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Research supports the use of mental imagery (MI) to increase performance on subsequent motor tasks. Elite athletes, coaches, and sport psychologists agree that MI is effective in positively influencing performance. Recent neuroscience research has established that there is functional equivalence in brain structures when using MI to imagine executing a task and physically executing the same task. To maximize functional equivalence in a MI intervention, Holmes and Collins (2001) introduced the PETTLEP model of MI. Despite overwhelming evidence for the effectiveness of PETTLEP MI, little is known about the optimal time-of-day to practice MI to influence subsequent performance to the highest degree. This study assesses the best time-of-day to use PETTLEP MI to maximize performance in a dart throwing task. Participants for this study included (n=30) undergraduate students that received a one session PETTLEP MI intervention immediately prior to the task (preparatory MI) or 12 hours prior to the task, including 8 hours of nighttime sleep. Data was collected by totaling scores on the dart throwing task based on accuracy and consistency. Baseline scores were compared to post-intervention test scores.

The results of a repeated-measures analysis of variance (ANOVA) for dart throwing performance indicated no significant improvement in accuracy ($p > .05$) or consistency ($p > .05$) following the PETTLEP MI intervention. Further analysis revealed no significant dart throwing improvement for accuracy ($p > .05$) or consistency ($p > .05$) based on the timing of PETTLEP MI intervention, indicating no difference in the change from pre-test to post-test between preparatory and consolidation PETTLEP MI groups. These findings suggest that a single session PETTLEP MI intervention for dart throwing is not sufficient to see performance improvements. Although

significant results were not found, future PETTLEP MI interventions should consider the use of additional PETTLEP training sessions, the inclusion of skilled performers doing a task they are familiar with, and assessing sleep characteristics, as participants in the current study were found to be poor and disordered sleepers.

OPTIMAL TIMING OF A PETTLEP MENTAL IMAGERY INTERVENTION ON A DART THROWING TASK

by

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Approved by

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Committee Chair

To my parents Tom and Mary, sister Lori, and wife Ana-Maria for their guidance and support.

APPROVAL PAGE

This thesis has been approved by the following committee of the Faculty of The Graduate School at The University of North Carolina at Greensboro.

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CHAPTER I

INTRODUCTION

Mental imagery (MI) has been found to produce improvements in motor skills (Driskell, Copper, & Moran, 1994; Feltz & Landers, 1983; Weinberg, 2008) and is one of the most widely used performance enhancement techniques employed by athletes and sport psychologists (Orlick & Partington, 1988; Vealey, 1994). Recent neuroscience imaging research has begun to answer questions related to maximizing the performance benefits of MI. A number of neuroscience studies have utilized fMRI and PET neuroimaging techniques to provide evidence of an overlap of active brain regions when participants perform a motor task or use MI to recreate the same motor task (Decety et al., 1994; Gerardin et al., 2000; Guillot et al., 2008a; Lotze & Halsband, 2006). This overlap, termed functional equivalence (Decety, 1996), guided Holmes and Collins (2001) to develop the PETTLEP model of MI. This model of MI is designed specifically to maximize functional equivalence by emphasizing the seven components of PETTLEP (Physical, Environment, Task, Timing, Learning, Emotion, and Perspective). Initial research utilizing the PETTLEP model has found it to be highly effective in producing performance gains. For example, Smith et al. (2007) found that performance improved in a dose-response fashion as more aspects of the PETTLEP model were incorporated into the six week MI training intervention for a field hockey shot task. Other research has found PETTLEP MI to be as effective as physical practice (PP) (Smith et al., 2007, 2008; Wright & Smith, 2007) and to be superior to traditional MI (Wright & Smith, 2007) in producing performance gains over the course of a six week intervention.

Preparatory MI refers to the performance of MI immediately prior to task performance. Several studies have found traditional, one session preparatory MI to be effective in producing performance gains with little practice of the actual task. Perkins, Wilson, and Kerr (2001) utilized a preparatory MI intervention and found a significant gain in a laboratory grip strength task. Similar results have been found for muscular endurance (Lee, 1990) and golf putting (Murphy & Woolfolk, 1987). Malouffe (2008) used a tennis serve task and found that preparatory MI benefited subsequent performance when assessed in terms of accuracy. Conversely, some studies indicate that preparatory MI interventions have no effect on subsequent performance (Nordin & Cumming, 2005; Taylor & Shaw, 2002). Due to the inconsistent results concerning preparatory MI, future research is necessary concerning additional variables that might influence the effects of MI on performance. One intriguing variable to consider is the timing of the MI relative to performance.

The benefits of sleep on the learning of a motor task have been well documented over the past several decades. Researchers believe a process known as consolidation protects newly learned information from the interference of other competing sensory information. Benson and Feinberg (1977) found that participants who slept for 8 hours shortly following learning of a paired-associate word list exhibited a significantly higher level of recall and less temporal fluctuation over a 24 hour period, when compared with a group that was awake for 16 hours and then slept for 8 hours following learning. Fischer et al. (2002) used a finger tapping motor task to evaluate the impact of sleep and sleep deprivation following learning. Participants who slept for 8 hours following learning increased accuracy and speed of execution at retest, compared to the sleep deprived group. Korman et al. (2007) found similar performance benefits on a finger tapping task for a short sleep (a nap) lasting only 90 minutes when compared to a non-sleeping group. Walker et al. (2004) published a timeline of the process of stabilization and consolidation that is thought to occur following the learning of a finger tapping task. According to this timeline, the most essential stage for increased performance occurs during the first session of overnight sleep following learning. This period is known as the enhancement stage of consolidation and has been found to produce increased speed and accuracy in a finger tapping task. Karni et al. (1994) found that consolidation is dependent upon achieving REM sleep stages following learning, as REM deprived participants did not improve on a visual discrimination task based on pre-test to post-test scores. Gais et al. (2000) found that late stage sleep alone is not enough to influence the consolidation of learned information and experiencing all stages of sleep is essential to achieve performance improvements in a texture task. Given these findings for tasks that require learning of a novel skill, researchers have become interested in understanding the potential role of sleep in the consolidation of the benefits of a MI session.

Debarnot et al. (2009) compared traditional MI, PP, and control groups to evaluate the role of sleep in producing performance gains in a pointing task. Following a pre-test to establish a baseline performance score, traditional MI and PP groups received their assigned training condition followed by an initial post-test (post-test 1). Results indicated that both MI and PP groups performed at a higher level following training, as compared to pre-test scores. Following post-test 1, participants in both groups slept for 8 hours and returned for a second post-test (post-test 2). Results indicated that the PP group did not improve their performance following sleep, but the traditional MI group showed a further increase in speed and accuracy on the pointing task. Results thus suggest that sleep served to further consolidate the learning that occurred for the traditional MI group, but did not confer any additional benefits for the PP or control groups.

Purpose and Hypothesis

When attempting to establish an optimal time-of-day to use MI to maximize performance, several possibilities emerge. Research partially supports precompetitive traditional MI and its benefits on motor performance (Cohn, 1990; Murphy & Woolfolk, 1987; Perkins et al., 2001; Malouffe et al., 2008), and precompetitive PETTLEP MI prior to performance of a cognitive task (Wright & Smith, 2007). Research also supports that the consolidation of MI with sleep benefits subsequent performance (Debarnot et al., 2009). However, research comparing preparatory imagery and imagery delivered prior to sleep is necessary to establish the optimal time-of-day to practice MI. Also, attention must be directed to examining sleep as the crucial mediator between MI and performance gains, as periods of sleep as short as 90 minutes have been found to influence subsequent performance (Korman et al., 2007).

The purpose of this study is to determine the effects of sleep on the efficacy of a PETTLEP MI intervention. It is hypothesized that PETTLEP MI administered prior to sleep will yield the most benefits for performance. The rationale for this belief lies in the consolidation effects resulting from a period of sleep. The effects of a PETTLEP MI intervention prior to sleep and the consolidation of images and memory that take place during sleep are expected to outweigh the positive effects of PETTLEP MI delivered immediately prior to the task during the preparatory MI condition.

CHAPTER II

LITERATURE REVIEW

Use and Support of MI

Mental imagery (MI) is a dynamic state during which an individual simulates the performance of a specific motor task mentally, without any body movement (Decety, 1996). The effects of MI on performance are widely supported throughout the sport and exercise science literature. For instance, it is well documented that imagery can significantly enhance the performance of motor skills (Driskell, Copper, & Moran, 1994; Feltz & Landers, 1983, Weinberg, 2008). Further, MI is the most common mental skill used by sport psychologists and their athletes as a performance enhancement technique (Orlick & Partington, 1988; Vealey, 1994). According to coaches, imagery is the most useful mental skill a player can use and is employed more than any other mental training technique (Hall & Rodgers, 1989). As of 2008, there have been over 200 studies that have tested the effects of MI on performance (Weinberg, 2008). Athletes at all levels use imagery for a variety of cognitive and motivational reasons, and elite athletes use imagery more extensively and systematically than non-elite athletes (Hall, Rodgers, & Barr, 1990). As of the 1988 Olympic Games in Seoul, Korea, 86% of sport psychology consultants used imagery with their clients (Gould, et al., 1989). MI of a successful performance outcome boosts self-efficacy in a task and can positively influence subsequent competition performance (Mamassis & Doganis, 2004). MI has been used in a variety of settings to produce performance gains associated with learning a new skill (Denis, 1985), practice between competitions (Feltz & Landers, 1983), and as a precompetitive primer for the upcoming competition (Cohn, 1990; Wright & Smith, 2007; Malouff, 2008). Despite over a century of imagery research, the method of delivery to optimize sport performance remains highly variable and controversial (Murphy, 1994; Weinberg 2008; Weinberg, Seabourne, & Jackson, 1981).

