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The effect of directing attention externally toward a visible or imagined object

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THE EFFECT OF DIRECTING ATTENTION EXTERNALLY TOWARD A VISIBLE OR IMAGINED OBJECT

by

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AN ABSTRACT OF THE THESIS OF

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Utilization of an external focus of attention has been proved to be beneficial in the motor learning literature. When people focus on the effects of the movement (i.e., external focus of attention), the motor skill is enhanced compared to directing attention to the body movements (i.e., internal focus of attention). Previous studies that have examined the effect of focus of attention on learning a motor skill often used visible or imagined objects to elicit an external focus of attention. However, the effects of these different types of external focus instruction have not been investigated thoroughly. It was unclear prior to this thesis how the focus of attention effect is influenced by the use of imagery. The purpose of the present study was to investigate the difference between directing attention to a visible object and an imagined object when performing and learning the standing long jump.

It was hypothesized the group of participants who practiced with an imagery instruction would perform similarly in the post-test with or without an object that was used to elicit an external focus of attention. It was also hypothesized the group of participants who practiced with a visible object would perform similarly during the post-test with the same visible object; but the performance would decline in the post-test with no object. Additionally, it was hypothesized performance during practice with imagery instruction is expected to not change performance when post-testing in imagery and visual-object instruction conditions.

The results indicated there was no difference in the effect of the two different types of instructions. That is, performance during the practice and post-test were similar for the participants who imagined an object during the practice phase compared to the participants who practiced with an object. The post-test with and without an object were also similar within the same group as well as between the two groups. The results of the study provided additional evidence vision does not influence the focus of attention effect. Participants who practiced the standing long jump with a visible cone did not change the performance on the transfer test when the cone was removed. Also, participants who were instructed to direct their attention toward an imaginary cone performed just as well as participants who focused their attention on a visible cone on both the retention and transfer test. Therefore, the primary finding of the present experiment is that the focus of attention effect can be induced through the use of imagery.

DEDICATION

I dedicate this thesis to my parents, friends, professors, and coaches, who supported and nurtured me. Especially, Dr. Jennifer Romack, who showed me what commitment and passion are as a great researcher, mentor and person. I regret that I could not finish my thesis before she ended her fight with cancer. At the same time, I am very honored that I was accepted for a master's and doctoral program with her recommendation letters to represent that I am her student. I would like to pass on her passion and dedicate my self to the field of kinesiology. Rest in peace, Dr. Romack.

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After almost eight years of my life in the United States, I realized I am just one out of thousands of pieces of a big puzzle called life, and all I did was to just do my best. I have gathered the other pieces from people to help me get closer to the completion of my puzzle. Finally, I would like to express my gratitude to the faculty of SIUC's kinesiology department. Everyone helped me and was such a positive influence on me to be a good student and teaching assistant. I learned so much from each of you and enjoyed the experiences I have had here.

This thesis is the beginning of my career as a researcher for people to have a healthy life and for athletes to seek their peak performance.

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INTRODUCTION

Practitioners in sport and rehabilitation settings have always sought methods for more effective and efficient teaching and coaching strategies. The discipline of motor behavior has yielded an understanding of a variety of factors that influence motor performance and learning such as the effects of instruction, feedback, and the design of practice schedules on the skill acquisition process. In the field of motor learning, the investigation of attentional focus has become one of the biggest topics in the past two decades. Since Wulf and her colleagues brought this topic into the scientific research field (Wulf, Prinz, Wolfgang, Hob, & Marcus, 1998), the strength and consistency of this phenomenon have intrigued many researchers. Attention here is defined as, "what we are thinking about (or not thinking about) or what we are aware of (or not aware of) when we perform activities" (Magill, 2007, p.195). Magill extended this definition to the amount of cognitive effort that performers put in when performing activities. In the following sections, the literature review will provide an in-depth review of the topic of focus of attention as it relates to the motor learning process.

Focus of Attention

Origin of Focus of Attention

Wulf and Weigelt (1997) conducted two initial experiments to examine the effect of different instructions as they related to how a mover focuses their attention during the execution of a motor task. In the first experiment, participants practiced a ski slalom type movement using a ski simulator for three consecutive days. One group of participants received instruction about the optimal timing of applied force, and the other group did not receive any instruction. The results showed the group that did not receive any instruction was significantly better than the group that received specific instruction about the timing of applied force. However, a question still remained about the results of the experiment: That is, have the observed differences been due to the learner's inability to handle relevant information related to the movement in the early acquisition phase? Wulf and Weigelt postulated that the attention capacity of the beginners in the study was greatly restricted during the initial acquisition phase of learning the novel ski slalom movement. Based on the results and this speculation, the authors conducted a second experiment using similar instructions of a four-day period. Specifically, the authors examined if increasing the length of the acquisition phase and delayed provision of instruction altered the outcome of the study. Participants practiced the same ski slalom movement for three days, and the instruction about the optimal timing of force was provided after the three days of practice. However, the results again revealed a significant drop in performance after the provision of the instruction about the optimal timing of force, which rejected the assumption that the results of the first experiment were the results of the novices being overwhelmed by the complexities of the practiced task. Based on the results of this pair of experiments, Wulf and Weigelt concluded that instructing participants to focus their attention on the movements of the practice task was not as effective as allowing the learner to choose how to direct their attention.

Defining Focus of Attention

Wulf et al. (1998) described that the goal of providing instructions to a beginner who is learning a new motor skill is to correct errors in the movement pattern. However, the author provided some anecdotal evidence that paying attention to one's movement can hinder performance. For example, Schneider and Fisk in 1983 (as cited in Wulf et al., 1998) described that when Schneider thought about which foot was carrying his weight in a turn during downhill skiing, he noticed substantial performance decrements for the rest of the slope. Furthermore, Wulf and Weigelt (1997) provided evidence that providing instructions about a movement's timing when practicing a ski slalom movement declined the performance and effects of learning the task compared to providing no instruction for the same task. This conclusion is what led Wulf et al. to examine the effects of two different methods of directing attention: internally or externally. The authors defined an internal focus of attention as instructions related to the learner's own body movements and defined an external focus of attention as instructions related to the effects of the performer's actions on the environment. Based on the findings of their earlier work, Wulf et al. hypothesized utilizing an external focus would be more effective than using an internal focus of attention instruction.

To test this hypothesis, the authors again used a ski slalom simulator. The ski simulator consists of two rails with a platform on wheels. When participants stand on the platform and shift their body weight from side-to-side, the platform moves toward the direction where the weight is shifted, simulating the movements of an actual ski slalom. The participants were randomly assigned to one of three groups: an internal-focus group, external-focus group, or control group. All participants received instruction to "move with as large of an amplitude as possible," as a general goal for the task. In addition, the internal group received instruction to exert force with the outer *foot* as long as possible. In contrast, the external group was instructed to try to exert force on the outer *wheels* as long as possible. Both instructions were similar, but the former directs attention to the body movements (i.e., internally), and the latter directs attention to the effects of the movement (i.e., externally) since it requires the participants to think about moving the wheels on the platform. Results showed performance benefits when utilizing an external focus of attention during practice and on the retention test. Moreover, the internal-group was significantly worse than the control group during the acquisition phase. In the retention test, however, the internal focus and control group did not differ. This result supported the authors' hypothesis that utilizing an external focus was beneficial in learning ski slalom type movements, and the internal focus instruction had disruptive effects on motor behavior.

To test the generalizability of the focus of attention effect, Wulf et al. (1998, Experiment 2) examined balance performance while standing on a stabilometer. Participants attempted to balance on an unstable platform for 90 seconds for 14 trials over two days of practice. Participants then returned on a third day to complete a retention test. Participants in the internal group were told to "focus on the feet and try to keep them at the same height," while the participants in the external group were told to "focus on the red markers (on the platform) and try to keep them at the same height." The results showed that the stability of both groups improved during practice. However, the external group performed significantly better than the internal group on the retention test. This result indicated that directing attention internally interrupted the automatic control processes of maintaining balance. The results also indicated that directing attention to the effect of the movement (i.e., externally) promoted an automated form of motor coordination.

When teaching a motor task, performers must often focus on multiple components of the motor skill. For example, when hitting a ball with a bat, a performer might need to allocate his or her attention towards the grip of the bat, speed and location of the ball, or how to efficiently move to swing the bat. It is important for practitioners to provide instruction that effectively directs the mover to focus his/her attention on relevant cues to facilitate the motor learning process. As discussed earlier, practitioners can direct performers' attention internally or externally. It is important to point out that in the context of this research the word "external" does not mean that attention is direct towards an external object. Rather, it means that the mover is directing their conscious attention towards the desired result of the movement. In attempting to clarify this concept Wulf, McNevin, Fuchs, Ritter, and Toole (2000, Experiment 1) conducted a study to ensure that the benefits of directing attention externally were the result of focusing on the desired results and not simply the byproduct of focusing attention away from the body. To do this the authors instructed participants to focus their attention externally in two different ways. For one group of participants attention was directed externally towards an approaching tennis ball. For the second group of participants, attention was directed towards hitting the tennis ball towards a target located on the other side of the net. The results showed that there was an increase in performance in both groups, and both groups performed similarly during practice. However, the two groups performed significantly different during the post-test. Specifically, the group that directed their attention to the effect of the movement on the environment significantly scored higher than the group that directed their attention to the approaching ball. The results verified that the benefits of an external focus of attention were the result of directing attention towards the desired result of the movement rather than simply directing attention away from the body.

The Constrained Action Hypothesis

To explain the focus of attention effect McNevin, Shea, and Wulf, (2003), Wulf, McNevin, and Shea (2001), and Wulf, Shea, and Park, (2001) proposed the constrained action hypothesis. According to this hypothesis, when an individual tries to consciously control their body movements by directing attention internally, the mover disrupts the motor system by interfering with automated movements that would normally be done at a subconscious level. Whereas when a mover directs attention to the effects of the movement, the movements are executed subconsciously. As a result, the motor system is able to operate unconstrained, resulting in a more effective form of motor control.

To test the predictions of the constrained action hypothesis, Wulf, McNevin et al. (2001, Experiment 2) compared an external and internal focus of attention when performing a balance task. Participants stood on an unstable platform with the goal of keeping the platform horizontally balanced for 90-seconds. The instruction for the internal focus of attention condition was to focus on keeping the feet horizontal, whereas the instruction for the external focus of attention condition was to focus on keeping the markers on the platform horizontal. In this study, fast Fourier transformation (FFT) analysis by the mean frequency of the power density spectrum was chosen to measure the magnitude of postural adjustments being made by the motor control system. According to the authors, constrained or compromised motor control systems are characterized with lower frequency components in MPF. On the contrary, higher frequency components indicate more subtle postural adjustments, thus these patterns exhibit an unconstrained and more coordinated motor system. Therefore, the authors predicted if this were the case, the constrained movements should exhibit lower frequency components while attention is directed internally, while higher frequency adjustments exhibits the incorporation of exploration of higher degrees of freedom, which should be observed in the external focus conditions. The results of this study were consistent with these predictions.

The results of the study also replicated previous findings using the same balance task (e.g., Wulf et al., 1998; Wulf, McNevin et al., 2001, Experiment 1). That is, there was no significant difference in the practice phase, but the external condition displayed greater stability with smaller and faster postural adjustments during the retention test. The results of this study provided the first quantifiable data that support the prediction of the constrained action hypothesis. The magnitude of errors (i.e., greater RMSE in the internal conditions and lower RMSE in the external conditions) showed the difference in the effects of external and internal focus of attention. Furthermore, the external condition possessed a higher frequency content in MPF that are seen in efficient motor control systems, while the internal conditions exhibited a lower MPF, which is indicative of a constrained motor system.

