting that the soccer athletes had greater ability to use mental imagery than their counterparts.

A previous study by Costello and McGregor (1957) using EEG examined the relationship between the vividness of visual images and suppression of the alpha rhythm. They took 20 subjects and had them visualize four different images in a normal state, and also in a drowsy state. They concluded that suggested suppression of the alpha activity could be the result of the vividness of the image and the extent to which higher order thought processes were involved. The elite soccer group may have more vivid images due to their previous experiences with the scenarios and high imagery ability. Therefore, they exert greater effort with a higher concentration when they were asked to conduct mental imagery rehearsal; their alpha activity was significantly decreased from the baseline level. The association of alpha activity and mental imagery warrants further investigations, specifically on how EEG activity relates to using different types of imagery, visual and kinesthetic. This line of research may provide a better understanding of how the process of mental imagery impacts our brain, as well as its' influences on the effectiveness of mental practice engaged by athletes in various sports.

Conclusion and Future Research

The results of the present study indicated that when using imagery with either elite or novice soccer players, visual imagery was preferred over kinesthetic imagery regardless of the level of soccer skills. Moreover, the alpha activity pattern of EEG was different between elite soccer athletes and novice players during mental imagery on soccer scenarios. A significant decrease of alpha amplitude suggests that the elite soccer players had higher levels of concentration during their mental imagery rehearsal compared with the novice players.

Since many variables can alter someone's mental imagery ability such as past experience with the task or with mental imagery itself, future studies should gather more background information from subjects. Different positions the athletes have played or whether or not they have used imagery before could help to examine possible unknown confounding variables. One example could be goalies. They experience a penalty kick from a different angle from the rest of the positions; they are trying to block the kick from going into the goal instead of doing the actual kicking. This could make it more difficult for them to be able to use mental imagery in that specific scenario. Also, if someone has been instructed on how to perform imagery in the past, they may be more comfortable and rate higher then someone who has never used mental imagery before.

Mental imagery is an important topic related to performance improvement. More investigations are needed to further the knowledge of mental imagery and how it could maximize the benefits to athletes and their performance.

References

Abma, C. L., Fry, M. D., Li, Y., & Relyea, G. (2002). Differences in imagery content and imagery ability between high and low confident track and field athletes. *Journal of Applied Sport Psychology, 14*(2), 67-75.

Arvinen-Barrow, M., Weigand, D. A., Thomas, S., Hemmings, B., & Walley, M. (2007). Elite and novice athletes' imagery use in open and closed sports. *Journal of Applied Sport Psychology, 19*(1), 93-104.

Atienza, F.L., Balaguer, I., & Garcia-Merita, M.L. (1994). Video modeling and imaging training on performance of tennis service of 9-to 12-year-old children. *Perceptual and Motor Skills, 87*(2), 519-529.

Bakker, F. C., Boschker, M., & Chung, J. (1996). Changes in muscular activity while imagining weightlifting using stimulus or response propositions. *Journal of Sport Exercise Psychology, 18*, 313-324.

Beisteiner, R., Höllinger, P., Lindinger, G., Lang, W., & Berthoz, A. (1995). Mental representations of movements. brain potentials associated with imagination of hand movements. *Electroencephalography and Clinical Neurophysiology/Evoked Potentials Section, 96*(2), 183-193.

Bird, E. I. (1984). EMG quantification of mental rehearsal. *Perceptual and Motor Skills, 59*, 899-906.

Blair, A., Hall, C., & Leyshon, G. (1993). Imagery effects on the performance of skilled and novice soccer players. *Journal of Sports Sciences, 11*(2), 95-101.

Breitling, J., Guenther, W., & Rondont, P. (1986). Motor responses measured by electrical activity mapping. *Behavioral Neuroscience, 100*, 104-116.

Callow, N., & Hardy, L. (2004). The relationship between the use of kinaesthetic imagery and different visual imagery perspectives. *Journal of Sports Sciences, 22*(2), 167-177.