In the motor learning literature, MI is considered a reliable complement to PP in enhancing cognitive and motor performance. Accordingly, the effects of MI on the improvement of motor skill learning are now well-established (Feltz & Landers, 1983; Guillot et al., 2008; Weinberg, 2008). In a meta-analysis by Feltz and Landers (1983) a total of 60 studies yielding 146 effect sizes were found to produce an overall effect size of 0.48, indicating that MI produced effects on performance better than no practice at all. Feltz and Landers (1983) also evaluated variables moderating the performance benefits of a MI intervention and found that more experienced athletes show greater gains in performance following MI.

Theories of MI

A variety of imagery applications have been examined and shown to be successful in increasing performance. Although the positive effects of an imagery intervention are accepted, there are several rivaling theories that attempt to explain these performance gains. In 1931, Jacobson, the pioneer of the Psychoneuromuscular Theory, found that as an athlete engages in sport movements the brain transmits impulses to the muscles to execute the movements (Jacobson, 1931). According to the Psychoneuromuscular Theory of MI, imagery produces similar impulses in the absence of the execution of the movements (Jacobson, 1931). Perhaps the most interesting and applicable experiment to support this theory involved a study of downhill skiers. Printed EMG output of skiers' muscle firings during an imagery session of an imagined downhill race were found to match the terrain of the ski run. Participant's muscle firings corresponded to times during the race when greater muscle contraction was necessary (Suinn, 1980).

An alternative theory, the Symbolic Learning Theory asserts that MI creates a coding system or mental blueprint that is used to provide a framework to make future actions automatic. Sackett, the pioneer of this theory, asserts that movements are symbolic components of a task that an athlete rehearses (Sackett, 1934). For example, MI rehearsal can help a figure skater become familiar with spatial and temporal elements involved in executing a routine which then facilitates the athlete's ability to link these actions together. This theory has been supported by research findings asserting that the use of MI produced greater improvement on movement tasks that require cognitive coding as opposed to pure motor tasks, like weightlifting (Feltz & Landers, 1983).

A third rationale of how MI serves to influence performance is the Bioinformational Theory. According to this theory, a mental image is an organized set of characteristics stored in long term memory. During MI, stimulus characteristics are used to describe the situational aspects of the environment. Response characteristics are also stored to describe the necessary response to the situation that is imagined (Lang, 1979). In support of this theory, research has indicated that experienced athletes benefit more from imagery than do novices (Feltz & Landers, 1983; Issac, 1992). According to the Bioinformational Theory, experienced athletes have a network of successful responses stored in memory that they can activate during MI which leads to increased performance following the use of MI (Feltz & Landers, 1983).

These theories are clearly supportive of the idea that MI can benefit performance on a physical task. The first theory, Psychoneuromuscular Theory (Jacobson, 1931), speaks to the mechanisms inside the brain that trigger muscular response and the ability of MI to trigger the same response as does physical activity. Symbolic Learning Theory (Sackett, 1934), on the other hand, follows a cognitive framework of information coding and learning. The last theory, Bioinformational Theory (Lang, 1979), takes a behavioral view of activating stored environmental and stimulus responses in order to better perform a task.

PETTLEP MI

Despite decades of research documenting the benefits of MI interventions, researchers and practitioners continue to work to develop a MI intervention model that addresses important variables known to influence the efficacy of the intervention (Holmes & Collins, 2001; Keil, Holmes, Bennett, Davids, & Smith, 2000). To address this issue and provide a more streamlined and consistent version of a MI intervention, Holmes and Collins (2001) developed the PETTLEP method of MI.

The PETTLEP model of MI was introduced based on neuroscience research indicating a significant overlap in active regions of the brain during MI of a motor movement and the actual execution of the same movement (Holmes & Collins, 2001). Neuroimaging techniques including functional magnetic resonance imaging (fMRI) and positron emission tomography (PET) have provided detailed illustrations of the areas of the brain that are activated when mentally imaging a motor movement. The brain regions active during MI are then compared to the regions that are active during the actual physical performance of the same movement. Results of the brain scan data indicate a significant overlap of brain structures that are active during PP and MI (Ganis et al., 2004). Kosslyn, Ganis, and Thompson (2001) state that using MI to simulate movements could facilitate performance by exercising shared brain regions between physical execution and mental imagery. Research from Beisteiner, Hollinger, Lindinger, Lang, and Berthoz (1995) has shown that the more brain regions that are shared between imagery and motor performance; the more beneficial imagery is likely to be in strengthening the neural pathways used during motor performance.

The PETTLEP model of MI (Holmes & Collins, 2001) provides a framework upon which practitioners and researchers can construct an individualized MI intervention. The PETTLEP model emphasizes seven aspects found to influence MI, based on past research. PETTLEP stands for Physical, Environment, Task, Timing, Learning, Emotion, and Perspective. This approach provides a detailed checklist for effective MI use for all participants and attempts to provide functional equivalence between the imaged action and the actual execution of the task. According to Holmes and Collins (2001), in order to achieve functional equivalence through a MI intervention, the seven components of PETTLEP must be emphasized.

The Physical aspect of PETTLEP refers to the participant's physical state during an MI intervention. If MI is most effective when functional equivalence is high, physiological arousal during MI should be equal to that of the competitive task. For example, when providing a MI intervention for a football player, it is important to emphasize reaching a state of arousal that is similar to that at which the athlete performs during competition. Several studies have provided a multimodal intervention that combined MI with relaxation techniques in an effort to decrease arousal. Results showed that the relaxation portion of the intervention was not an essential component in the performance increases observed as a result of the MI interventions (Conroy, 1997; Gray, Haring, & Banks, 1984). Although relaxation is not a necessary component of a MI intervention, it might be important for tasks such as target shooting which would be more functionally equivalent if the athletes were in a relaxed state.

The Environment component of MI draws a parallel between the competitive environment and the MI environment. In order to achieve functional equivalence, Holmes and Collins (2001) state that MI should be conducted in a similar environment to the competition. For example, a pitcher should use MI on the elevated clay surface of a pitching mound to increase contextual awareness for the competitive environment. In support of this component of the model, Smith et al. (2007) found that gymnasts and field hockey players performed better after a MI intervention performed in the same environment as the competition.

According to the Task portion of the PETTLEP model of MI, participants are more likely to achieve positive results when using imagery if the script is personalized to simulate their own experiences (Holmes & Collins, 2001). The process of creating a personalized imagery script includes a procedure known as response training, introduced by Lang, Kozak, Miller, Levin, and McLean (1980). The PETTLEP model of MI is designed to increase functional equivalence by attempting to mentally recreate the conditions that the motor task is executed under and an individual's physiological responses to these challenges. For example, a basketball player may include a detailed description of the anxious butterflies in his stomach prior to a competition or the feeling of rubbery legs that he experiences in the fourth quarter of a game. PETTLEP MI scripts differ from traditional interventions by incorporating an individual's kinesthetic description of the motor task, whereas traditional scripts primarily focus on what the participant sees during the task.

The delivery method or modality of an imagery intervention has also been found to affect the outcome of the performance. Hale (1994) acknowledges that the modality should present the participant with an imagery experience that is realistic and employs the motor representation as fully as possible. In the past, written scripts were the primary modality used by sport performance consultants in their work with athletes. More recently, researchers and consultants have begun to explore using audio and video modalities in their imagery interventions. Smith and Holmes (2004) compared three imagery modalities in a golf putting task. Forty male participants (mean age = 25.3 years, SD=6.45) were chosen and randomly placed in one of four groups: video imagery, audio imagery, written script, or reading control group. The purpose of this study was to compare the delivery method of a MI script and assess the impact of the modality on golf putting performance. The audio and video scripts were equally effective in producing performance gains in the golf putting task based on a comparison of pretest to posttest scores. The written script group performed the same task at a lower level of success than both the audio and video groups. This study suggests a greater auditory functional equivalence was produced by using an individualized audio or video recorded script in a golf putting task when compared to traditional, written MI scripts (Smith & Holmes, 2004).

The Timing component of PETTLEP has been found to contribute to the efficacy of a MI intervention. Several studies have evaluated performance benefits of using real-time and slow motion MI to complete a task (Whetstone, 1995; Weinberg & Gould, 2003; Andre & Means, 1986), with results showing that real-time MI interventions are most beneficial to increase performance.

The Learning aspect of the model states that researchers and practitioners account for learning changes that occur over time. As experience increases throughout the execution of a task, the physiological and kinesthetic sensations of the participant may change. Holmes and Collins (2001) argue that the MI script must be modified based on the participant's individual physiological responses to create the highest rate of functional equivalence.