Electromyography Support

Additional evidence supporting the constrained action hypothesis has been provided through the use of electromyography (EMG). For example, Vance, Wulf, McNevin, Tollner, and Mercer (2004) conducted one of the earliest studies using EMG within a focus of attention paradigm. Vance et al. (2004) postulated that EMG activity may provide information about nervous system operation under a specific attentional focus. If the predictions of the constrained hypothesis are correct, the authors predicted that there should be observable differences in neuromuscular activity when participants direct their attention externally or internally. Further, if utilizing an external focus of attention is beneficial by evoking automaticity of the movements, the authors also concluded that the results should manifest in a more efficient muscle recruitment pattern.

In this early study by Vance et al. (2004), the authors examined muscular behavior during an elbow flexion task. Also, during the elbow flexion task, EMG activities were monitored in the agonist (i.e., biceps) and antagonist (i.e., triceps) muscles. The instruction for the internal focus group was to focus on the movement of the arm, whereas the external focus group was told to focus on the curl bar. Vance et al. (2004, Experiment 1) tested the task without controlling the time it took to complete the skill. Participants attempted a total of two sets of 10 repetitions with internal and external instructions. The results of the study showed a general increase in the EMG activities under the internal condition, although the EMG data were not statistically significant between the attentional conditions. However, the results of the study also showed a greater angular velocity under the external focus instruction than the performance with the internal focus instruction. The authors explained that this result indicates the adoption of a more efficient movement when attention is directed externally. In Experiment 2, the authors tested the same task with a controlled speed using a metronome. The results of Experiment 2 revealed that during flexion, the EMG activity of the triceps was greater in the internal condition compared to the external condition. That is, there was greater coactivation at the elbow joint in the internal condition. In summary, a faster movement was observed in Experiment 1 when the external focus instruction was provided. Since participants moved the same resistance at a faster speed, there was a potential explanation that performance with an external focus promoted a more efficient movement pattern. In Experiment 2, the EMG activities showed greater muscle activations in the elbow flexion when the internal focus instruction was provided. This “noise” in the EMG activity under an internal focus of attention provided support for the constrained action hypothesis concluding that there was a disruption to the motor system when a mover directs his or her attention internally. In contrast, a lower EMG activity was observed when adopting an external focus of attention. This result indicated an economical muscular coordination pattern in an elbow flexion task while directing attention externally.

The study conducted by Vance et al. (2004) provided initial evidence that adopting an external focus of attention produces an efficient muscle recruitment pattern. However, the Vance et al. (2004) study did not strictly control the speed of muscular contraction, which may have affected the muscular recruitment pattern. This led Marchant, Greig, and Scott (2009) to conduct a study that utilized a constant elbow flexion velocity. Participants exerted their maximum force against a lever that moved at a constant speed throughout the range of motion during the elbow flexion. In addition, Marchant et al. (2009) examined how force production changed by adopting an external or internal focus of attention. The authors assumed if utilizing an external focus of attention influences behavior of motor unit recruitments, it should also influence the force output as well. The study revealed an interesting result. The external condition had less muscular activity compared to the internal condition; however, the force produced in the elbow flexion was greater than the internal condition. This result further supported the conclusion that utilizing an external focus of attention enhanced movement efficiency.

A more economical neuromuscular coordination pattern as a result of adopting an external focus of attention has also been observed in other tasks. For example, Lohse, Sherwood, and Healy (2010) examined the effects of using an external or internal focus of attention when throwing darts. The instruction in the external condition was to focus on the flight of the dart, while the instruction in the internal condition was to focus on the participants' arm when they threw the dart. The EMG activities of the agonist (i.e., triceps) and antagonist muscles (i.e., biceps) were measured in addition to the errors (i.e., the distance from the bull's eye). The results showed less muscular activity in the triceps in the external condition than the internal condition while less performance errors were observed in the external condition compared to the internal condition. The results of the Lohse et al. (2010) study extended the findings reported by Vance et al. (2004) and Marchant et al. (2009), and provided neuromuscular evidence supporting the predictions of the constrained action hypothesis.

The Focus of Attention Effects in Standing Long Jump

In addition to the ski slalom movements, balance task, dart throwing, and elbow flexion that have been discussed, the robustness of the focus of attention has intrigued researchers, and a variety of tasks have been used to examine the focus of attention effect in both lab and field settings. Of particular importance to the current thesis is how the focus of attention effect applies to complex whole body movements that require the control of many degrees of freedom. The standing long jump is a power based task and effective tool to determine the power output of an individual in many sports (e.g., football, basketball, track & field). Possessing greater power and the ability to efficiently control multiple body segments is not only important to compete in sports, but it is also a critical ability to function in daily life (e.g., avoiding a dangerous situation and transporting a heavy object).

One of the initial studies that examined the effect of focus of attention on standing long jump performance was conducted by Porter, Ostrowski, Nolan, and Wu (2010). The authors recruited 120 untrained college students. Participants were randomly assigned to one of two groups: An internal (n = 60) condition or external condition (n = 60). The jumping distance was measured and analyzed for the effect of the two foci instructions. The specific instruction for the internal condition was, ‘‘when you are attempting to jump as far as possible, I want you to focus your attention on extending your knees as rapidly as possible.’’ The instruction for the external condition was, “when you are attempting to jump as far as possible, I want you to focus your attention on jumping as far past the start line as possible.’’ Participants in each group attempted five trials with the specific focus of attention instruction. The results revealed that the external condition outperformed the internal condition. The results further indicated that directing attention externally had an immediate influence on standing long jump performance. Also, participants attempted the standing long jump only for five trials in a single day, thus it is not physiologically possible that muscular hypertrophy caused the differences in the performance outcome. As a result, participants who attempted the standing long jump with an external focus of attention jumped farther than those who attempted the jump with an internal focus of attention. Since this initial study conducted by Porter et al. (2010), several additional studies have reported similar results using the standing long jump (e.g., Ducharme, Wu, Lim, Porter, & Gerald, 2015; Wu, Porter, & Brown, 2012). The standing long jump is a valid and reliable task to use to investigate research questions related to the focus of attention effect, especially questions related to how this effect is associated with complex whole body movements.

Methodological Considerations

Adopting an external focus of attention has been shown to facilitate the learning of a motor skill in a variety of tasks (e.g., balance task by Wulf et al.,1998, Experiment 2; accuracy tasks such as dart throwing by Lohse et al., 2010; strength task by Vance et al., 2004; Marchant et al., 2009; standing long jump, Porter et al., 2010, and Wu et al., 2012). However, there may be other factors that partially influence the results of these studies, such as directing attention to an imagined or visible target. A visible target in this context means an object that is visible to the participant which affords the opportunity for goal directed behaviors through the use of an external focus of attention towards the visible target. An imagined target means that there is no visible object in sight of the participant, however the attention of the participant is directed externally towards an imagined target. For example, Porter, Anton, and Wu (2012) used a cone as a cue to elicit an external focus of attention when performing the standing long jump. A cone was placed on a jumping mat directly in front of the participant, and participants were told to focus on jumping as close to the cone as possible. In this case, the cone served as a visible cue that was in sight of the participants. In other cases, the cue that is used to direct performers' attention is imagined. For example, McKey and Wulf (2012) examined the effect of an external foci of attention using a dart throwing task. One of the instructions provided to participants was to focus on hitting the bull's eye (i.e., a visible target). In another condition participants were instructed to imagine the flight of the dart as it traveled towards the target (i.e., no visible target). Depending on the provided instruction, participants are often prompted to focus their attention towards a visible cue (e.g., cones by Porter et al., 2012) or imagined future performance (e.g., flight of a dart by McKey & Wulf, 2012). What has not been well investigated is the efficacy of using a visible or imagined target to effectively focus a learner's attention. The following section will review the literature related to the topic of imagery and how this practice strategy influences motor skill acquisition.

Imagery

Among a variety of topics in the field of motor learning, imagery is one of the most studied research areas. Within the area of research examining the topic of imagery, there are several analogous terms synonymous with imagery such as mental practice, mental rehearsal, and visualization. Operationally, the definition of imagery in this literature review will be "creating or recreating an experience in the mind" (Weinberg & Gould, 2007, p. 229). To explain the phenomena of imagery, the following section will introduce previous findings in sport psychology regarding imagery. Some theoretical interpretations of imagery will also be discussed.

Function of Imagery

According to Weinberg and Gould (2007) from Paivio's original model, there are four different categories of imagery: Motivational specific, motivational general, cognitive specific, and cognitive general. Motivational specific is the use of imagery about a specific event or scenario to improve confidence. Motivational general is used to increase or decrease arousal, to be positive, or to be confident. On the cognitive side, there is cognitive specific and cognitive general. Cognitive specific is used to imagine a specific movement such as taking a shot in basketball. Cognitive general is when imagining is used to mentally rehearse a series of movements. Imagery in terms of function may improve performers' motor skills by increasing motivation, by thinking about executing a successful motor skill, or rehearsing a situation in their mind prior to initiating the movement. The present thesis will place an emphasis on the cognitive side of imagery functions since the purpose of imagery-based instruction is to examine how thinking about an imagined object affects the efficacy of focus of attention. In the subsequent sections the theoretical interpretations suggesting why the use of imagery can enhance motor performance will be discussed.

Psychoneuromuscular theory

According to Weinberg and Gould (2007), the psychoneuromuscular theory originated from the ideomotor principle of imagery proposed by Carpenter (1894). When engaging in imagery of a specific motor task, the same muscles that are used during an actual movement are innervated. This consequently facilitates the neuromuscular activity patterns. Some of the first scientific findings of this principle were reported by Jacobson (1931) and Suinn (1972 & 1976) (as cited in Weinberg & Gould, 2007). These early studies detected electrical signals in the muscles that were used during imagery in the absence of overt movement of the body. More recently, Jowdy and Harris (1990) further examined the neuromuscular activities during imagery between high and low skill jugglers. Participants imagined the practice of juggling three tennis balls while listening to an imagery instruction from a cassette tape for a total of two-minutes. The EMG activity was measured during this two-minute period. The results replicated previous findings reported by Carpenter, Jacobson, and Suinn in that the muscular activities were significantly greater during imagery trials compared to relaxed baseline measures. These findings suggest that the neuromuscular activities during imagery provide opportunities for the brain in conjunction with neuromotor units to practice an actual motor skill even though performers do not overtly move their body parts; and therefore, imagery works because of these neuromuscular activations.

Symbolic Learning Theory

Another interpretation to explain how imagery works is theorized by Sackett (1934) (as cited in Williams, 1998). When people engage in mental practice it creates a motor program by symbolizing specific movement parts in the central nervous system allowing the learner to become familiar with the task. That is, the symbolic learning theory explains that imagery works because performers can plan motor activities in advance. Therefore, neuromuscular activities are not required to improve performance.