Costello, C. G., & McGregor, P. (1957). The relationships between some aspects of visual imagery and the alpha rhythm. *The British Journal of Psychiatry, 103*(433), 786.

Davidson, R. J., & Schwartz, G. E. (1977). Brain mechanisms subserving self-generated imagery: Electrophysiological specificity and patterning. *Psychophysiology, 14*(6), 598-602.

Dickstein, R., & Deutsch, J. E. (2007). Motor imagery in physical therapist practice. *Physical Therapy, 87*(7), 942.

Driskell, J. E., Copper, C., & Moran, A. (1994). Does mental practice enhance performance? *Journal of Applied Psychology, 79*(4), 481-491.

Feltz, D. L., & Landers, D. M. (1983). The effects of mental practice on motor skill learning and performance: A meta-analysis. *Journal of Sport Psychology, 5*(1), 25–57.

Féry, Y. A. (2003). Differentiating visual and kinesthetic imagery in mental practice. *Canadian Journal of Experimental Psychology, 57*(1), 1-10.

Ganis, G., Thompson, W. L., & Kosslyn, S. M. (2004). Brain areas underlying visual mental imagery and visual perception: An fMRI study. *Cognitive Brain Research, 20*(2), 226-241.

Glisky, M. L., Williams, J. M., & Kihlstrom, J. F. (1996). Internal and external mental imagery perspectives and performance on two tasks. *Journal of Sport Behavior, 19*(1)

Gray, S. W. (1990). Effect of visuomotor rehearsal with videotaped modeling on racquetball performance of beginning players. *Perceptual and Motor Skills, 70*(2), 379-385.

Gregg, M., Hall, C., & Hanton, S. (2007). Perceived effectiveness of heptathletes' mental imagery. *Journal of Sport Behavior*, *30*(4), 398.

Hall, C., Buckolz, E., & Fishburne, G. J. (1992). Imagery and the acquisition of motor skills. *Canadian Journal of Sport Sciences = Journal Canadien Des Sciences Du Sport*, *17*(1), 19-27.

Hardy, L., & Callow, N. (1999). Efficacy of external and internal visual imagery perspectives for the enhancement of performance on tasks in which form is important. *Journal of Sport and Exercise Psychology, 21*, 95-112.

Hemery, D. (1988). *Psycho-Social Factors in the Development of Sports Highest Achievers,*

Highlen, P. S., & Bennett, B. B. (1979). Psychological characteristics of successful and nonsuccessful elite wrestlers: An exploratory study. *Journal of Sport Psychology, 1*, 123-137.

Highlen, P. S., & Bennett, B. B. (1983). Elite divers and wrestlers: A comparison between open-and closed-skill athletes. *Journal of Sport Psychology, 5*(390-409)

Hinshaw, K. (1991). The effects of mental practice on motor skill performance: Critical evaluation and meta-analysis. *Imagination, Cognition, and Personality, 11*(1), 3-35.

Hodes, C. L. (1991). The effectiveness of mental imagery and visual illustrations: A comparison of two instructional variables. *Journal of Research and Development in Education, 26*, 46-56.

Intons-Peterson, M. J. (1983). Imagery paradigms: How vulnerable are they to experimenters' expectations? *Journal of Experimental Psychology.Human Perception and Performance, 9*(3), 394-412.

Isaac, A. R., & Marks, D. F. (1994). Individual differences in mental imagery experience: Developmental changes and specialization. *British Journal of Psychology (London, England : 1953), 85 (Pt 4)*(Pt 4), 479-500.

Jacobson, E. (1934). Electrical measurements of neuromuscular states during mental activities. *American Journal of Physiology, 94*, 22-34.

Kellner, S. (1979). *Taking it to the limit with basketball cybernetics*. New York, NY: Durite Printing.

Klimesch, W. (1999). EEG alpha and theta oscillations reflect cognitive and memory performance: A review and analysis. *Brain Research Reviews, 29*(2-3), 169-195.