The Emotion portion of the PETTLEP model has been found to be a vital element in achieving enhanced performance through a MI intervention. Botterill (1997) referred to emotion as the missing link in MI interventions. In order for memory strengthening to occur, a performer must attach accurate and meaningful emotion to their MI. Lang's Bioinformational Theory (1985) emphasizes the importance of using emotionally meaningful MI. In order for a performer to incorporate meaningful emotions, physiological and kinesthetic sensations during the execution of the task should be documented. For example, the jittery feeling that is experienced minutes before the start of a race should be included in the PETTLEP MI script. However, it is important to always frame the emotions as positive, as negative emotions can counteract the benefits of MI on performance.

The Perspective component refers to the way in which MI is viewed by the participant during rehearsal. A first person or internal perspective for MI is executed as if the participant were seeing it through his/her own eyes. A third person or external perspective is used by performers as if they were watching a video of themselves perform. Holmes and Collins (2001) emphasize using a combination of both internal and external MI perspectives to achieve optimal functional equivalence.

Smith et al. (2007) conducted two studies involving the use of PETTLEP imagery. The first study utilized a field hockey shot task involving 48 participants (24 male, 24 female, mean age = 20.37 years, SD=3.26). The intervention took place daily, over a six week period. Participants were randomly assigned to one of four groups: sport specific MI, clothing MI, traditional MI, and control group. The sport specific MI group completed their MI intervention while wearing their game uniform and standing on their home field. The clothing MI group completed their MI intervention at their place of residence while wearing their uniform in a standing position. The traditional MI group completed their intervention from their own residence, wearing everyday clothes, in a seated position. The control group spent an equal amount of time reading field hockey literature. Results indicated that the sport specific MI group performed better at the field hockey shot task than clothing MI, traditional MI, and control groups. Results were interpreted as evidence that as more components of the acronym PETTLEP were introduced, the impact on performance increased.

The second study of the same publication by Smith et al. (2007) involved the use of PETTLEP MI in a balance beam task. Forty female gymnasts between the ages of 7 and 14 (mean age = 10.1 years, SD=1.81) were recruited from a local gymnastics club. Participants were randomly assigned to one of four groups: physical practice (PP), PETTLEP MI, traditional MI, and control. Participants in the PETTLEP imagery group dressed in sport clothing, used imagery in a competitive environment where they typically performed, used an internal (first person) perspective, and involved multi-sensory information. Those in the traditional MI group received stimulus training which emphasized characteristics of the visual environment, with no kinesthetic sensations included. All members in the traditional MI group included similar stimulus characteristics to describe the task and had their scripts tailored to match the length of the PETTLEP MI group. The traditional MI group performed their intervention at their residence, in regular clothing. Although some aspects of the PETTLEP model were also used by the traditional MI intervention group (Timing & Perspective), a comprehensive PETTLEP MI intervention was only used by the PETTLEP MI group. Participants were asked to complete their MI intervention three times per week for 3-5 minutes for the six week study. The PP group practiced the task three times per week for 3-5 minutes over the six week intervention. The PETTLEP MI and PP groups showed greater improvement from pre-test to post-test than the traditional MI group which improved more than the control group. Smith et al. (2007) found that when using PETTLEP imagery, performance was equal between the physical practice only group and the MI only group. This indicates the importance of identically reproducing the competitive experience in order to maximize imagery transfer to subsequent performances and identifies PETTLEP imagery as the most effective delivery method for facilitating increased performance.

Smith et al. (2008) compared PETTLEP MI + Physical Practice (PP), PETTLEP alone, PP alone, and control groups in a golf bunker shot task. Each group practiced two times per week for six weeks. The PETTLEP group received one session of PETTLEP MI and one PP session. PETTLEP alone and PP alone received two sessions per week of their respective treatment. The control group read a Jack Nicklaus golf book twice a week. Results of the study indicated that the

PETTLEP MI + PP group produced the greatest increase in performance, but PP and PETTLEP MI group were equal in their performance increase from pre to post test, and all groups improved more than the control group.

Wright and Smith (2007) utilized a one session pre-performance PETTLEP imagery intervention on a cognitive task that lasted forty five minutes. They compared PETTLEP MI to traditional MI and PP to assess the effectiveness of the three interventions on a racing video game task. As the intervention was carried out immediately prior to performance, implications may be apparent for the use of PETTLEP imagery as part of a pre-performance routine. Eighty undergraduate students (Mean age=20.0, SD=3) completed the MIQ-R as a screening method to assess their ability to formulate and control mental images. Participants were randomly assigned to one of four groups. Following the pre-test practice session that included three trials of the racing game, the PETTLEP group received response training. Response training (Lang, Kozak, Miller, Levin & McLean, 1980) prompts participants as to their specific individualized feelings during MI. For example, a participant's nervousness and anticipation about an upcoming sharp turn in the race track would be emphasized. The use of response training created individualized imagery scripts for each participant, which has been emphasized by Holmes and Collins (2001) as being essential to the PETTLEP model of MI. The traditional MI group received stimulus training, which focuses on the stimuli (what they see) and not the individual responses to the situation (what they feel). The PETTLEP group sat at the computer where the pre-test was conducted, heard music from the videogame, touched the keyboard, imaged at real-time speed, and involved all applicable emotions they would experience while playing the game. The PETTLEP group practiced MI for forty five minutes, with a break in between each lap around the track. The traditional imagery group received a brief relaxation session. Participants then sat in a comfortable chair and were instructed to close their eyes and practice MI for forty five minutes, with breaks in between each lap. Although some aspects of the traditional imagery group were similar to the PETTLEP group, it was less strongly based on the aspects of PETTLEP. The PP group completed forty-five minutes of practice on the same computer as the pre-test. The control group received a placebo treatment in which they completed concentration grids for forty-five minutes. All participants then completed the post test in which 5 laps were averaged to arrive at the mean score for their racing performance. Results indicated that the PETTLEP intervention was more effective than the traditional MI intervention from pre-test to post-test. Also, the PP group did improve from pre-test to post-test, but not significantly better then the PETTLEP group. The implications of this finding translate well into the sporting realm, as PETTLEP interventions have been shown to be a more suitable substitute for PP. Perhaps the most unexpected and intriguing finding of this research involves the retention test completed 3 weeks following the intervention to evaluate the lasting effects of the intervention. The PETTLEP group was the only group that showed that skills can be maintained over a three week period, as compared to PP, traditional MI, and control groups. Although the findings were not statistically significant, the PETTLEP imagery group continued to show a performance improvement, whereas the PP and traditional MI groups did not.

Wakefield and Smith (2009) examined the optimal frequency of using a PETTLEP MI intervention to increase performance in a handball accuracy task. Groups of eight participants each were randomly assigned to a group that practiced PETTLEP MI one-time, two-times, or three-times per week over the course of four weeks. Results indicated that the group that practiced MI three-times per week performed at a higher level than the one or two-times per week groups, although all three groups showed improvement from pre-test to post-test. While results indicate that a higher frequency of MI is beneficial to improve performance, the volume of MI trials should have been examined. For example, one performer may complete PETTLEP MI three-times per week, including twenty trials of the task during each session for a total of sixty trials per week. Another performer may use PETTLEP MI for sixty trials, only once per week to reach the same volume of MI. The volume of imaged content has yet to be examined in addition to other aspects of the dose-response relationship when administering a PETTLEP MI intervention. Wakefield and Smith (2009) urge future researchers utilizing a PETTLEP model of MI to examine all aspects of the dose-response relationship.

Timing of a MI Intervention

Preparatory imagery is defined as MI that is used immediately prior to a task (Murphy & Joudy, 1992). Gould, Weinberg and Jackson (1980) found that athletes typically utilized MI immediately prior to competition as a precompetitive “psych up”. For example, before Mark McGuire would step into the on-deck circle to prepare for an at-bat, he would stand in the dugout with his bat over his shoulder, eyes closed, imaging his subsequent at-bat. He would incorporate the pitcher on the mound, any previous at-bats in which they may have faced each other, details from the scouting report, and environmental cues in this brief, self-induced imagery session.

Reviews by Murphy and Jowdy (1992) and Gould, Damarjian, and Greenleaf (2002) examine the impact of preparatory MI immediately before a motor task with some studies showing positive effects and others not. Recent research on traditional forms of preparatory MI has not yielded significant positive results. In one recent study involving a dart throwing task with novices, self-instructional imagery and imagery with positive outcomes did not lead to significantly better performance than a control condition that involved counting backwards by 7s from a specific large number (Nordin & Cumming, 2005). According to a review by Weinberg (2008), MI has been found to be effective in the laboratory setting with little practice if the performance immediately follows the session of MI. Perkins, Wilson, and Kerr (2001) found that a brief MI intervention prior to a laboratory grip strength task increased performance on subsequent efforts. Brief MI interventions have also shown positive results in a muscular endurance task (Lee, 1990) and in a golf putting task (Murphy & Woolfolk, 1987). In a laboratory putting task 51 participants were randomly assigned to positive imagery, negative imagery, or putting as usual control groups. The positive MI group imaged a successful outcome (making the put) while the negative MI group imaged an unsuccessful attempt (missing the put). The positive MI group performed better than the negative MI group, but did not differ from the control group (Taylor & Shaw, 2002). Thus, the impact of a preparatory MI intervention should be studied further in an effort to better understand performance benefits associated with the specific timing of a MI intervention.