One of the findings that supported the symbolic learning theory was published by Feltz and Landers (1983). Those authors conducted one of the first meta-analyses about mental practice and through the review they provided initial support for the symbolic learning theory based on empirical investigations. According to the authors, when tasks that require higher levels of cognitive processing (e.g., maze learning and sequence learning) are compared with tasks that are low in cognitive processing and high in motor components (e.g., stabilometer), the tasks that requires more cognitive processing enhanced performance to a larger degree when using imaging. These trends (i.e., greater effects in more cognitive dependent tasks) were evident in 66 studies the authors reviewed for their meta-analysis. Moreover, the authors criticized the psychoneuromuscular theory because the studies that examined EMG activities and mental practice did not include performance measures as a dependent variable. That is, the studies that supported the psychoneuromusuclar theory showed increased EMG activity during mental practice compared to baseline measures. These results only suggest the relationship of mental practice and EMG activity, but did not provide evidence of performance improvements through mental practice. Therefore, these results cannot explicitly conclude mental practice enhances motor performances due to neuromotor unit recruitment during mental practice.

Another study that supported the symbolic learning theory was conducted by Hird, Landers, Thomas, and Horan (1991). That study was one of the most prominent studies in the mental practice area that showed the relationship of physical and mental practice. The authors examined different ratios of physical and mental practice in two different tasks that required participants to practice one cognitive dependent task (i.e., pegboard puzzle) and one motor dependent task (i.e., rotary pursuit). The pegboard task (i.e., more cognitive skill) consists of planning, memorizing, and putting correct wooden pieces in a correct sequence, and thus it required less movement but great cognitive processing. On the other hand, the rotary pursuit tracker (i.e., more motor task) consists of tracking a light with a stylus on the board that moved in a circular manner at a constant velocity. Participants were asked to hold a stylus and keep the tip of it on a track, and thus it consists of mostly motor elements. Participants were pretested on both tasks and randomly assigned to one of the six experimental groups with varying combinations of physical and mental practice. Specifically, one group completed 100% physical practice, another group completed a ratio of 75%: 25% of physical and mental practice, another group completed a ratio of 50%: 50% of physical and mental practice, a fourth group completed a ratio of 25%: 75% of physical and mental practice, while another did 100% mental practice, and finally there was a control group that did not practice the task physically or mentally. Participants practiced for a total of nine days, and a post-test was conducted on day 10. The results showed a significant improvement between pre-post tests for both pegboard and pursuit rotary tasks in all the groups except for the control group. The effect size analyses revealed that test results were better in order as the number of physical practice increased, however, the differences were relatively small. The results of this study provide additional evidence for the symbolic learning theory.

Imagery Practice Summary

The use of imagery can enhance the learning of a motor skill in two different ways: motivationally and cognitively. By imagining a future performance, performers can increase motivation or confidence, or performers can cognitively practice a motor task in their mind. In terms of how cognitive engagement in imagery can improve performance, there are multiple theoretical interpretations. The psychoneuromuscular theory explains the neural output during imagery practice is the biggest factor that affects learning a motor skill. Rather than the neuromuscular connections, the symbolic learning theory suggests it is coding and symbolizing the elements of the motor task that allow performers to become familiar with the task, which enables them to improve the motor skill. Even though there are still different interpretations regarding how the use of imagery works, the consensus in the literature is that imagery is more effective than no practice but not as effective as physical practice alone. An additional conclusion drawn from the literature is that skills that require higher amounts of cognitive processing benefit more from imagery compared to skills that require less cognitive processing. In the next section, visual influence in learning a motor skill will be discussed.

Visual Attention

Humans use their senses such as auditory, vision, and proprioception to interact with the external environment. As it relates to the motor learning process, vision is one of the senses that we heavily rely on to acquire a skill. According to Magill (2007), the process in which directing visual attention to locate relevant information to successfully prepare and execute the task is called visual search. Magill further explains that people can actively or passively direct their visual attention to identify specific contextual cues within the environment when pursuing the achievement of an action goal.

There are several studies supporting the influence of this characteristic of visual behavior. For example, Vickers (1992) examined gaze patterns in adults when putting a golf ball. Five low-handicapped golfers (i.e., high skilled golfers) and seven high-handicapped golfers (i.e., lower skilled golfers) were recruited for the study. Participants wore a special helmet that measured their eye movements to determine the frequency and duration of gazing patterns while executing the golf putt. The results showed that the low-handicapped golfers had significantly fewer gaze shifts to different locations in the environment and spent less time preparing each putt. One of the most prominent findings in that study was that low-handicapped players fixated more on the ball in the preparation and backswing phase, whereas the high-handicapped players fixated their gaze more on the club. Also, a longer fixation on the club was related to a higher incidence of missed putts; whereas a longer fixation on the ball was related to a higher incidence of making the putt. The results of that study clearly indicated a difference in visual behavior between high and low skilled golfers. Furthermore, it was observed that there were clear visual behavioral differences between successful and failed trials. Therefore, there appears to be a relationship between the performance outcomes and visual behavior, which also appears to be linked to the skill level of the learner.

In a related study that was designed to investigate the relationship between gaze behavior and motor performance, Vickers (1996) examined the visual characteristics of 16 skilled female basketball players while shooting a free throw. Eight subjects were determined to be expert free throw shoots while the other eight were classified as near expert shooters. Participants wore a device that measured the pupil and corneal reflex, which specifically measured the participant's line of gaze. The data collection consisted of the participants shooting free throws until each participant reached 10 made shots and 10 missed shots. Since the participants continued to shoot until they missed 10 shots, the number of the total shots varied. Gaze behavior was collected in preparation of the shot, immediately before the shot, during the shot, and post-shot. The gaze behaviors of successful and failed shots were compared within participants.

The results showed that there was a significant difference in accuracy between experts and near experts. With regard to eye movements and duration, there was no difference between the total duration of shooting time between the experts and near experts. However, differences were observed in the pre-shot phase between experts and near experts. Specifically, the mean duration of the final fixation (i.e., pre-shot phase) in the experts was significantly longer than the near experts. Vickers named this longer final fixation behavior in experts the "quiet eye." The duration of the final fixation to a critical cue (e.g., the golf ball, or basketball goal) in the pre shot phase is consistently longer in experts, and this visual behavior appears to be consistent across tasks among other visual search behaviors (e.g., frequency, gaze shifts, and duration spent on each relevant cues on the environment).

In the area of studies that examine visual behavior when learning a motor skill, what has become evident is that there are different visual search patterns utilized by high and low skilled learners. These visual search patterns vary in terms of the frequency and duration of fixation on relevant cues within the learning environment. Additionally, different gaze patterns are utilized between successful and unsuccessful motor trials. Before discussing the impact of imagery or vision on the utilization of an external focus of attention, another factor needs to be considered in relation to the present thesis.

The Guidance Hypothesis

In addition to the influence of directing attention to an imagined or visible object, there is another factor in the present study that may affect the skill acquisition process. An instruction is a piece of information that is verbally provided to performers before the execution of a motor task. In contrast, augmented feedback is information that is verbally provided to performers after the execution of a task. Although this literature review emphasizes the effect of instructions, when considering motor performance, practitioners need to understand that both instruction and augmented feedback reciprocally influence motor performance and learning. Depending on the outcome of a performance, the content of augmented feedback that a coach provides to the performer may differ. Additionally, the content of instruction may need to be modified based on the content of the augmented feedback. In this way, instruction, motor performance, and augmented feedback are closely related. Thus, theories that are constructed in the study of augmented feedback may be useful in the study of instruction. The guidance hypothesis was first proposed by Salmoni, Schmidt, and Walter (1984). The majority of the theories in motor learning to explain this phenomenon have been investigated through the use of augmented feedback. Therefore, the following section will explain the key terms and general findings related to the topic of augmented feedback, and then the principle of the guidance hypothesis will be discussed.

Augmented Feedback

Feedback is categorized into two types: Task-intrinsic feedback and augmented feedback. According to Magill (2007), task-intrinsic feedback is sensory information in response to internal or external stimuli such as proprioception and vision. For example, when you shoot and miss a basketball free-throw, you might feel that you shot too hard, released the ball too much to the right, or that the ball left the fingers incorrectly. This neural and perceptive information is a typical example of task-intrinsic feedback. Augmented feedback is "the information about performing a skill that is added to sensory feedback and comes from a source external to the person performing the skill (Magill, 2007, p. 333)." Using the same basketball-shooting example, if an athlete misses a shot and the coach tells the athlete that the shot was missed because they did not bend the knees and follow-through on the shot; this would be an example of augmented feedback because the feedback was provided from an external source (i.e., the coach). Augmented feedback is divided into two subcategories: Knowledge of result (KR) and knowledge of performance (KP). KR is the provision of information about the outcome of a performance (e.g., hit or missed) and KP is the provision of information about movement characteristics. For example, following a golf shot a coach may indicate to the golfer that they missed the cup by two cm. This type of information is an example of KR because the information is related to the outcome of the movement. However, the coach may also tell the golfer that they missed the shot because they swayed too much during the shot. This is an example of KP because the feedback is specific to the movement characteristics of performing the golf shot.

Depending on a performer's skill level and the characteristics of the task, augmented feedback may or may not be effective. In a situation in which task intrinsic feedback is unavailable, augmented feedback is essential for skill acquisition. However, when there is a sufficient amount of task-intrinsic feedback, the provided augmented feedback becomes redundant and does not improve skill acquisition. For example, if a golfer wants to loft a ball from a bunker onto a tall hill and cannot see the target, then KR provided by a coach or fellow golfer that can see the hole is beneficial for the performer since task intrinsic feedback (i.e., visual information) is unavailable. However, in a putting situation on a flat green, performers can typically see their results simply from naturally available visual information. In this case, KR would be redundant with available task intrinsic feedback, and thus it may not improve learning.

Function of KR and the Proposition of the Guidance Hypothesis

Like many areas of research, the study of augmented feedback is not without a history of contradictory results and ambiguity in developing the best methods of implementing KR and KP in a motor learning context. Salmoni et al. (1984) disagreed with most of the results of the studies and interpretations that were conducted in the 1950's to 1980's because much of the research failed to separate the temporary and transient effects of augmented feedback. That is, a number of research studies conducted through that time period failed to distinguish the results of performance during a skill acquisition phase and learning effects; therefore, there were contradictory interpretations and results about the effect of augmented feedback.

In seeking for a conclusion regarding the contradictory results in the studies that examined the effects on augmented feedback in motor skill, Salmoni et al. (1984) reviewed 250 articles and summarized the difference between performance and learning effects. Their review concluded there were three functions of KR: Motivational, associational, and guidance. Of the three functions, the authors described guidance has having the strongest effect on the skill acquisition process. The concept that KR leads the performer to more optimal movements means that the learner uses KR as a guide to perform future trials because the augmented feedback provides information about correct or incorrect behaviors which is then used by the mover to generate a more optimal motor solution. Therefore, as the number of trials and KR increases, the accuracy of the performance outcome should also improve. The authors also concluded that if KR is essential for the motor learning process then the learner likely develops a dependency on the provided augmented feedback. Such a dependency should then result in performance deficits when KR is removed, which is often the case during a retention or transfer test.

To test this prediction, Schmidt, Young, Swinnen, and Shapiro (1989) examined the guidance hypothesis through the use of summary KR. Participants were randomly assigned to conditions in which they received summary KR following every trial or following every fifth, tenth or fifteenth trial of a ballistic timing task. Participants attempted the task in six blocks of 15 trials in the acquisition phase and had 25 trials as the immediate retention test. And finally, participants returned two days later and completed a delayed retention test. The task required participants to slide a lever to the right, then to the left and then again towards the right side of a course to learn a specific movement sequence with a total movement time of 550 ms. The provided KR was the constant error from the goal timing (i.e., difference in timing error from the 550 ms goal). The results in the acquisition phase revealed the effectiveness of KR during practice. That is, after the first block, a significant difference was observed between the one and five summary KR groups, and between the t10 and 15 summary KR groups. Generally, the results showed greater improvements in the task with the participants that received a greater amount of KR. The difference in the immediate retention test did not reveal any differences among the groups. However, the delayed retention test showed an inverse relationship with the acquisition phase. That is, the participants that received reduced amounts of feedback during practice ultimately performed better on the delayed retention test.