Knudstrup, M., Segrest, S. L., & Hurley, A. E. (2003). The use of mental imagery in the simulated employment interview situation. *Journal of Managerial Psychology, 18*(6), 573-591.

Kosslyn, S. M., & Moulton, S. T. (2008). 3 mental imagery and implicit memory. *Handbook of Imagination and Mental Simulation,* , 35.

Kosslyn, S. M., Thompson, W. L., Wraga, M., & Alpert, N. M. (2001). Imagining rotation by endogenous versus exogenous forces: Distinct neural mechanisms. *Neuroreport, 12*(11), 2519.

Lang, P. J. (2007). A bio-informational theory of emotional imagery. *Psychophysiology, 16*(6), 495-512.

Lejeune, M., Decker, C., & Sanchez, X. (1994). Mental rehearsal in table tennis performance. *Perceptual and Motor Skills, 79*(1 Pt 2), 627-641.

Marks, D. F., & Isaac, A. R. (1995). Topographical distribution of EEG activity accompanying visual and motor imagery in vivid and non-vivid imagers. *British Journal of Psychology(1953), 86*(2), 271-282.

Marks, D.F., Uemura, K., Tatsuno, J., & Imamura, Y. (1985). EEG topographical analysis of imagery. In J. McGaugh (Ed.), *Contemporary Psychology: Biological Processes and Theoretical Issues*, 211-223, Amsterdam: Elsevier.

Martin, K. A., & Hall, C. R. (1995). Using mental imagery to enhance intrinsic motivation. *Journal of Sport and Exercise Psychology, 17,* 54-54.

Moulton, S. T., & Kosslyn, S. M. (2009). Imagining predictions: Mental imagery as mental emulation. *Philosophical Transactions of the Royal Society B: Biological Sciences*, *364*(1521), 1273.

Murphy, S., Jowdy, D., & Durtschi, S. (1990). *Report on the U.S. Olypic Committee survey on imagery use in sport.* Colorado Springs, CO: U.S. Olympic Training Center.

Neisser, U. (1967). *Cognitive psychology* Prentice-Hall Englewood Cliffs, NJ.

Neuper, C., Scherer, R., Reiner, M., & Pfurtscheller, G. (2005). Imagery of motor actions: Differential effects of kinesthetic and visual–motor mode of imagery in single-trial EEG. *Cognitive Brain Research*, *25*(3), 668-677.

Ozel, S., Larue, J., & Molinaro, C. (2004). Relation between sport and spatial imagery: Comparison of three groups of participants. *The Journal of Psychology: Interdisciplinary and Applied*, *138*(1), 49-64.

Prather, D. C. (1973). Prompted mental practice as a flight simulator. *Journal of Applied Psychology*, *57*(3), 353-355.

Robin, N., Dominique, L., Toussaint, L., Blandin, Y., Guillot, A., & Le Her, M. (2007). Effects of motor imagery training on service return accuracy in tennis: The role of imagery ability. *USEP, 2*, 175-186.

Rodgers, W., Hall, C., & Buckolz, E. (1991). The effect of an imagery training program on imagery ability, imagery use, and figure skating performance. *Journal of Applied Sport Psychology, 3*(2), 109-125.

Salmon, J., Hall, C., & Haslam, I. (1994). The use of imagery by soccer players. *Journal of Applied Sport Psychology, 6*(1), 116-133.

Sanders, C. W., Sadoski, M., Bramson, R., Wiprud, R., & Van Walsum, K. (2004). Comparing the effects of physical practice and mental imagery rehearsal on learning basic surgical skills by medical students. *American Journal of Obstetrics and Gynecology, 191*(5), 1811-1814.

Shoenfelt, E. L., & Griffith, A. U. (2008). Evaluation of a mental skills program for serving for an intercollegiate volleyball team. *Perceptual and Motor Skills, 107*(1), 293-306.