Malouffe (2008) conducted a MI intervention study on the benefits on serving accuracy after a traditional preparatory MI session. Participants consisted of one hundred fifteen adults, 61 men and 54 women (mean age 37.68). Participants were divided into three separate groups, pre-serve positive MI, pre-serve self-talk, or control and were asked to execute a tennis serve twenty times (10 deuce court/10 advantage court). Results indicate that pre-serve positive imagery (*d*= .60) and pre-serve self-talk (*d*= .51) were effective methods of performance enhancement. Although research has demonstrated the benefit of using preparatory MI, specifics concerning the dose-response relationship and time-of-day to utilize MI to maximize performance remain unanswered.

Sleep and Consolidation

Research in the field of motor learning and sport and exercise science have demonstrated the benefit of sleep on learning. Sleep is known to influence recall and retention of learned material through a process known as consolidation. Muller and Piltzecker (1900) introduced the memory consolidation hypothesis stating that recently learned information can be lost due to interference by the presentation of new information. They suggested that processes underlying new memories initially persist in a fragile state and consolidate over time. Consolidation is defined as a process whereby a memory becomes increasingly resistant to interference from competing or disrupting factors with the continued passage of time (McGaugh, 2000).

Benson and Feinberg (1977) utilized a Jenkins and Dallenbach paradigm and used a paired-associate list to test the participants (n=60) on the effect sleep has on learning. A Jenkins and Dallenbach paradigm compares the recall scores of two groups of subjects, a sleep group and a wake group. The sleep condition group learns at night, followed by 8 hrs of sleep. Participants are then tested for recall at 24, 48, or 72 hrs after original learning. The waking condition group learns in the morning and stays awake for 16 hrs, followed by 8 hrs of sleep. They are tested for recall also at multiples of 24 hrs. The amount of sleep and wakefulness are equal for both groups, but differ in the sequence of sleeping and waking relative to the timing of learning information. Participants who experienced a period of sleep shortly after learning were found to demonstrate a higher level of recall and less temporal fluctuation over a 24 hour period than that which occurs when a period of waking follows original learning (Benson & Feinberg, 1977).

Fischer et al. (2002) utilized an index finger-to-thumb opposition finger tapping task to evaluate the impact of sleep and sleep deprivation on performance. Participants (n=20) were trained in the task at 10:00p.m. before an 8 hour period during which participants either slept or stayed awake. Both groups were then retested at 7:30a.m., thirty minutes after wakeup for the sleeping group. Results indicated that sleep after practicing a finger tapping task increased accuracy and speed at retest when compared to the sleep deprived group.

Korman et al. (2007) utilized a finger tapping task to study the impact of a 90 minute nap on learning and memory. Stabilization occurs when a new memory trace is converted to a memory that is resistant to interference. Results indicated that stabilization in the performance of a finger tapping task was seen in the daytime nap group (90 minutes), who slept following initial learning and prior to learning a new finger tapping sequence. Participants were then retested 24 hours later and results indicated that the nap group performed better than the non-nap group. Korman et al. believe that the 90 minute nap stabilized or protected the tapping sequence memory trace from the interference of leaning a new tapping sequence.

Walker et al. (2004) proposed a detailed timeline of the stabilization and consolidation of a motor memory following initial training in a series of finger tapping sequences. Following initial training, the finger tapping sequence is learned, which leads to performance improvements in subsequent trials. Between 10 minutes and 6 hours following initial training (with no sleep), the learned task memory undergoes the first stabilization phase of consolidation which makes it resistant to interference from other memory traces. During the first night of sleep following training, the enhancement stage of consolidation occurs, which results in speed and accuracy improvements.

Karni et al. (1994) found that memory consolidation is dependent upon REM sleep cycles. Participants (n=6) completed a visual discrimination task after normal sleep or disturbed REM sleep. The normal sleep group improved performance when compared to pre-test levels while the REM sleep deprived group did not show improvement. Gais et al. (2000) found that experiencing all stages of sleep is important to consolidation of a texture task. Participants were divided into three groups, early stage sleep only, late stage sleep only, and full sleep. Participants that experienced all levels of sleep showed improvement in the texture task at the post-test. Participants who were only allowed to experience either early or late stage sleep did not increase performance demonstrating that early and late sleep stages alone are not sufficient to result in memory gains.

Debarnot et al. (2009) examined the role of sleep in learning a novel pointing task. Participants (n=30) were randomly assigned to PP, traditional MI, or a card game control group.

Each group was tested on a pointing task at pre-test, received training (PP, MI, or control), completed post-test 1 prior to sleep, and completed post-test 2 following 8 hours of sleep. Results indicate that the PP and MI groups both improved their performance following training (post-test 1), as compared to pre-test scores. Results further support improved accuracy and speed of execution in a learned pointing task following 8 hours of sleep after using MI, compared to PP and control groups (post-test 2). The PP group stabilized with 8 hours of sleep and did not improve performance on Post-test 2 as compared to the MI group which improved beyond their post-test 1 performance following 8 hours of sleep. Debarnot et al. (2009) found that sleep increased performance on a pointing task more for the MI group than for the PP group. In line with previous research documenting the performance benefits of sleep after PP, results show that similar consolidation processes occur following the use of MI.

In the time since Holmes and Collins (2001) introduced the PETTLEP model of MI, a number of trends have emerged from studies utilizing this procedure. In summary, PETTLEP MI has been found to be equally effective as PP in producing performance gains (Smith et al., 2007; Wright & Smith, 2007; Smith et al., 2008) and when MI is combined with PP, the greatest performance benefits are evident (Smith et al., 2008). The implications of this finding suggest that a session of PETTLEP MI is a reasonable substitute for PP. PETTLEP MI has been found to be effective in increasing performance in a preparatory, one session intervention (Wright & Smith, 2007) as well as over the course of four (Wakefield & Smith, 2009) and six week periods (Smith 2004; Smith et al., 2007; Smith et al., 2008).

As research on PETTLEP MI begins to answer the specifics of what, where, when, and how imagery should be performed, the optimal time-of-day to utilize PETTLEP MI to have a positive effect on performance is yet to be investigated. Although the past research clearly demonstrates the powerful effect that PETTLEP MI has on motor performance, it is still unclear as to the benefit of utilizing a preparatory PETTLEP MI intervention as compared to a pre-sleep PETTLEP MI intervention. With the recent findings of Debarnot et al., (2009) indicating a greater performance benefit for the traditional MI group following 8 hours of sleep than for the PP group, sleep has become an important variable to examine. For that reason, the purpose of the present study is to examine the performance difference in a dart throwing task between a one session pre-performance PETTLEP MI intervention and a one session PETTLEP MI intervention completed prior to night-time sleep.

CHAPTER III

OUTLINE OF PROCEDURES

Participants

Participants consisted of 30 male and female (n=16 and n=14, respectively) undergraduate students. A questionnaire was used to evaluate participant's level of experience in dart-throwing. The students were recruited through cooperation with the faculty of the university's Kinesiology department. Participants received extra credit from their professor for completing the study. Each participant signed an informed consent which included a document stating there was no penalty for dropping out of the study. All procedures were conducted in accordance with the ethical guidelines of the University of North Carolina at Greensboro. Based on results from power analyses, the appropriate number of participants for this study was determined to be fifteen (n=15) per group, with a total of thirty for the entire study (n=30).

Measures

Movement Imagery Questionnaire-Revised. Scores on the Movement Imagery Questionnaire-Revised (MIQ-R; Hall & Martin, 1997) were used to assess a participant's imagery ability. The MIQ-R was used to ensure that participants were capable of performing MI. The MIQ-R is an 8-item questionnaire asking participants to first physically perform a simple movement and then visually or kinesthetically image the movement they just performed. Next, the participants rated the ease or difficulty with which they were able to image. Ratings are on a 7-point Likert scale, ranging from 1 (very hard to see/feel) to 7 (very easy to see/feel). The items were averaged to form a visual and a kinesthetic subscale. Both subscales have acceptable levels of internal reliability. The MIQ-R has been found to have acceptable concurrent validity when correlated with its earlier version, the MIQ, with correlations of -.77, -.77 and -.87 for the visual subscale, kinesthetic subscale, and overall score respectively (Hall &Martin, 1997). Consistent with previous studies utilizing the MIQ-R, an exclusion criterion of 25% total score was used to limit the study participants to those that could form sufficient mental images. No participants were excluded from the current study due to low MIQ-R scores.