The phenomenon of increased performance with KR during practice and decreased learning was explained as “the role of KR as guidance has forced the subjects to concentrate (or rely) too much on KR performance, so that the task is learned effectively" (Salmoni et al., 1984, p. 381). The authors hypothesized this was because the learners relied on KR during practice due to its strong guidance effects, but did not rely on other information that was effective in the further development of the skill, such as intrinsic feedback. Altogether, the phenomenon can be explained in the following way: reduced feedback strategies (e.g., summary KR) do not provide strong guidance during the acquisition phase because of the low frequency of KR that is provided, thus performance in the acquisition phase is worse compared to participants that received KR at a higher frequency. Yet, the performers that received a reduced amount of augmented feedback learned how to use other available information (i.e., task-intrinsic feedback) during this period. Therefore, performers who received less KR ultimately learned the skill better than movers that received a higher frequency of augmented feedback during practice. This is likely the result of receiving a high frequency KR causing the learner to ignore task intrinsic feedback while at the same time developing a dependency on the provided augmented feedback. Thus, practicing with a higher amount of KR is detrimental in situations where KR is removed on later post-testing.

The Present Study

The use of an external focus of attention has been demonstrated to be consistently effective compared to the adoption of an internal focus of attention (e.g., ski slalom movement in Exp. 1 and balance task in Exp. 2 in Wulf et al., 1998; golf pitching in Wulf et al.,1999; tennis forehand in Exp. 1 in Wulf et al.,2000; elbow flexion strength in Marchant et al., 2009; Vance et al., 2004; dark throwing in Lohse et al., 2010; standing long jump in Porter et al., 2010; Wu et al., 2012). Furthermore, in the body of research examining the topic of imagery, it has been consistently demonstrated that the utilization of imagery during practice enhances motor performances (Feltz & Landers, 1983; Hird et al.,1991). The guidance hypothesis (Part et al., 2000; Salmoni et al., 1984; Schmidt et al., 1989; Winstein & Schmidt, 1989) explains the effectiveness of augmented feedback (e.g., knowledge of results) in learning a motor skill. However, if augmented feedback is provided too frequently, it can cause a dependency to develop on the delivered feedback. This dependency can cause depressed motor learning effects if the augmented feedback is later removed. Additionally, studies investigating visual attention have shown that there is a relationship between performance outcome and visual search behavior (Vickers, 1992; 1996).

Research on the topic of focus of attention often uses instructions that require participants to imagine the future performance of a motor skill to elicit an external focus (e.g., flight of a thrown dart in McKay & Wulf, 2012; the trajectory of a hit tennis ball in Wulf et al., 2000). However, examinations about the impact of providing instructions about the future performance of a skill on focus of attention have not been thoroughly investigated. This method of investigation is needed because directing attention toward a visible object or imagined object in a future performance may affect motor performance and learning. Based on this premise, it is important to note that focus of attention is a purely cognitive phenomenon and may not be directly linked to visual attention. For example, when instructing a jumping task a practitioner may direct attention to a performer's knees (i.e., an internal focus of attention) by telling them to focus on extending the knees as fast as possible when jumping. In this case, the practitioner does not mean to "look" at the knees. Rather, the practitioner means for the mover to think about the action of the knees while jumping. While research on visual attention is primarily concerned with the investigation regarding where and how a performer controls his/her gaze, research related to focus of attention is primarily concerned about addressing what a performer thinks about or pays attention to while executing a motor skill. Thus, visual attention and focus of attention are different bodies of research, both practically and theoretically.

However, there are occasions where prompting a particular focus of attention also aligns with visual attention. For example, in a recent study Porter et al. (2012) instructed participants to jump towards a cone that was placed in front of the mover at a distance of three meters. Such an instruction induced an external focus of attention while at the same time prompted a specific use of visual attention as the volunteer had to visually fixate on the present cone. While the cue used in that study directed attention cognitively towards the cone, it also directed participant's visual attention toward the same object. Studies examining the efficacy of visual attention have primarily examined hand-eye coordination (e.g., golf putting by Vickers, 1992; basketball free throws by Vickers, 1996) as it relates to the motor learning process. Moreover, these studies have examined the functions of vision while manipulating an object and how the function of hand-eye coordination influences the accuracy of a movement. Therefore, there is a limited theoretical explanation to directly explain how visual attention and cognitive attention may be associated with the performance of a skill that does not require the successful manipulation of an object (e.g., standing long jump). Therefore, it is essential to investigate how directing attention towards a visible target and an imagined (i.e., non-visible) target influences the focus of attention effect.

As described above, research on the topic of imagery has shown that utilizing imagery during practice can be beneficial for motor learning (Feltz & Landers, 1983; Hird et al., 1991). However, there is presently an insufficient theoretical rational to explain why directing cognitive attention through the use of imagery may affect motor performance and learning. Specifically, all previous literature examining the motor learning effects of imagery have examined a relatively long-term effect of practicing (e.g., nine days in Hird et al.,1991) through mental rehearsal or mental practice in the absence of physical practice. In the proposed study, participants were told to imagine an object, but the imagination of a target was not practiced. That is, participants were provided an instruction that required them to imagine an object while they physically practiced a motor skill. Another theoretical limitation of the existing body of research on the topic of imagery and motor learning is that the utilization of mental practice has been specific to learning a movement pattern or movement sequence (e.g., mental practice on moving pins or rotary pursuit tracker in Hird et al., 1991). In the present study, the provision of imagery instruction was not movement-related. That is, performers were not instructed to imagine their performance (i.e., mentally rehearse the task). Instead, performers were instructed to imagine an invisible target to elicit an external focus. Therefore, theories used to explain imagery effects did not directly apply to the present study because methods used in the present study were structurally different than those used in previous research to investigate the effects imagery has on the motor learning process. As discussed in the literature review, mental practice may have a neuromuscular or cognitive influence on motor performance (Jowdy & Harris, 1990). Then, it was hypothesized that cognitive processing would be prompted by asking a learner to image an object, which may partially influence the subsequent performance. However, the current study did not examine the rehearsal of a movement; therefore, the existing theories of neuromuscular adaptation by mental practice were not directly applicable to the results of the present study.

This lack of a theoretical framework generates a clear research question; specifically, what may cause possible differences between the two proposed types of external focusing instructions? It was hypothesized that practicing with a visible target would elicit an external focus of attention during practice. Specifically, this elicitation of an external focus of attention in this condition would be solely dependent on the visible target (e.g., a cone) being present. As a result of this dependency being developed, it was also predicted that if the cone was removed the beneficial effects of using an external focus of attention would be lost. However, if the learner practiced with an imagery cone, then the beneficial effects of adopting an external focus should be observed regardless if the cone is physically present or absent. Such findings would suggest that the present theoretical models of imagery may not be complete, and there are additional mechanisms that have yet to be discovered that explain the effects of imagery on the motor learning process. Therefore, the current study investigated the following questions: If a target is imagined, is it still possible to effectively elicit an external focus of attention when compared to eliciting an external focus with a visible target? Secondly, if an experimenter instructs a participant to imagine an object and focus on that imaginary object, does it have the same effect compared to having them direct their attention towards a visible target? Thus, the purpose of the present study was to investigate the difference between directing attention to a visible object and an imagined object when performing and learning the standing long jump. If directing attention towards visible and imaginary objects has the same effect on practice performance, then it seems plausible that practicing with a visible object may actually negatively affect the motor learning process. Based on the guidance hypothesis (Salmoni et al., 1984), a visible object may become a source of practice context dependency. As a result of this dependency being developed during practice, it was predicted that the removal of the visible object on a later post-test would result in a significantly degraded change in motor behavior. Thus, practicing with a visible object would be detrimental to motor learning if that object is not present during the post-test. Therefore, the following hypotheses were tested in this study:

- The group of participants that practice with mental imagery to elicit an external focus (e.g., imagining a target) could perform similarly on the post-test when a visible target is present compared to when the target is absent.
- It was also predicted that the group of participants that practiced with a visible target would perform similarly in the retention test when the visible target was present; however, it was also predicted that the same group would perform significantly worse on a post-test when there was no visible target.
- During the practice phase, two groups will not be significantly different across the eight trials.
- Also, during the practice phase, the performance of participants in each condition will not be significantly different across the eight trials.

CHAPTER 2

METHOD

Participants

Male undergraduate students (*N* = 42) were recruited from various courses offered in the Department of Kinesiology at Southern Illinois University Carbondale (SIUC). Participants were semi-randomly assigned to one of the two groups: Visible External Focus (VEF) group or Imagery External Focus (IEF) group. The mean and standard deviation (SD) of the participants' height, mass, and age (*n* = 21) in the IEF group were 179.24 cm (*SD* = 7.04), 84.24 kg (*SD* = 12.03), and 22.00 yrs (*SD* = 2.86), respectively. The mean and SD of the participants' height, mass, and age (*n* = 21) in the VEF group were 179.06 cm (*SD* = 6.79), 81.11 kg (*SD* = 13.33), and 21.48 yrs (*SD* = 1.47), respectively. For the raw scores of the participants height, weight, and age, please refer to Appendix A. Participants were excluded if they failed to complete the two assigned days of testing. The experimental methods, procedures, and informed consent were approved by the SIUC Human Subject Committee before any recruitment and data collection.

Apparatus and Task

All data collection took place in the Motor Behavior Lab in the Department of Kinesiology at SIUC. The task performed to test the hypotheses for the present study was the standing long jump for the following reasons: 1) it has been used to validate the effects of focus of attention in several previous studies (e.g., Porter et al., 2010; Wu et al., 2012), and 2) this task also provides the opportunity to have a visible external focus in a performer's sight, and thus appropriate to compare the visual and imagery testing conditions.

Participants were told to place their feet at a comfortable width apart with the tip of their shoes behind an orange piece of tape, which served as a start line on the jumping mat. Prior to the initiation of the practice trials, an experimenter asked participants to step on white chalk to cover the bottom of the soles of their shoes. Subsequent to each trial, the experimenter measured the distance from the start line to the nearest chalk mark of either foot from the start line. The tape measure was not visible during any trials. After each trial, a towel was used to erase the chalk marks after the distance of the jump had been recorded. Participants attempted a total of 22 jumps (two pre-test trials, ten practice trials, and ten retention test/post-test trials).

Procedure

Upon arrival to the Motor Behavior lab on day 1, participants were informed of the purpose and procedure of the study. Participants were also informed that they needed to visit the Motor Behavior lab at SIUC for two consecutive days at a specific appointed time to complete the study. With their agreement on the consent form, participants completed five minutes of brisk walking as a warm up. To ensure a proper warm up, the experimenter monitored the warm up session for the entire time. After the warm up, participants received general instructions about starting position. During this procedure, participants were told to look ahead after each jump and immediately sit in a chair to avoid any visual influences on the performance. Following this procedure, the pre-test was conducted for two trials with 60 seconds sitting rest in-between the trials. Participants were told to, “jump to the best of your ability.” No attentional focus instruction was provided during the pre-test. Then, the practice phase began. Participants attempted eight standing long jumps with 60 seconds sitting rest in-between the trials. Prior to each jump, participants were told to jump to the best of their ability and the importance of following the prescribed instructions. In addition, a specific instruction was provided to participants based on the assigned condition.