Short, S. E., Afremow, J., & Overby, L. (2001). Using mental imagery to enhance children's motor performance. *JOPERD--the Journal of Physical Education, Recreation & Dance, 72*(2).

Spittle, M., & Morris, T. (2007). Internal and external imagery perspective measurement and use in imagining open and closed sports skills: An exploratory study. *Perceptual and Motor Skills, 104*(2), 387-404.

Suinn, R. M. (1972). Behavior rehearsal training for ski racers. *Behavior Therapy, 3*, 519.

Suinn, R. M. (1976). Body thinking: Psychology for olympic champs. *Psychology Today,* (July), 38-43.

Theiler, A. M., & Lippman, L. G. (1995). Effects of mental practice and modeling on guitar and vocal performance. *Journal of General Psychology, 122*(4), 329-344.

Ungerleider, S., & Golding, J. M. (1991). Mental practice among olympic athletes. *Perceptual and Motor Skills, 72*(3), 1007-1017.

Washburn, M. F. (1973). *Movement and mental imagery* Arno Pr.

Wohldmann, E. L., Healy, A. F., & Bourne, L. E. (2008). *A mental practice superiority effect: Less retroactive interference and more transfer than physical practice.*

Woolfolk, R. L., Parrish, M. W., & Murphy, S. M. (1985). The effects of positive and negative imagery on motor skill performance. *Cognitive Therapy and Research, 9*(3), 335-341.

Wrisberg, C.A.,& Ragsdale,M.R. (1979). Cognitive demand and practice level: Factors in the mental rehearsal of motor skills. *Journal of Human Movement Studies, 5*, 201-208.

Yue, G., & Cole, K. J. (1992). Strength increases from the motor program: Comparison of training with maximal voluntary and imagined muscle contractions. *Journal of Neurophysiology*, *67*(5), 1114.

Appendix A

INFORMED CONSENT FORM

The University of Memphis

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

Principal Investigators: Kate Marshall , 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 EEG pattern between individuals who use visual imagery vs. those use kinesthetic imagery during mental rehearsal. In the study, you will be asked to produce a maximum force on the apparatus first, then, you will listen to a tape that leads you through six general movements and a mental imagery of these movements using either visual or kinesthetic 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 six situations in a soccer game scenario and asked to mentally visualize yourself performing the soccer task, 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 when you go through mental rehearsal of soccer play scenarios.

Minimal risks of your participation would include little discomfort when 3 electrodes 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. 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

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 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 six soccer scenarios. Please try and imagine them as I say them 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 soccer scenarios 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}

"End Baseline"
{Marker - F9}
"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."

"I am now going to present you with six soccer-specific scenarios for you imagine. You may use visual or kinesthetic imagery, which ever came easier to you. 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. 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. 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. Please repeat this image over and over 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. 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. Repeat this image over and over 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 #4: Receiving a Pass and Turning - Imagine receiving a pass from your teammate. After a quick look over your shoulder, you receive the ball with your foot, hooking it around and in front of you so that your hips and shoulders face the entire field. Please repeat this image over and over again until I say 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: 50/50 Ball – Imagine a long ball is played over the top and out into space. It is a 50/50 ball and you take off in a sprint. You and your opponent are running neck and neck, but you gain one step ahead of them. You get there first and win possession of the ball. Please repeat this image in your head over and over again 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: Jumping and Heading – Imagine the opposing goalkeeper just punted the ball, you have a man on your back, you see the ball coming to you and you jump in the air to try to win the ball. Please repeat this image in your head over and over again 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 C

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 D

Name: ______________________

Date: ______________

Gender: M F

<u>Rating Scale</u>
<u>Soccer Scenarios</u>

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	RATING
#1) Penalty Kick Shooting	
#2) Trapping	
#3) Through Pass	
#4) Receiving, Turning & Passing	
#5) 50/50 Ball	
#6) Jumping & Heading	

*Self – Report:

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

Kinesthetic **Visual** **Neither**