Sleep Quality and Quantity. The Pittsburgh Sleep Quality Index (PSQI) (Buysse et al., 1989) was used to assess sleep quality at the pre-test and following the post intervention test. This test was utilized to obtain sleep information regarding disturbances during sleep/wakefulness cycles and to ascertain the participants' predisposition to benefit from a normal night of sleep. The PSQI is a self-rated questionnaire that measures sleep quality and sleep disturbances. The measure includes seven scores including subjective sleep quality, sleep latency, sleep duration, habitual sleep efficiency, sleep disturbances, use of sleeping medication, and daytime dysfunction. The sum of these seven scores produces one global score. The reliability coefficient for the seven component scores of the PSQI was found to be 0.83, indicating a high degree of internal consistency (Buysse et al., 1989). Participants also completed a brief questionnaire that assessed sleep quantity for the previous night.

Performance. Performance was assessed using a dart throwing task. The target consisted of a regulation bristle dartboard with a standard 0.75 cm bull's eye in the center and a 2 foot by 2 foot foam insulation segment surrounding the dartboard. The throwing line was identified with a plastic oche secured to the floor at a regulation distance of 1.828 meters for all participants in the study. The dartboard was placed at standard competition height, 1.727 meters from the floor. Performance on the dart throwing task was scored based on the distance from the center of the bull's eye in millimeters (mm) based on x and y coordinates.

MI intervention script

As discussed earlier, PETTLEP imagery is the most effective method of imagery delivery. Based on findings by Smith et al. (2004), an audio imagery script was used for the current research in place of a traditional imagery script as a method of increasing functional equivalence. In addition to the audio imagery script, participants followed a number of the principles of PETTLEP including listening to the recording in the same room as the dart throwing task, holding a dart, and standing behind the oche where they performed the dart throwing task. The audio script itself was 15 minutes in length. Response training was utilized to develop a MI script that emphasizes kinesthetic sensation associated with completing the dart throwing task. During the introduction to dart throwing session, participants listened to an audio recorded introduction that emphasizes proper dart throwing technique. During the 2 minute audio recording, participants stood in front of the dart board with a dart in their hand and performed the actions described in the recording. Participants were not permitted to throw the dart at this time. Immediately following this brief introduction to the mechanics of dart throwing, participants were allowed 20 practice throws to become familiar with the form described in the recording. Next, participants threw 10 darts to establish a pre-test measure for dart throwing performance. This number of throws was chosen based on recommendations by Van Raalte et al. (1995), who found that participants gained the necessary experience in the task and minimized boredom by avoiding a higher volume of practice throws. Following the pre-test, participants were asked to describe physiological sensations that they experienced while performing the dart throwing task. These responses were used to develop a PETTLEP MI script to be utilized by both of the PETTLEP MI groups.

Procedure

All participants received a PETTLEP MI intervention designed to improve their performance on the dart throwing task. Following the pre-test, participants were randomly assigned to either receive the PETTLEP MI intervention (a) 12 hours prior to the post-test with approximately 8 of those hours being sleep time (consolidated PETTLEP MI) or (b) 15 minutes prior to the post-test (preparatory PETTLEP MI). Post-testing was conducted between 8 a.m. – 11 a.m. for all participants.

Session 1 began approximately 24 hours prior to post-testing. Participants were instructed to come to the lab to complete informed consent, sleep and MI questionnaires, and the pre-test measure of dart throwing performance. After informed consent was signed by each participant, the MIQ-R was administered to determine imaging ability. Any participant with a score below 25% of the total point value on the MIQ-R was identified as not meeting the inclusion criteria and was excluded from the data analysis. However, all participants were allowed to participate until completion of the MI intervention. No participants were excluded from the current study due to low MIQ-R scores. The PSQI was also be filled out at this time to evaluate sleep quality. Sleep quantity was accessed using a simple questionnaire that asked participants to provide details on the amount of sleep they got during the previous night. Researchers briefed each participant as to the purpose of the study (investigating the effects of listening to audio recordings on dart throwing performance). Participants were asked to complete a short questionnaire to assess dart throwing experience and ability. Participants were randomly assigned to one of the two experimental conditions: consolidated PETTLEP MI or preparatory PETTLEP MI.

Participants listened to an audio recording giving brief instructions on correct dart throwing technique to use when completing the task. Following instructions, they were allowed to practice the dart throwing task by executing 20 throws prior to the start of the pre-test. They were informed as to the scoring system and were instructed to aim at the center of the board at all times. Both the pre- and post-test included throwing 10 darts, one at a time. The researchers measured the distance of the dart from the x axis and y axis for each of the 10 throws and recorded this information during each trial. The Pythagorean Theorem was used to measure accuracy by calculating the distance to the bull's eye in millimeters (mm). Consistency of performance was also calculated using bivariate variable error (BVE) to evaluate the clustering of dart throws.

Twelve hours prior to post-testing (between 8 p.m. - 11 p.m.), participants arrived at the research lab to complete session 2 of the study. At this time, the consolidated PETTLEP MI group listened to the 15-minute audio MI script while standing in front of the dartboard with their eyes closed and dart in hand. Following completion of the MI intervention, participants were asked to get a normal night of sleep, abstain from alcoholic beverages, and avoid any physical practice of dart throwing. Participants in the preparatory PETTLEP MI condition were asked to read a magazine for 15 minutes in order to provide equal exposure time for the experimental procedure across all groups.

During session 3 all participants completed the sleep quantity questionnaire to assess sleep characteristics for the previous night. Participants in the consolidated PETTLEP MI condition were asked to read a magazine for 15 minutes prior to the post-test. Participants in the preparatory PETTLEP MI condition listened to the 15-minute audio MI script and then completed the post-test. Each participant was given 10 warm-up throws to practice the technique prior to performing the post-test which consisted of 10 dart throws. Finally, a post-intervention manipulation check was used to evaluate prior experience using MI, level of commitment to the use of MI in the current study, effort in using MI, and if the participant practiced darts physically or mentally overnight.

Data analysis

Mean pre-test and post-test dart throwing scores and their standard deviations provided descriptive information. Four separate 2x2x2 mixed analyses of variance (ANOVAs) with repeated measures on time and with group as a between-subjects factor were used. The third independent variable was the between-subjects factor of sex, MI experience, or PSQI global score.

CHAPTER IV

RESULTS

Questionnaires

Participants average sleep score, as measured by the PSQI was 5.4 (±2.62). Mean MIQ-R scores (SD) were 49.36 (±9.28) out of 56 possible points for all participants. The MI preparatory group mean was 47.3 (±11.14) and the MI consolidation group mean was 51.4 (±12.96), indicating no significant difference between groups, $F(5,11)=2.63$, $p>.05$, $\eta^2= 0.54$. Individual scores on the MIQ-R were all above the threshold to be excluded from the current study.

Based on data collected from the MI manipulation check, all participants refrained from physical practice between baseline and post-intervention tests, as instructed. Eighteen of thirty participants indicated having experience using MI prior to the study. Results from the manipulation check indicate a score of 7.76/10 (±1.81) in effort in following along with the MI audio recording and a 7.63/10 (±2.03) in commitment to the MI intervention during the study. Levels of commitment and effort gathered from the manipulation check indicate a motivated group, overall. Participants indicated no consumption of alcohol between pre and post-test based on responses from sleep quantity questionnaires, as instructed. Results are organized by main effects for time and group and the interaction of time by group followed by the presentation of the main effect for the third between-subjects variable and the interactions that include that between-subjects variable. Results are separated based on accuracy and consistency measures. Accuracy was measured based on X and Y coordinates using Mean Radial Error (MRE) and consistency was measured using Bivariate Variable Error (BVE), as recommended by Hancock et al. (1995).

Accuracy

The main effect for time was not significant, $F(1,26)=0.57$, $p>.05$, $\eta^2= 0.02$. The main effect for group was not significant, $F(1,26)=2.83$, $p>.05$, $\eta^2= 0.10$. There was no significant interaction between the timing of MI intervention (group) and time, $F(1,26)=0.07$, $p>.05$, $\eta^2=0.01$.

Sex

There was a significant main effect for sex, $F(1,26)=21.66$, $p<.05$, $\eta^2= 0.45$, indicating that men performed more accurately ($M=65.19$, $SD=17.45$) than women ($M=99.00$, $SD=30.36$). There was no significant sex by time interaction, $F(1,26)=2.01$, $p>.05$, $\eta^2= 0.07$, nor was there a significant sex by group interaction, $F(1,26)=0.95$, $p>.05$, $\eta^2= 0.04$. Finally, the three-way interaction of sex by group by time was not significant, $F(1,26)=0.65$, $p>.05$, $\eta^2= 0.03$.

MI Experience

There was no main effect for MI experience, $F(1,26)=0.88$, $p>.05$, $\eta^2= 0.03$. There was no significant interaction between MI experience and time, $F(1,26)=1.423$, $p>.05$, $\eta^2= 0.05$, nor was there a significant MI experience by group interaction, $\mathrm{F}(1,26)=0.01$, $p>.05$, $\eta^2= 0.00$. The three way interaction of MI experience by group by time was not significant, $F(1,26)=0.16$, $p>.05$, $\eta^2= 0.01$.

Dart Throwing Experience

There was no main effect for prior dart throwing experience $F(1,26)=0.37$, $p>.05$, $\eta^2= 0.01$, nor was there a significant interaction between dart throwing experience and time , $F(1,26)=0.12$, $p>.05$, $\eta^2= 0.01$. There was no significant dart throwing experience by group interaction, $F(1,26)=.44$, $p>.05$, partial $\eta^2= 0.02$. Finally, the three way interaction of dart experience by group by time was not significant, $F(1,26)=0.02$, $p>.05$, $\eta^2= 0.00$.