For the VEF group, a 22.9 cm tall cone was placed at the distance of 3.9 m from the start line. This cone served as the visual target for the VEF group. Participants in the VEF group were additionally instructed to "focus on jumping as close to the cone as possible." For the VEF condition, the visible target (i.e., cone) was on the mat throughout the practice phase. To make the situations as identical as possible, the experimenter momentarily showed and placed the same cone used for the VEF group at the same distance, and confirmed if the participants had imagined the cone at the same distance. There was a triangle shape attached with tape on the side of the gray cone. To confirm that participants looked at the cone, the experimenter asked "what was the color of the cone?" and "what shape did you see on the cone?" after removing the cone from the participants' sight. Then, participants in the IEF group were instructed to "imagine the cone that you just saw," and they were instructed to "focus on jumping as close to the imaginary cone as possible." To remind and confirm that they were following the instructions, the verbal instruction was provided immediately before each trial. After the eight jumps, participants were asked to revisit the Motor Behavior Lab the next day.

On the day two, the post-tests for all participants were performed in two formats: Five jumps with a cone placed at 3.9 m from the start line, and five jumps without a cone. In both situations, the participants did not receive any instruction besides to perform to the best of their ability. To eliminate the possibility of order effects, the two different post-tests were counterbalanced across the two conditions.

Data Analysis Procedure

Statistical analyses were conducted with the Statistical Package for the Social Sciences (SPSS) version 18 with an alpha level of 0.05. Outliers were set as ± 2 SD points from the mean of the jumping performances in the practice phase for the data analysis. Practice data were analyzed using a 2 (condition) X 8 (trials) ANOVA with repeated measures on the second factor to see if there were significant differences between the groups during the practice phase and eight practice trials within each group and the interaction of the trials of the IEF and VEF groups. Paired samples t-tests were conducted to analyze if there was a difference in the two different post-test conditions (No cone and Cone condition) for both IEF and VEF groups. Also, independent t-tests were conducted to see if there were differences in retaining the motor skill (i.e., the no cone condition of the IEF group, and the cone condition of the VEF group) and transferability of the motor skill in each group (i.e., the cone condition of the IEF group, and the no cone condition of the VEF group).

CHAPTER 3

RESULTS

A total of 42 participants completed the present study (IEF = 21, VEF = 21). None of the participants were identified as outliers, thus data from all participants were included in the statistical analyses. Pre-test trials were analyzed as a baseline measurement using an independent samples t-test. The analysis revealed there was no significant difference between the groups in the scores of the pre-test trials for the IEF (M = 195.47 cm, SD = 29.3) and VEF (M = 194.23 cm, SD = 31.4) groups; $t(82) = 1.87$, $p > 0.85$. For the SPSS output of the pre-test, please refer to Appendix B. For the raw scores of the pre-test trials, please refer to Appendix C. *Figure 3.1* provides a summary of the means for the IEF and VEF groups for each phase of the experiment (i.e., pre-test, practice phase, and post-tests).

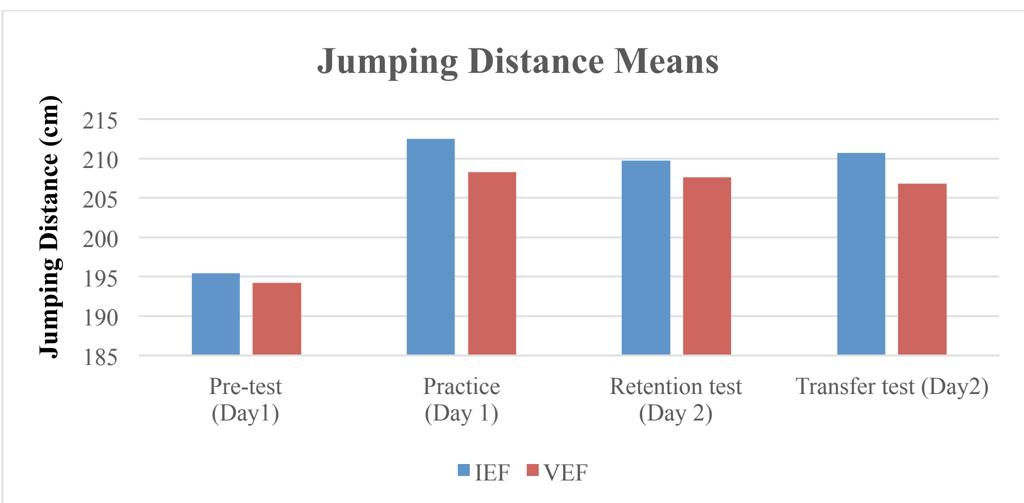

Figure 3.1 Performance means for the IEF and VEF groups in cm during the pre-test, practice, and post-tests.

Practice

A 2 (conditions) X 8 (trials) ANOVA with repeated measures on the second factor revealed there was a violation in sphericity. Thus, a Greenhouse-Geisser correction was applied to interpret the results across trials and between groups. Within the trials of each group, there were no differences throughout the practice session; $F(3.1, 124) = 2.13$, $p = 0.10$. Additionally, there was no significant interaction between conditions and trials; $F(3.1,124) = 0.91$, $p = 0.44$. Also, there was no significant difference between the groups during the practice phase; $F(1,40) = 0.23$, $p = 0.63$. Please refer to *Figure 3.2* below for a comparison of the jumping distances between the two groups during the practice phase of the experiment. For the SPSS output, please refer to Appendix D. For the raw scores of the practice phase, please refer to Appendix E.

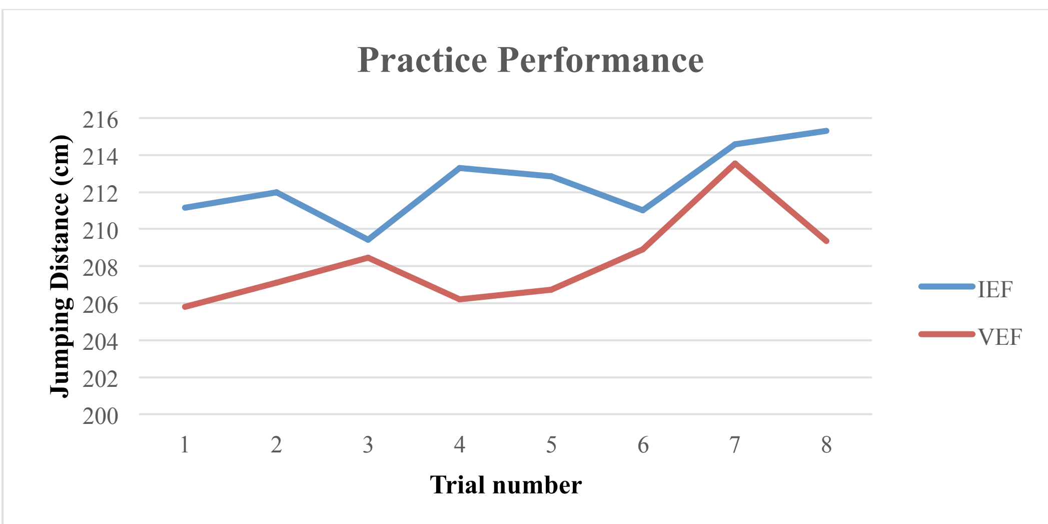

Figure 3.2. Average jump distances for both groups across the eight practice trials.

Post-Test

Within Group Comparison

There were two different post-tests conducted in the present study: Five trials with a cone present and five trials without cone. A paired samples t-test for the IEF group revealed no significant difference between the No-Cone (M = 209.75 cm, SD = 27.4) and Cone jumps (M = 210.73 cm, SD = 27.4); $t(104) = 6.16$, $p = 0.27$. There was also no difference between the No-Cone (M = 206.79 cm, SD = 29.5) and Cone jumps (M = 207.60 cm, SD = 26.5) completed by the VEF group; $t(104) = 7.88$, $p = 0.22$. *Figures 3.3* and *3.4* show the means of the five trials within the No-Cone and Cone conditions for the IEF and VEF groups, respectively. For the SPSS output for the IEF group, please refer to Appendix F. For the SPSS output for the VEF, please refer to Appendix G. For the raw scores of the post-tests for both groups, please refer to Appendix H.

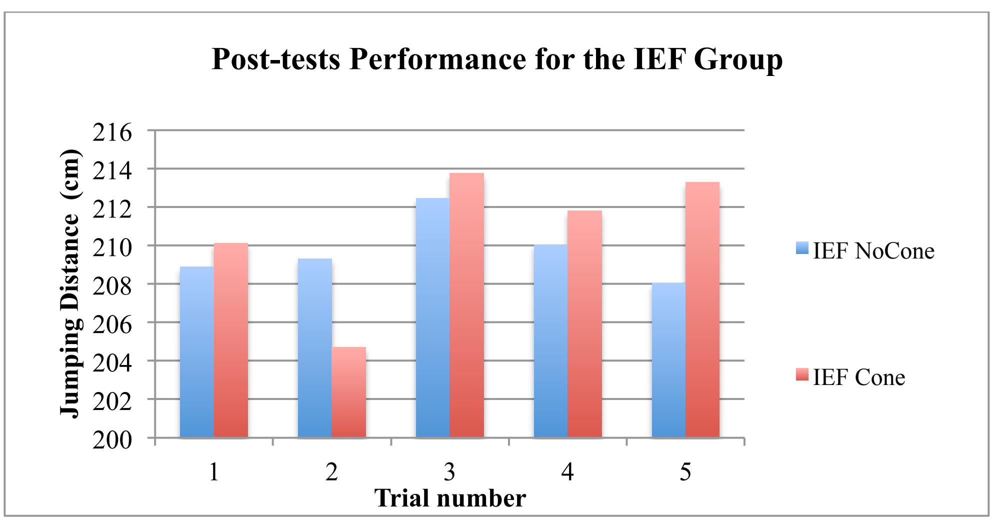

Figure 3.3 Means of the post-test performances of the IEF group.

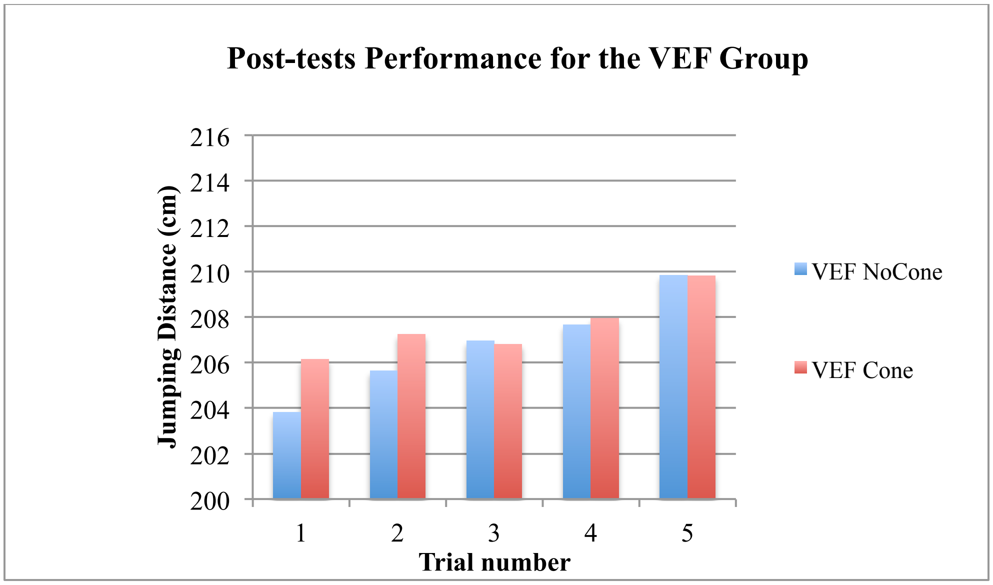

Figure 3.4 Means the post-test performances of the VEF group.