PSQI Global Score

There was no main effect for PSQI Global Score, $F(1,26)=0.96$, $p>.05$, $\eta^2= 0.04$.There was no significant interaction between PSQI global score and time , $F(1,26)=.09$, $p>.05$, partial $\eta^2= 0.00$, nor between PSQI global score and group, $F(1,26)=.44$, $p>.05$, partial $\eta^2= 0.02$. Finally, there was no significant PSQI by time by group interaction, $F(1,26)=.16$, $p>.05$, partial $\eta^2= 0.01$.

Consistency

The main effect for time was not found to be significant, $F(1,26)=0.39$, $p>.05$, $\eta^2= 0.02$. There was no significant main effect for group, $F(1,26)=3.69$, $p>.05$, $\eta^2= 0.12$. There was no significant interaction between group and dart throwing performance, $F(1,26)=0.31$, $p>.05$, $\eta^2= 0.01$.

Sex

There was a significant main effect for sex, $F(1,26)=0.00$, $p>.05$, $\eta^2= 0.40$, indicating male participants performed significantly better (M=68.41, SD=19.76) than females (M=98.84, SD=28.08). No significant interaction was found between sex and time, $F(1,26)=1.91$, $p>.05$, $\eta^2= 0.07$, nor was there a significant interaction for sex by group, $F(1,26)=0.04$, $p>.05$, $\eta^2= 0.00$. Finally, the three-way interaction of sex by group by time was not significant, $F(1,26)=0.04$, $p>.05$, $\eta^2= 0.00$.

MI Experience

There was no significant main effect for MI experience, $F(1,26)=1.13$, $p>.05$, $\eta^2= 0.04$. There was no significant interaction between MI experience, and time, $F(1,26)=0.63$, $p>.05$, $\eta^2= 0.02$, nor was there a significant MI experience by group interaction, $F(1,26)=0.06$, $p>.05$, $\eta^2=$

0.00. Finally, there was no significant MI experience by time by group interaction, $F(1,26)=0.15$, $p>.05$, $\eta^2= 0.01$.

Dart Throwing Experience

There was no main effect for dart throwing experience, $F(1,26)=0.47$, $p>.05$, $\eta^2= 0.00$. There was no significant interaction between dart throwing experience, and time, $F(1,26)=1.29$, $p>.05$, $\eta^2= 0.05$. There was no significant dart throwing experience by group interaction, $F(1,26)=0.00$, $p>.05$, $\eta^2= 0.00$. Finally, the three-way interaction of dart throwing experience by group by time was not significant, $F(1,26)=1.30$, $p>.05$, $\eta^2= 0.05$.

PSQI Global Score

There was no significant main effect for PSQI Global Score, $F(1,26)=0.44$, $p>.05$, $\eta^2= 0.02$. There was no significant interaction between PSQI global score and time, $F(1,26)=0.07$, $p >.05$, $\eta^2= 0.00$. There was no significant interaction between PSQI global score and group, $F(1,26)=0.05$, $p >.05$, $\eta^2= 0.00$. Finally, there was no significant interaction between PSQI Global Score, time, and group, $F(1,26)=0.36$, $p >.05$, $\eta^2= 0.01$

CHAPTER V

DISCUSSION

This study was designed to evaluate the impact of a single session PETTLEP MI intervention by comparing two popular times of usage. The researchers were especially concerned with the consolidation of MI following a period of overnight sleep and the impact this would have on dart throwing performance. Based on previous findings of the benefit of sleep consolidation following a single session of MI on a motor task (Debarnot, 2009), it was hypothesized that the consolidation group would outperform the preparatory MI group. The results of the current study do not support the hypotheses. In fact, contrary to previous findings, neither group improved on accuracy or consistency measures following the PETTLEP MI intervention. Secondly, the consolidation group did not improve to a greater extent than the preparatory group. Also, there were no significant interactions with prior MI experience, prior dart throwing experience, or PSQI global score; thus none of these variables impacted the nature of the effect of the MI on subsequent performance. A significant main effect was found for sex, indicating a better performance in both accuracy and consistency measures for male participants. The following discussion outlines considerations that should be made when implementing a PETTLEP MI intervention.

First, there was no significant increase in dart throwing performance from pre-test to post-test. Neither accuracy nor consistency measures improved following the PETTLEP MI intervention. The brief, single session PETTLEP MI intervention utilized to study the consolidation process of MI could explain the results. In the current protocol, a single session intervention was used to insure that the preparatory group did not have the opportunity to sleep overnight following the MI intervention. However, Wakefield and Smith (2009) found PETTLEP MI to be most successful when training sessions occurred at a frequency of three times per week, as compared to once or twice per week. Future researchers interested in studying the consolidation of MI should consider doing several weeks of education and generic PETTLEP MI training prior to applying these skills to a specific task. Previous research has utilized four to six weeks of PETTLEP MI training prior to performance testing (Smith et al., 2007; Smith et al., 2008, Wakefield & Smith, 2009). This longer training period with the PETTLEP MI may be necessary for performance gains to be observed and, hence, may be requisite to further understand how sleep impacts the benefits of a final MI session.

There was also no significant difference in the amount of improvement from pre-test to post-test between the consolidation group and the preparatory group in dart throwing accuracy or consistency. It was hypothesized that the consolidation group would improve to a greater extent than the preparatory MI group due to off-line learning that occurs during a period of overnight sleep. However, another consideration is that in order for memory consolidation to occur, a certain quality of sleep may be necessary. Sleep quality was assessed using the PSQI (Buysse et al., 1989) and indicated a mean global score of 5.4 (±2.62). A PSQI global score over 5 indicates a clinically significant level of poor or disturbed sleep over the past 30 days (Buysse et al., 1989). Perhaps this result is not surprising in a sample of undergraduate students. However, this may have impacted the extent to which sleep consolidated the MI training. Thus, although prior research has demonstrated the benefits of sleep on learning, it may be important to consider an individual's sleep quality characteristics prior to designing and implementing a PETTLEP MI script. If the participant is not receiving the necessary levels of sleep, PETTLEP MI may not be beneficial. Participants in the current study scored above the threshold for poor or disordered sleep.

Dart throwing experience may also have been a factor in the current study, as 8 of 30 participants had never thrown a dart prior to the study. Of the 22 participants who had previous dart throwing experience, only 5 had thrown darts at any point during the month prior to the start of the study. Participant's average score on a self-rated dart skill assessment was 3.76/10 points, indicating an overall poor dart-throwing ability. The lack of dart throwing experience may have created erratic performance from pretest to post-test. Previous research indicates that elite athletes use imagery more extensively, more systematically, and have more imagery skill than less successful and accomplished athletes (Calmels, d'Arippe-Longueville, Fournier, & Soulard, 2003; Salmon, Hall, & Haslam, 1994). Previous research utilizing a PETTLEP MI intervention to study performance evaluated athletes that were active in their sport at the time of the intervention (Smith et al., 2007; Smith et al., 2008). The current study used amateur dart throwers who were inexperienced at the task being performed. Thus, it is certainly possible that the failure to demonstrate improvements in performance as a function of the MI training was more a result of the participant's erratic performance which overshadowed the benefits of the MI. The PETTLEP MI intervention may have increased functional equivalence without improving dart throwing performance amongst novice dart throwers. Perhaps different dimensions of PETTLEP should be emphasized when implementing PETTLEP MI with novices, such as emotional regulation and confidence. Alternatively, it is also possible that a single session of PETTLEP is simply not sufficient to improve the performance of novices attempting a motor task. Future research should consider task expertise as an important factor in performance outcome.

Relatedly, prior experience in physically executing a task may help the performer create a more vivid and controllable mental image that can be used to increase kinesthetic awareness and make fine adjustments in mechanics necessary to get the dart closer to the target. Gregg et al. (2007) found that heptathletes MI was more effective in the events that participants were more experienced executing. When attempting to create mental images of the less familiar events, the heptathletes had trouble replicating the movements due to a lack of knowledge of what it looks and feels like while executing the action. Not only does inexperience physically executing a task impact performance, but it may also lead to less effective MI. Results from the MIQ-R indicate a high ability to form visual and kinesthetic images, with mean scores at 49.36 (±9.28)/56 possible points. The MIQ-R is a self-rated questionnaire that asks participants to perform a series of actions and rate themselves on the ease of visualization and kinesthetic feel. Actions such as jumping and standing on one leg are used to assess imagery ability. Perhaps the MIQ-R is not specific enough for generalizing MI ability to motor tasks which require precise movements and fine adjustments, such as dart throwing, and which the participants are relatively unfamiliar with.