Between Group Comparison

Differences between the groups were analyzed using an independent samples *t*-test. It is important to note that the between group comparison was made between the No-Cone condition of the IEF group and the Cone condition of the VEF group for the retention test, whereas the transfer test was a comparison between the Cone condition of the IEF and the No-Cone condition of the VEF group. The purpose of the retention test was to evaluate the retainability of what was practiced, however, the transfer test assessed the participants' ability to adapt to a modified testing environment. An independent samples *t*-test did not reveal a significant difference between the IEF (M = 209.75 cm, SD = 27.4) and VEF (M = 207.60 cm, SD = 26.5) groups during the retention test; $t(208) = 0.575$, $p = 0.28$. Similarly, there was no difference during the transfer test between the IEF (M = 210.73 cm, SD = 27.4) and VEF groups (M = 206.79 cm, SD = 29.5); $t(206.89) = 1.01$, $p = 0.16$. *Figure 3.5* and *3.6* shows the means of the two groups during the retention and transfer tests, respectively. For the SPSS output, please refer to Appendix I and J for the retention and transfer test, respectively.

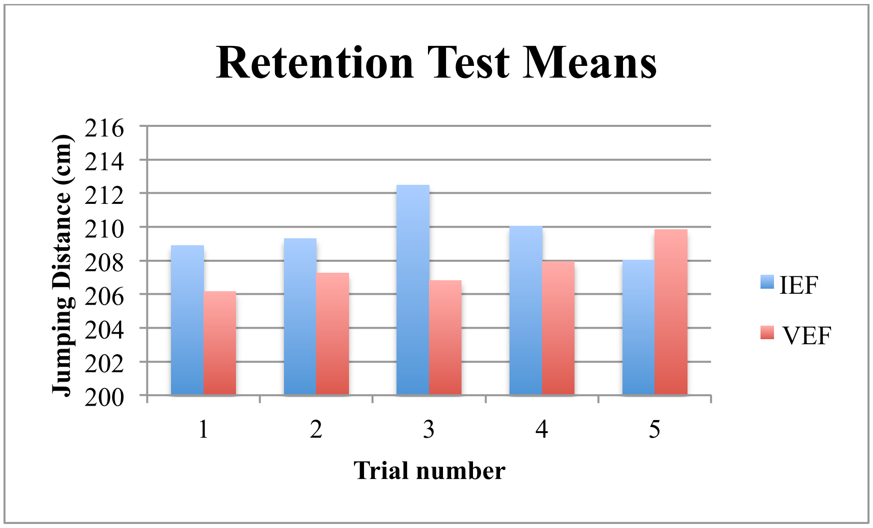

Figure 3.5 Means of the IEF (blue) and VEF (red) in the retention test.

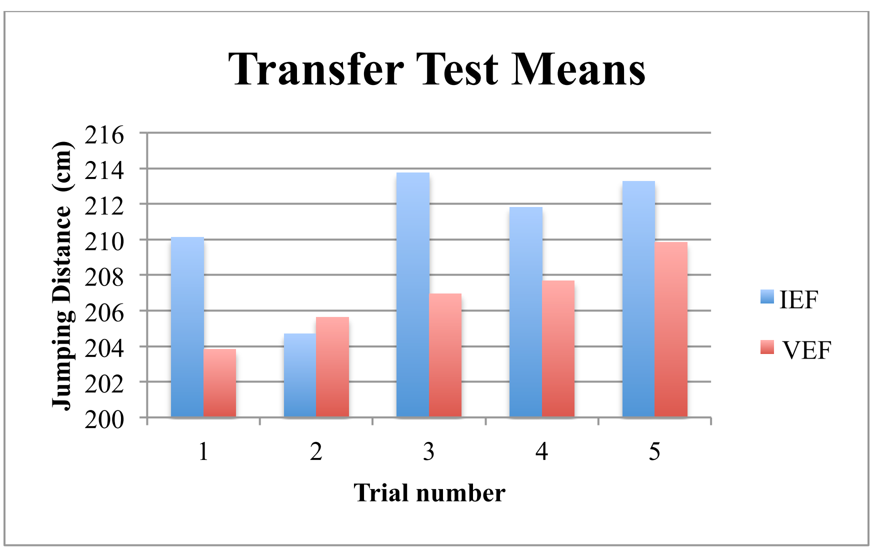

Figure 3.6 Means of the IEF (blue) and VEF (red) in the transfer test.

CHAPTER 4

DISCUSSION

Purpose and Predictions

The purpose of the present study was to investigate the effect of different types of instructions that were designed to elicit an external focus of attention. Specifically, the goal was to examine the influence of varying instructions on standing long jump performance by directing attention externally to a visible target or an imaginary target. It was hypothesized that 1) participants performing the standing long jump towards an imagined cone (i.e., IEF group) would perform similarly on the post-test with or without a cone; and 2) participants performing the standing long jump towards a visible cone (i.e., VEF group) would perform similarly on the post-test with a cone (i.e., the retention test); however, the same group would perform significantly worse on the post-test when the cone was removed (i.e., transfer test); and 3) the two groups would not perform differently across the practice trials; and finally, 4) performance of the participants within each condition would not be different across the practice trials.

The results of the study supported the first hypothesis regarding the IEF group—the participants who practiced with an imaginary cone did not differ in standing long jump performance in the post-test with or without a cone (i.e., the retention and transfer test). However, the second hypothesis, regarding the VEF group, was not supported. The results revealed that standing long jumping performance when the cone was removed (i.e., the transfer test) was not different from the retention test with a cone. The third and fourth hypotheses were also supported. That is, the standing long jump performance of the IEF and VEF groups did not differ between or within the groups during the practice phase of the experiment. Thus, both groups performed similarly during the practice phase. An in-depth discussion of the results of the experiment's different phases is provided in the following sections.

Practice

The fourth proposed hypothesis, which predicted there would be no difference across the practice trials, was established to investigate the inter-trial variability that existed within the groups. Of particular interest was the trial-trial variability of the IEF group. During the practice phase, the experimenter stood where the imaginary cone would be and each participant was momentarily shown on the first trial the actual cone that was used for the VEF group. Before the second trial, the cone was not shown to the participants, but the experimenter again stood and gestured to where the cone should be when imagined. From the third to the eighth trial, participants were asked to imagine the cone just like their previous jumps, and jump as close to the imaginary cone as possible. As described above, the instructions were essentially the same but became simplified as the number of trials increased to avoid redundancy. If there were a significant difference across the trials, it would suggest that the instructions were ineffective in eliciting the participants to correctly imagine the cone. However, considering there was no change in jumping performance within the IEF, the findings of the statistical analysis indicate that asking participants to imagine a cone was just as effective as initially showing them the cone.

Post-Tests: The Guidance Hypothesis Interpretation

The primary aims in the present study were 1) to investigate whether the use of a cone to elicit an external focus of attention developed a dependency during the practice phase, which negates learning effects in the post-test when the cone was removed; and 2) to investigate whether there were performance differences induced by the two forms of external foci instructions. Based on these aims, the primary hypothesis of the present thesis was established in accordance with the guidance hypothesis (Salmoni et al., 1984). The first hypothesis, that the IEF group would not differ in the post-test with or without a cone, was supported. However, the second hypothesis, that participants in the VEF group would perform worse during the post-test when the cone was removed, was not supported. There was, again, no difference between the Cone and No-Cone conditions in the VEF group. Consequently, it does not appear that the VEF developed a dependency on having the cone present during practice. This finding is not consistent with the predictions of the guidance hypothesis.

The results of the present study showed that the standing long jump performance of the VEF group did not change when the cone was removed during the transfer test. If such a dependency were developed, then there should have been a significant drop in jump performance when the cone was removed, which was not the case. In addition, there was no difference between the IEF and VEF groups in the retention or transfer tests. When the results of this study are examined as a whole, it appears that a cone being present did not hinder or enhance the jump performance relative to imagining a target cone.

Post-Tests: Visual influence of Focus of Attention.

As noted above, there was no difference between the IEF and VEF groups during the retention or transfer tests. These findings provide further evidence that the participants' ability to effectively direct their attention externally was not reliant on the cone being physically present on the jump mat. Furthermore, this lack of difference between the two experimental groups provides additional evidence that the focus of attention effect is driven by underlying cognitive mechanisms rather than available visual information.

These results are consistent with previous research that has investigated the role of visual information on the focus of attention effect. For example, a study conducted by Makaruk, Porter, and Makaruk (2013) had thirty elite-level male shot-putters attempt to throw the shot with underhand and overhand throws using an internal, external, or neutral focus of attention. Participants were instructed to throw the shot to a target that was placed out in front of the throwing ring. During the underhand throws, participants faced the field so that the target was in sight of the athletes. However, the overhead throws were attempted facing away from the field. Thus, participants could not see the target. The results of that study revealed the benefits of utilizing an external focus of attention were significant in both overhead and underhand throws, which indicated performance enhancements were not dependent on the athlete being able to visually see the desired target. Furthermore, Schlesinger, Porter, and Russell (2013) conducted a study using a manual tracking task to investigate the impact of visual attention relative to cognitive focus of attention. Participants were asked to track a target displayed on a computer screen that moved in unpredicted patterns. On some of the trials, the target was partially visually occluded. The results showed there was no significant interaction between full vision trials and partially occluded trials. The results of the present study along with the findings of Makaruk et al. (2013) and Schlesinger et al. (2013) provide compelling evidence that the efficacy of utilizing an external focus of attention does not depend on available visual information.

Imagery Influence of Focus of Attention

As described in Chapter 1, the theories that have been proposed to explain the effectiveness of imagery on motor performance are not directly applicable to the theoretical model of the present study. This is because previous literature examined the effects of imagery over relatively long periods of time in the absence of physical practice (e.g., 9 days in Hird et al.,1991). In the present study participants did not practice the standing long jump through a traditional use of imagery, and the practice session was relatively short (i.e., eight trials).

Participants were simply asked to imagine a cone immediately before each trial. In other words, imagery was used in addition to physical practice rather than in the absence of physical practice. Secondly, participants in the present study were asked to imagine a cone prior to performing the standing long jump. Previous research that examined the effects of imagery on the motor learning process (e.g., Hird et al, 1991) had investigated the influence of mental practice by mentally rehearsing movements that were required to successfully execute a motor skill rather than imagining an object in the environment in relation to the performance of a motor skill. These structural differences in methodology generated the lack of theoretical explanations for the hypotheses proposed in the present study.

The benefits of imagery on the motor learning process have been shown in a number of studies (e.g., Guillot, Desliens, Rouyer, & Rogowski, 2013; Hird et al.,1991; Van Gyn, Wenger, & Gual, 1990). However, the effects of how imagining an object in the environment influences the motor performance and learning process had not been investigated prior to the present experiment. The results of the present study suggest that directing attention towards an imagined cone was equally effective as directing attention towards a cone that was physically present.