A meta-analysis by Feltz and Landers (1983) indicated the optimal duration of a MI script being less than 1 minute or between 15 and 20 minutes. For this reason, the PETTLEP MI script duration of approximately 15 minutes was utilized for the current study. The form of mental imagery used for the Feltz and Landers (1983) meta-analyses were more traditional forms of MI when compared to the PETTLEP model employed by the authors of the current study. The PETTLEP model asks participants to become more active when performing MI by attempting to recreate various aspects of actual competition. In the case of the current study, we asked participants to hold a dart in their hands while they stood in front of the dartboard and listened to the audio script. Participants were allowed to perform any movements while listening to the PETTLEP MI script, but were not permitted to actually throw the dart at the board. While traditional forms of MI may have asked an individual to sit in a quiet room, focus on their breathing, and read from a written script, PETTLEP MI is a more active form of MI. Considering this, asking individuals to stand in front of the dartboard for 15 minutes while keeping a dart throwing pose may have been created fatigue and loss of interest. Despite efforts to evaluate participant's MI experience through the use of a manipulation check, it is impossible to know if each individual followed along with the PETTLEP MI audio script. Results from the manipulation check indicate a score of 7.76/10 (±1.81) in effort in following along with the MI audio recording and a 7.63/10 (±2.03) in commitment to the MI intervention during the study. Future research using PETTLEP MI should examine optimal duration of a PETTLEP MI session as well as the optimal number of sessions necessary to see enhancements in performance.

Holmes and Collins (2001) recommend individualizing MI scripts as much as possible to allow the imager to relate to every aspect of the script from physiological responses to hitting a bull's eye to the mental focus and self-talk associated with zoning in on the red, circular, bull's eye. The response training used to create the PETTLEP MI scripts was conducted during the pilot study (n=4) and not individualized for each participant. Instead, a combination of the pilot participant's responses was used to create a general PETTLEP MI script. Personalization would be ideal in a consultation role for a mental skills coach or sport psychologist, but the creation of 30 individualized PETTLEP MI for research purposes was not feasible. Future research should consider personalizing scripts as much as possible in order to maximize functional equivalence and increase participant investment.

Future research and field use of PETTLEP MI should consider several important themes highlighted in the current study. A participant or client may be a poor or disordered sleeper which can affect the offline learning process that occurs during sleep. Prior to designing and implementing a PETTLEP MI intervention, an assessment of sleep quality should take place in order to design the most individualized program possible. The benefits of consolidation during sleep have been well documented and future research should continue to test the offline learning of a motor task following PETTLEP MI (for a review see Walker & Stickgold, 2004). When considering the new task, participant experience should be taken into account, as individuals with prior dart throwing experience performed significantly better than novice dart throwers. PETTLEP MI may not be as effective in novice performers that are inconsistent with the task as compared to competitive athletes used in previous research using PETTLEP MI (Smith & Holmes, 2004; Smith et al., 2007; Smith et al., 2008). Ideally, a dose-response study utilizing various durations, frequencies, and schedules of PETTLEP MI interventions should be conducted to answer the elusive question of when and how to practice MI for maximal effectiveness.

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APPENDIX A.

PETTLEP MI SCRIPT

Please get in a relaxed pose, while staying in the form described earlier by the dart throwing lesson. Please take a deep breath in through your nose for a count of three. One… Two… Three… and exhale out of your mouth for a count of six seconds. One… Two… Three… Four… Five… Six. Please repeat this process several times, starting right now. Inhale through your nose again. One… Two… Three. And exhale out of your mouth One… Two… Three… Four… Five… Six. Please continue to use this breathing cadence to get into a calm and relaxed state of mind. Please use this pattern while thinking about the imagery that you are about to perform. One more time in through the nose, One… two… three and then out of the mouth, One… Two… Three… Four… Five… Six. Now notice the relaxed feeling that takes over your body as you exhale and the relaxed state that takes over while breathing deeply. One more time, One… two… three and then out of the mouth, One… Two… Three… Four… Five… Six.

Next, I want you to close your eyes and imagine the dart board that you have been standing in front of since you've been in this room. Colors of black, green, and red make up the board and lines of blue make a cross in the middle of the board. As you think about this, you can picture it as you imagine it in your mind. You can almost reach out and touch it. Imagine yourself in a white painted cement block room with no windows. You can hear the buzz from the florescent lights above as you keep your eyes closed and imagine the room that you are standing in. Remember to breathe along with the cadence, in through your nose, One… Two… Three. Now out of your mouth, One… Two… Three… Four… Five… Six.

On the wall in front of you, imagine the dart board with numbers strewn about the board as well as the various colors and concentric circles. In the middle of the board, you can see the red bull’s eye, nothing more than a tiny dot. As you zone in on this red area closer and closer, the area is getting larger and larger as if you are zooming into a picture on a computer. You zoom more and more, and now you see an enlarged red bull’s eye in front of you. As this size increases, you begin to feel more confident in your ability to hit this area and the anticipation is creating excitement to throw the dart. As you hold the dart in your hand, you can feel the weight of the dart and the bumps from the rough dart grip. Remember to breathe along with the cadence, in through your nose, One… Two… Three. Now out of your mouth, One… Two… Three… Four… Five… Six.

As you shift your weight to your front foot, your arm hangs relaxed at your side. You feel no tension in your body. A sense of calm takes over. You focus more on your visual target in front of you. You zoom in on the red bull’s eye and you attempt to lift your arm and throw the dart. As your arm comes up, your elbow pivots forward and releases the dart. As you wait in nervous anticipation, the dart flies through the air and finally lands with a loud thud in the red area in which you were aiming. A feeling of excitement takes over as you realized you’ve achieved your goal of hitting this small area. This makes you want to try it again.

As you grab another dart, you get in the same position with your throwing foot slightly in front of your non-throwing foot, leading with your throwing arm side. You feel the weight of the dart and the metallic bumps rolling between your thumb and index finger. As your elbow cocks back behind your ear, the motion from the elbow down to your hand pivots through the throwing motion and propels the dart towards the board. The dart flies through the air and finally impacts the board with a thud and lands in the red bull's eye. After the throw, you realize that your hand is still pointed out in front of you as described in the dart throwing lesson. Again, you aimed at the center of the board and the dart went exactly where you were aiming. The excitement that comes with mastering a task is beginning to grow inside of you as you anxiously grab another dart to try again. With each throw, your confidence rises as you begin to feel more adept at throwing darts. As you lift your arm and feel the weight of the dart and bumps on the metallic area, you zone in on the red area on the board and repeat the throwing motion. As the dart lands with a thud, you realize that you have once again hit the bull's eye. With this result, you take a deep breath Remember to breathe along with the cadence, in through your nose, One… Two… Three. Now out of your mouth, One… Two… Three… Four… Five… Six.

As you complete this task, you realize that you can repeat this throw over and over again. As you visualize the dart board, the red region begins to grow and you become more confident in your ability. You trust yourself that where you are aiming is where you will throw the dart. With each throw you are able to make minor adjustments to get the dart closer to the red bull's eye in the center of the board. This is your goal, this is what you set out to do with each throw. Repeatedly hitting the red bull's eye is the goal. Remember to breathe along with the cadence, in through your nose, One… Two… Three. Now out of your mouth, One… Two… Three… Four… Five… Six.

We feel completely relaxed and confident in our abilities to throw the dart into the bull's eye. Our emotions are confident as we anticipate throwing a great round. This feeling of excitement the surrounds this new activity is increasing as we want to demonstrate our dart throwing skills to friends. One more time, as we think about this task that we are about to do, I want you to picture the environment. The white cement walls, no windows, buzzing of the lights, dart board with green black and red with random numbers, and a blue cross on the board with lines intersecting in the red section of the board. As you think about this task and the performance that will follow, confidence comes as you feel prepared for the task after mentally imaging. One last time, as we become more and more relaxed, we're going to take a deep breathe along with the cadence, in through your nose, One… Two… Three. Now out of your mouth, One… Two… Three… Four… Five… Six.

APPENDIX B.

MEASURES

Dart Throwing Experience Assessment

1. Have you ever played darts before? Circle: Yes or No

2. During the past month, how many times have you participated in dart throwing?
____

3. How would you rate your dart throwing ability on a 1-10 scale?

←--→
1 2 3 4 5 6 7 8 9 10
Poor Average Elite

Sleep Quantity Assessment

1. What time did you go to bed last night? ________________
2. What time did you fall asleep last night? _______________
3. What time did you wake up this morning? ______________
4. How many hours of sleep did you get last night? ________
5. Is this a typical night of sleep for you? Circle: Yes or No
6. How many alcoholic beverages did you consume last night before you fell asleep? _________

Post-task Imagery Evaluation

1. Prior to this study, what prior experience did you have using mental imagery?

    a. If you had experience, how did this affect you in this study?

2. On a scale of 1 (lowest) to 10 (highest), how would you rate your commitment to using mental imagery during the audio recording prior to throwing darts?

3. On a scale of 1 (lowest) to 10 (highest), how would you rate your effort in using mental imagery during the audio recording prior to throwing darts?

4. Since the first dart throwing session, did you physically practice throwing darts?

5. Since the first dart throwing session, did you mentally practice throwing darts?

MOVEMENT IMAGERY QUESTIONNAIRE – REVISED (MIQ-R)

Craig R. Hall and Kathleen A. Martin, 1997

RATING SCALES

Visual Imagery Scale

7	6	5	4	3	2	1
Very easy To see	Easy to see	Somewhat Easy to see	Neutral (Not easy not hard	Somewhat Hard to see	Hard to see	Very Hard to see

Kinesthetic Imagery Scale

7	6	5	4	3	2	1
Very easy To Feel	Easy to Feel	Somewhat Easy to Feel	Neutral (Not easy not hard	Somewhat Hard to Feel	Hard to Feel	Very Hard to Feel

MOVEMENT IMAGERY QUESTIONNAIRE REVISED TEST ITEMS

1. STARTING POSITION: Stand with your feet and legs together and your arms at your sides.

   ACTION: Raise your right knee as high as possible so that you are standing on your left leg with your right leg flexed (bent) at the knee. Now lower your right leg so that you are again standing on two feet. Perform these actions slowly.

   MENTAL TASK: Assume the starting position. Attempt to feel yourself making the movement just performed without actually doing it. Now rate the ease/difficulty with which you were able to do this mental task.

   Rating

2. STARTING POSITION: Stand with your feet slightly apart and your hands at your sides.

   ACTION: Bend down low and then jump straight up in the air as high as possible with both arms extended above the head. Land with your feet apart and lower your arms to your sides.

   MENTAL TASK: Assume the starting position. Attempt to see yourself making the movement just performed with as clear and vivid a visual image as possible. Now rate the ease/difficulty with which you were able to do this mental task.

   Rating

3. STARTING POSITION: Extend the arm of your nondominant hand straight out to your side so that it is parallel to the ground, palm down.

ACTION: Move your arm forward until it is directly in front of your body (still parallel to the ground). Keep your arm extended during the movement and make the movement slowly.

MENTAL TASK: Assume the starting position. Attempt to feel yourself making the movement just performed without actually doing it. Now rate the ease/difficulty with which you were able to do this mental task.

Rating

4. STARTING POSITION: Stand with your feet slightly apart and your arms fully extended above your head.

ACTION: Slowly bend forward at the waist and try and touch your toes with your fingertips (or if possible, touch the floor with your fingertips or hands). Now return to the starting position, standing erect with your arms extended above your head.

MENTAL TASK: Assume the starting position. Attempt to see yourself making the movement just performed with as clear and vivid a visual image as possible. Now rate the ease/difficulty with which you were able to do this mental task.

Rating

5. STARTING POSITION: Stand with your feet slightly apart and your hands at your sides.

ACTION: Bend down low and then jump straight up into the air as high as possible with both arms extended above the head. Land with your feet apart and lower your hands to your sides.

MENTAL TASK: Assume the starting position. Attempt to feel yourself making the movement just performed without actually doing it. Now rate the ease/difficulty with which you were able to do this mental task.

Rating

6. STARTING POSITION: Stand with your feet and legs together and your arms at your sides.

ACTION: Raise your right knee as high as possible so that you are standing on two feet. Perform these actions slowly.

MENTAL TASK: Assume the starting position. Attempt to see yourself making the movement just performed with as clear and vivid a visual image as possible. Now rate the ease/difficulty with which you were able to do this mental task.

Rating

7. STARTING POSITION: Stand with your feet slightly apart and your arms fully extended above your head.

ACTION: Slowly bend forward at the waist and try and touch your toes with your fingertips (or if possible, touch the floor with your fingertips or hands). Now return to the starting position, standing erect with your arms extended above your head.

MENTAL TASK: Assume the starting position. Attempt to feel yourself making the movement just performed without actually doing it. Now rate the ease/difficulty with which you were able to do this mental task.

Rating

8. STARTING POSITION: Extend the arm of your non dominant hand straight out to your side so that it is parallel to the ground, palm down.

ACTION: Move your arm forward until it is directly in front of your body (still parallel to the ground). Keep your arm extended during the movement and make the movement slowly.

MENTAL TASK: Assume the starting position. Attempt to see yourself making the movement just performed with as clear and vivid a visual image as possible. Now rate the ease/difficulty with which you were able to do this mental task.

Rating

Movement Imagery Questionnaire (MIQ-R)

The Revised Movement Imagery Questionnaire (MIQ-R) (Hall & Martin, 1997) was used to assess each subject’s ability to imagine movement. The purpose of the MIQ-R was to evaluate the subject’s ability to see (visual imagery) and feel (kinesthetic imagery) movements. This instrument consists of 8 items, 4 visual and 4 kinesthetic, each item being a separate movement. The MIQ-R is a revised version of the MIQ (Hall & Pongrac, 1983). The test-retest coefficient for the MIQ is .83 for a 1-week interval (Hall, Pongrac, & Buckolz, 1985). Similarly, Atienza et al. (1994) reported internal consistencies of .89 for the visual subscale and .88 for the kinesthetic subscale of the MIQ. Hall and Martin (1997) found a significant correlation between the MIQ and the MIQ-R in both scales, visual and kinesthetic. They conclude that the MIQ-R is an acceptable revision of the MIQ.

Completing an item on the MIQ-R questionnaire requires several steps. First, the movement is produced by the subject exactly as described. Second, the movement is imaged either visually or kinesthetically (no movement is actually performed). Third, a value is assigned from a seven-point rating scale regarding the ease/difficulty with which the movement was imaged. A low rating indicates that a movement is difficult to image and a high rating indicates that a movement is easy to image. A visual score and a kinesthetic score for each subject is obtained by summing the items. Therefore, each of these two scores (visual and kinesthetic) can range from 4-26.

Subject's Initials ______________ID# ___________________Date Time _____AM/PM

PITTSBURGH SLEEP QUALITY INDEX

INSTRUCTIONS:
The following questions relate to your usual sleep habits during the past month only. Your answers should indicate the most accurate reply for the majority of days and nights in the past month.

Please answer all questions.

1. During the past month, what time have you usually gone to bed at night?
BED TIME ___________

2. During the past month, how long (in minutes) has it usually taken you to fall asleep each night?
NUMBER OF MINUTES ___________

3. During the past month, what time have you usually gotten up in the morning?
GETTING UP TIME ___________

4. During the past month, how many hours of actual sleep did you get at night? (This may be different than the number of hours you spent in bed.)
HOURS OF SLEEP PER NIGHT ___________

For each of the remaining questions, check the one best response. Please answer all questions.

5. During the past month, how often have you had trouble sleeping because you . . .

a) Cannot get to sleep within 30 minutes

Not during the past month_____	Less than once a week_____	Once or twice a week_____	Three or more times a week_____

b) Wake up in the middle of the night or early morning

Not during the past month_____	Less than once a week_____	Once or twice a week_____	Three or more times a week_____

c) Have to get up to use the bathroom

Not during the	Less than	Once or twice	Three or more

past month_____	once a week_____	a week_____	times a week_____

d) Cannot breathe comfortably

Not during the past month_____	Less than once a week_____	Once or twice a week_____	Three or more times a week_____

e) Cough or snore loudly

Not during the past month_____	Less than once a week_____	Once or twice a week_____	Three or more times a week_____

f) Feel too cold

Not during the past month_____	Less than once a week_____	Once or twice a week_____	Three or more times a week_____

g) Feel too hot

Not during the past month_____	Less than once a week_____	Once or twice a week_____	Three or more times a week_____

h) Had bad dreams

Not during the past month_____	Less than once a week_____	Once or twice a week_____	Three or more times a week_____

i) Have pain

Not during the past month_____	Less than once a week_____	Once or twice a week_____	Three or more times a week_____

j) Other reason(s), please describe____
____

How often during the past month have you had trouble sleeping because of this?

Not during the past month_____	Less than once a week_____	Once or twice a week_____	Three or more times a week_____

6. During the past month, how would you rate your sleep quality overall?
Very good ___________
Fairly good ___________
Fairly bad ___________
Very bad ___________

7. During the past month, how often have you taken medicine to help you sleep (prescribed or "over the counter")?

Not during the past month_____	Less than once a week_____	Once or twice a week_____	Three or more times a week_____

8. During the past month, how often have you had trouble staying awake while driving, eating meals, or engaging in social activity?

Not during the past month_____	Less than once a week_____	Once or twice a week_____	Three or more times a week_____

9. During the past month, how much of a problem has it been for you to keep up enough enthusiasm to get things done?
No problem at all __________
Only a very slight problem __________
Somewhat of a problem __________
A very big problem __________

10. Do you have a bed partner or roommate?
No bed partner or room mate __________
Partner/roommate in other room __________
Partner in same room, but not same bed __________
Partner in same bed __________

If you have a roommate or bed partner, ask him/her how often in the past month you have had . . .

a) Loud snoring

Not during the past month_____	Less than once a week_____	Once or twice a week_____	Three or more times a week_____

b) Long pauses between breaths while asleep

Not during the past month_____	Less than once a week_____	Once or twice a week_____	Three or more times a week_____

c) Legs twitching or jerking while you sleep

Not during the past month_____	Less than once a week_____	Once or twice a week_____	Three or more times a week_____

d) Episodes of disorientation or confusion during sleep

Not during the past month_____	Less than once a week_____	Once or twice a week_____	Three or more times a week_____

e) Other restlessness while you sleep; please describe___________________________
____

Not during the past month_____	Less than once a week_____	Once or twice a week_____	Three or more times a week_____