Limitations

As is the case with all research, the present study is not without limitations that need to be discussed. One of the limitations was the absence of a control condition or a condition that was instructed to focus their attention internally. Since the primary purpose of the current study was to investigate the different types of external focus of attention instructions, and possible interaction with the use of imagery to prompt an external focus, an internal focusing group was not included. However, the inclusion of both an internal and control condition may have provided a deeper understanding of how directing attention externally through the use of imagery compared to directing attention internally or neutrally (i.e., control condition). This is a possibility that needs to be addressed in future research.

Another limitation of the present experiment that needs to be noted is the relatively low number of practice trials. Although the number of practice trials were limited to eight trials due to physiological fatigue concerns when performing a motor skill that requires maximal power output such as the standing long jump, the number of trials may not have been sufficient to elicit changes in motor learning. Previous studies (e.g., Porter et al., 2010; Wu et al., 2012) that examined the focus of attention effect on standing long jump performance had fewer trials during practice with no retention test. Based on the methods used in previous focus of attention research (Porter et al., 2010; Wu et al., 2012) utilizing the standing long jump, eight practice trials should have been enough to elicit performance effects if the independent variable was powerful enough. However, it is possible that additional days of practice might have changed the outcomes observed in the present experiment.

Future Directions

The results of the thesis can be used as a framework in future research through additional experimentation. First, it would be valuable to develop a study to examine how focus of attention can be directed towards multiple imagined objects. The results of the present study showed that there was statistically no difference between directing attention to a single visible or single imagined object. Then it may be valuable to examine if directing attention to multiple objects will show the same effect. For example, participants in the visible group could practice with multiple visible objects (e.g., several cones) that are placed in increments of increasing distance. Then participants would be instructed to jump with a single leg as close to the first cone as possible, and then jump with the other leg as close to the second cone as possible, and so on until all cones have been reached. Participants in the imagery group would be instructed to imagine multiple cones at increasing distances. If imagining multiple cones changes the motor performance between the visible and imagery group, it would be theoretically important to investigate what causes the difference between the results of the present study and this possible future experiment.

Lastly, another consideration for future research is to test imagery ability prior to data collection. Previous research has demonstrated that the vividness of one's imagination (i.e., imagery ability) affects the impact mental practice has on the motor learning process (e.g., Issac, 1992; Robin, Dominique, Toussaint, Blandin, Guillot, & Her, 2007). Thus, it would be theoretically important to have participants take an imagery ability test prior to data collection and categorize participants based on the vividness of their imaginations. This method would allow the researcher to test if imagery ability has an impact on how directing attention externally towards an imagined target influences motor performance. It is possible that participants with high imagery ability may benefit more from this form of practice compared to participants with low imagery ability.

Conclusion and Practical Application

Previous studies that have examined the effects of focus of attention on learning a motor skill often use equipment (e.g., cone) to direct attention or the strategy of imagining a future performance (e.g., trajectory of a ball) to properly focus attention. What was unclear prior to this thesis was how the focus of attention effect is impacted by the use of imagery. The present study investigated the difference between directing attention to a visible object and an imagined object when performing and learning the standing long jump. The results of the present study provided additional support that focus of attention and visual attention are two distinct aspects of motor behavior. That is, when participants were instructed to direct their attention toward an imaginary cone they performed just as well as participants that focus their attention on a visible cone. Therefore, the primary finding of the present experiment is that the focus of attention effect can be induced through the use of imagery. This is a noteworthy observation and makes a unique contribution to the existing bodies of research examining focus of attention and imagery.

In addition to the scientific contributions this study makes to the existing body of research, the results of the present study also have practical implications. For example, sport coaches and strength and conditioning specialists often use equipment such as hurdles, cones, and ladders during practice and training sessions. Some of the necessary equipment can be expensive, and the absence of some pieces of equipment can affect the quality of the training environment. However, the results of the present study show that enhancing motor performance may be possible in the absence of training equipment. That is, directing attention to an imagined object may have the same effect as directing their attention to a visible object or target. Such a finding provides valuable insight for practitioners who do not have accesses to desired equipment. Additionally, in a situation where the mover is unable to see a desired target due to impaired vision or blindness, directing attention to a visible object is not effective. Therefore, directing attention to an imagined object provides an alternative form of practice for both the patient and the practitioner.

Furthermore, directing attention to an imagined target can offer additional training benefits. For example, if a practitioner intends to direct attention within a three-dimensional environment, the desired point of attentional direction may not be on the floor, wall, or ceiling. Rather, attention may need to be directed to a specific location in space. For instance, a basketball coach teaching an athlete to shoot with a higher arch would want to direct the athlete's attention to an apex of the desired arch to increase his or her shooting angle. This creates a challenge because the coach cannot place an object in the air which can then be used to direct the basketball players focus of attention. In this case, having the athlete imagine an object in the air would provide the opportunity for attention to be effectively directed to improve basketball shooting mechanics. Although further studies will be necessary to support these ideas, the results of the present study suggest that there is no difference between directing attention to a visible object and an imagined object; and thus, the benefits of directing attention to an imagined object has great practical use.

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APPENDICES

APPENDIX A

IEF Group

PARTICIPANT	HEIGHT(cm)	MASS (kg)	AGE(yrs)
1	177.8	98.9	23
2	182.9	86.2	20
3	177.6	65.8	20
4	167.6	93	22
5	190.5	79.4	20
6	188	92.1	23
7	170.2	74.8	23
8	175.3	99.8	21
9	180.3	80.3	23
10	177.8	105.7	33
11	180.3	77.1	21
12	188	97.5	20
13	182.9	88.5	23
14	177.8	92.5	20
15	167.6	54.4	23
16	182.9	79.4	21
17	182.9	79.4	21
18	167.6	73.5	20
19	175.3	83	24
20	190.5	83.9	20
21	180.3	83.9	21
MEAN	179.24	84.24	22.00
SD	7.04	12.03	2.86

VEF group

PARTICIPANT	HEIGHT (cm)	MASS(kg)	AGE(yrs)
22	174	59	23
23	180.3	88.5	22
24	185.4	78.9	19
25	170.2	87.1	22
26	177.8	63.5	19
27	180.3	85.3	19
28	182.9	72.6	22
29	195.6	102.1	21
30	180.3	108.9	21
31	180.3	90	23
32	170.2	77.1	24
33	172.7	91.2	20
34	185.4	79.8	21
35	185.4	77.1	21
36	182.9	83.9	22
37	170.2	74.8	20
38	167.6	83	23
39	177.8	64.4	22
40	180.3	88	23
41	185.4	99.8	23
42	175.3	79.4	21
MEAN	179.06	82.59	21.48
SD	6.79	12.44	1.47

APPENDIX B

Independent samples test

	Levene's Test for Equality of Variance		t-test for Equality of means				
	F	Sig.	t	df	Sig. (2-tailed)	Mean difference	Std. Error Difference
Performance Equal variance assumed	.112	.739	.187	82	.852	1.24048	6.62669
Equal variance not assumed			.187	81.635	.852	.24048	6.62669

Descriptive data

Groups	N	Mean	Std. Deviation	Std. Error Mean
Performance 1	42	195.4714	29.33433	4.52639
2	42	194.2310	21.26632	4.83993

APPENDIX C

The IEF group: Pre-test raw scores and average.

Participant	**1**	**2**	**3**	**4**	**5**	
Trial 1	152.4	233.0	162.4	165.2	236.4	
Trial 2	150.0	234.8	164.8	182.4	253.0	
Participant	**6**	**7**	**8**	**9**	**10**	
Trial 1	160.4	188.2	202.8	172.2	191.8	
Trial 2	160.4	191.8	220.6	165.2	194.8	
Participant	**11**	**12**	**13**	**14**	**15**	
Trial 1	165.2	206.2	204.2	206.0	225.8	
Trial 2	157.2	201.2	206.0	206.6	230.6	
Participant	**16**	**17**	**18**	**19**	**20**	**21**
Trial 1	248.0	177.6	171.2	188.6	186.6	203.4
Trial 2	265.0	187.6	174.0	192.0	193.0	231.2

The VEF group Pre-test raw scores and average.

Participant	**22**	**23**	**24**	**25**	**26**	
Trial 1	220.8	140.8	189.2	127.2	193.0	
Trial 2	224.0	147.0	191.0	145.8	203.4	
Participant	**27**	**28**	**29**	**30**	**31**	
Trial 1	200.8	239.0	232.2	179.6	238.6	
Trial 2	215.8	240.6	247.0	187.7	250.8	
Participant	**32**	**33**	**34**	**35**	**36**	
Trial 1	155.6	189.2	242.0	208.6	167.2	
Trial 2	153.0	202.8	242.4	213.6	169.2	
Participant	**37**	**38**	**39**	**40**	**41**	**42**
Trial1	181.2	170.0	172.0	189.0	192.8	180.8
Trial2	171.0	179.0	202.4	195.0	186.0	180.6

APPENDIX D

Mauchly's Test of Sphericity[a]

Measure: MEASURE_1

Within Subjects Effect	Mauchly's W	Approx. Chi-Square	df	Sig.	Epsilon[b] Greenhouse-Geisser	Epsilon Huynh-Feldt	Epsilon Lower-bound
Performance	.068	100.791	27	.000	.443	.496	.143

Tests of Within-Subjects Effects

Source		Type III Sum of Squares	df	Mean Square	F	Sig.
Performance	Sphericity Assumed	1037.518	7	148.217	2.128	.041
	Greenhouse-Geisser	1037.518	3.100	334.670	2.128	.098
	Huynh-Feldt	1037.518	3.474	298.618	2.128	.090
	Lower-bound	1037.518	1.000	1037.518	2.128	.152
Performance * Groups	Sphericity Assumed	442.369	7	63.196	.908	.501
	Greenhouse-Geisser	442.369	3.100	142.694	.908	.442
	Huynh-Feldt	442.369	3.474	127.322	.908	.451
	Lower-bound	442.369	1.000	442.369	.908	.346
Error(Performance)	Sphericity Assumed	19498.370	280	69.637		
	Greenhouse-Geisser	19498.370	124.005	157.239		
	Huynh-Feldt	19498.370	138.976	140.300		
	Lower-bound	19498.370	40.000	487.459		

Tests of Between-Subjects Effects

Measure: MEASURE_1

Transformed Variable: Average

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Intercept	14868463.574	1	14868463.574	2342.473	.000
Groups	1470.860	1	1470.860	.232	.633
Error	253893.448	40	6347.336		

Between-Subjects Factors

		N
Groups	1	21
	2	21

APPENDIX E

The IEF group: Practice phase raw scores and average.

Participant	**1**	**2**	**3**	**4**	**5**
Trial 1	153.6	236.4	165.4	198.8	247.0
Trial 2	172.2	251.0	176.4	189.2	247.2
Trial 3	164.8	221.8	173.4	189.4	248.2
Trial 4	159.6	237.8	168.8	195.8	246.0
Trial 5	176.8	240.4	169.8	193.4	245.0
Trial 6	164.4	243.4	175.0	198.0	243.6
Trial 7	170.0	236.8	175.8	192.0	246.8
Trial 8	162.4	251.0	166.0	195.8	242.0
Average	165.5	239.8	171.3	194.1	245.7

Participant	**6**	**7**	**8**	**9**	**10**
Trial 1	169.0	191.2	258.8	222.2	194.4
Trial 2	184.0	204.4	257.0	212.4	196.0
Trial 3	180.4	198.2	256.8	216.8	197.4
Trial 4	196.8	205.2	256.0	225.0	196.4
Trial 5	199.2	207.2	260.4	213.8	195.2
Trial 6	180.0	214.0	249.0	225.4	199.6
Trial 7	200.6	215.2	255.8	222.8	197.8
Trial 8	204.0	215.4	255.0	220.0	208.2
Average	189.3	206.4	256.1	219.8	198.1

Participant	**11**	**12**	**13**	**14**	**15**
Trial 1	176.6	225.8	215.8	219.0	242.0
Trial 2	163.8	205.6	214.6	216.6	247.2
Trial 3	177.4	230.6	215.6	212.8	240.4
Trial 4	172.2	236.2	217.8	218.4	251.6
Trial 5	165.6	231.8	212.0	222.2	250.0
Trial 6	165.6	229.2	216.8	217.0	239.2
Trial 7	176.6	227.0	212.8	215.6	248.6
Trial 8	176.8	234.0	217.0	214.0	249.6
Average	171.8	227.5	215.3	217.0	246.1

Participant	16	17	18	19	20	21
Trial 1	277.6	205.6	196.0	200.6	193.0	245.6
Trial 2	275.0	200.2	192.6	199.4	199.6	247.0
Trial 3	261.2	200.4	191.6	189.6	198.0	233.0
Trial 4	267.8	192.2	193.4	199.0	199.0	243.8
Trial 5	267.2	198.6	181.2	200.6	205.0	234.6
Trial 6	261.0	197.2	194.6	191.8	193.8	233.0
Trial 7	270.6	198.6	191.2	207.8	194.8	248.8
Trial 8	272.8	193.8	188.8	196.0	206.0	253.0
Average	269.2	198.3	191.2	198.1	198.7	242.4

VEF group: Practice phase raw scores and average

Participant	22	23	24	25	26
Trial 1	230.0	167.0	209.4	173.8	198.2
Trial 2	237.2	167.6	211.4	172.8	218.6
Trial 3	233.0	187.2	218.6	165.4	208.0
Trial 4	233.4	179.2	213.4	170.4	211.0
Trial 5	220.0	179.0	214.6	167.4	217.2
Trial 6	223.8	174.4	208.4	167.8	217.2
Trial 7	216.0	174.6	215.0	166.6	217.6
Trial 8	229.6	163.2	212.8	168.8	204.0
Average	227.9	174.0	213.0	169.1	211.5

Participant	27	28	29	30	31
Trial 1	192.0	243.6	266.6	178.2	243.0
Trial 2	206.8	247.2	264.2	178.2	245.0
Trial 3	213.0	234.8	254.1	178.4	240.6
Trial 4	199.2	242.2	251.0	178.0	250.0
Trial 5	198.8	237.2	260.3	179.2	238.0
Trial 6	208.2	234.0	261.2	179.0	245.8
Trial 7	213.0	250.8	254.4	178.0	250.6
Trial 8	207.8	246.0	262.3	177.0	243.4
Average	204.9	242.0	259.3	178.3	244.6

Participant	32	33	34	35	36
Trial 1	176.4	210.0	252.4	216.8	184.2
Trial 2	171.0	213.6	254.6	208.8	180.0
Trial 3	169.2	216.8	249.4	215.6	190.0
Trial 4	169.8	212.0	261.8	196.7	186.4
Trial 5	152.4	218.4	268.6	212.2	197.4
Trial 6	165.0	223.0	259.0	208.8	193.2
Trial 7	164.6	220.8	270.2	209.0	292.6
Trial 8	168.0	229.0	254.0	209.0	196.0
Average	167.1	218.0	258.8	209.6	202.5

Participant	37	38	39	40	41	42
Trial 1	198.4	184.6	200.3	198.0	200.6	198.2
Trial 2	181	173	213.0	200.0	209.6	196.0
Trial 3	194.4	183.4	216.9	201.2	213.2	194.6
Trial 4	183.0	181.6	205.0	211.2	199.0	196.0
Trial 5	200.0	175.4	189.4	209.4	214.0	192.0
Trial 6	196.0	175.6	205.2	213.8	224.8	203.2
Trial 7	192.0	172.0	202.4	214.4	216.0	194.2
Trial 8	200.0	186.0	203.0	218.0	217.0	201.6
Average	193.10	178.95	204.40	208.25	211.78	196.98

APPENDIX F

Post-test SPSS output: The IEF No Cone condition and Cone condition

Paired Samples Statistics

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	NoCone	209.7486	105	27.43458	2.67734
	Cone	210.7305	105	27.36662	2.67071

Paired Samples Test

	Paired Differences				
				95% Confidence Interval of the Difference	
	Mean	Std. Deviation	Std. Error Mean	Lower	Upper
Pair 1 NoCone - Cone	-.98190	16.34469	1.59508	-4.14501	2.18120

Paired Samples Test

		t	df	Sig. (2-tailed)
Pair 1	NoCone - Cone	-.616	104	.540

APPENDIX G

Post-test SPSS output: VEF No Cone condition and Cone condition

Paired Samples Statistics

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	NoCone	206.7886	105	29.45706	2.87471
	Cone	207.6048	105	26.54184	2.59022

Paired Samples Test

	Paired Differences				
				95% Confidence Interval of the Difference	
	Mean	Std. Deviation	Std. Error Mean	Lower	Upper
Pair 1 NoCone - Cone	-.81619	10.61766	1.03618	-2.87097	1.23859

Paired Samples Test

		t	df	Sig. (2-tailed)
Pair 1	NoCone - Cone	-.788	104	.433

APPENDIX H

The IEF Post-test scores, average of each test, & overall average.

Participant	**1**	**2**	**3**	**4**	**5**
Trial 1 cone	180.0	235.0	167.0	204.2	229.8
Trial 2 cone	174.8	245.0	170.8	193.0	231.4
Trial 3 cone	178.0	234.8	167.2	201.4	232.4
Trial 4 cone	179.0	246.2	167.8	198.2	230.0
Trial 5 cone	174.8	241.4	170.6	194.0	232.0
Average	177.3	240.5	168.7	198.2	231.1
Trial 6 no cone	167.6	250.2	162.0	207.6	227.2
Trial 7 no cone	183.4	234.4	167.2	201.8	228.9
Trial 8 no cone	170.6	246.0	168.4	206.2	229.9
Trial 9 no cone	171.4	245.8	162.2	206.0	233.2
Trial 10 no cone	182.6	243.8	167.0	202.4	130.3
Average	175.1	244.0	165.4	204.8	209.9
Overall AVE.	176.2	242.3	167.0	201.5	220.5

Participant	**6**	**7**	**8**	**9**	**10**
Trial 1 cone	203.1	204.9	229.2	213.0	196.8
Trial 2 cone	95.8	213.4	229.4	210.0	198.2
Trial 3 cone	204.7	209.9	242.2	214.0	198.0
Trial 4 cone	201.3	203.5	250.4	227.8	200.0
Trial 5 cone	201.3	210.0	242.2	235.8	196.0
Average	181.2	208.3	238.7	220.1	197.8
Trial 6 no cone	205.7	211.4	252.6	229.6	189.0
Trial 7 no cone	193.0	211.0	252.8	213.0	189.6
Trial 8 no cone	205.4	209.7	253.6	222.2	201.6
Trial 9 no cone	183.8	203.4	255.0	202.2	195.2
Trial 10 no cone	206.8	202.9	255.0	234.6	192.0
Average	198.9	207.7	253.8	220.3	193.5
Overall AVE.	190.1	208.0	246.2	220.2	195.6

Participant	11	12	13	14	15
Trial 1 cone	175	224.6	208.2	220.2	234.4
Trial 2 cone	168.2	230.2	209.6	214	246
Trial 3 cone	177.2	224.8	214	220	252
Trial 4 cone	168.2	220.6	218	207.2	241.6
Trial 5 cone	168.2	222.6	215	217.2	236.6
Average	171.4	224.6	213.0	215.7	242.1
Trial 6 no cone	161	221.2	212.2	211	235.8
Trial 7 no cone	154.2	225.8	215.2	209	232.6
Trial 8 no cone	168.8	225.6	216.6	202.6	237.8
Trial 9 no cone	164.2	228	214.2	216	242.4
Trial 10 no cone	164.2	224.8	220	210.6	242.6
Average	162.5	225.1	215.6	209.8	238.2
Overall AVE.	166.9	224.8	214.3	212.8	240.2

Participant	16	17	18	19	20	21
Trial 1 cone	257.2	197.6	194.2	192.0	201.0	245.2
Trial 2 cone	261.8	196.8	192.8	193.0	193.0	231.6
Trial 3 cone	269.0	203.0	201.0	196.0	212.0	237.0
Trial 4 cone	265.0	203.0	200.0	192.4	200.6	227.0
Trial 5 cone	274.0	203.4	198.8	197.0	207.0	241.0
Average	265.4	200.8	197.4	194.1	202.7	236.4
Trial 6 no cone	240.6	186.2	200.4	191.4	192.8	231.0
Trial 7 no cone	262.4	191.6	195.0	203.2	193.0	238.6
Trial 8 no cone	265.6	189.4	199.6	200.0	211.0	231.2
Trial 9 no cone	259.2	191.0	199.6	196.0	208.0	234.0
Trial 10 no cone	249.0	197.8	205.8	196.8	202.6	237.2
Average	255.4	191.2	200.1	197.5	201.5	234.4
Overall AVE.	260.4	196.0	198.7	195.8	202.1	235.4

The VEF Post-test Scores, Average of Each Test, & Overall Average.

Participant	**22**	**23**	**24**	**25**	**26**
Trial 1 cone	229.2	175.4	218.2	174.0	200.0
Trial 2 cone	224.8	169.0	226.0	167.2	199.1
Trial 3 cone	222.0	184.0	213.4	166.0	201.7
Trial 4 cone	229.0	176.0	230.8	172.4	207.2
Trial 5 cone	229.2	179.6	220.0	173.8	204.1
Average	226.8	176.8	221.7	170.7	202.4
Trial 6 no cone	224.8	153.0	208.2	169.2	200.1
Trial 7 no cone	220.0	158.0	208.8	167.2	202.9
Trial 8 no cone	225.2	170.2	222.2	169.4	209.0
Trial 9 no cone	225.0	172.2	218.6	161.0	199.8
Trial 10 no cone	238.2	173.2	231.2	162.8	203.8
Average	226.6	165.3	217.8	165.9	203.1
Overall AVE.	226.7	171.1	219.7	168.3	202.8

Participant	**27**	**28**	**29**	**30**	**31**
Trial 1 cone	205.2	227.2	256.0	186.2	244.0
Trial 2 cone	214.0	227.0	262.8	182.4	239.0
Trial 3 cone	206.2	226.8	256.0	173.2	241.0
Trial 4 cone	202.6	226.0	252.2	177.0	242.0
Trial 5 cone	195.8	245.0	260.2	176.8	241.0
Average	204.8	230.4	257.4	179.1	241.4
Trial 6 no cone	204.2	239.2	254.6	177.2	241.0
Trial 7 no cone	203.2	245.0	239.8	187.0	241.0
Trial 8 no cone	203.8	246.0	239.0	187.0	242.0
Trial 9 no cone	202.2	240.0	249.6	183.4	236.6
Trial 10 no cone	221.6	249.0	247.0	184.0	243.8
Average	207.0	243.8	246.0	183.7	240.9
Overall AVE.	205.9	237.1	251.7	181.4	241.1

Participant	32	33	34	35	36
Trial 1 cone	170.0	218.0	242.6	206.6	200.0
Trial 2 cone	162.6	226.2	259.0	201.4	193.2
Trial 3 cone	165.2	229.6	254.2	204.6	199.4
Trial 4 cone	162.8	223.6	266.4	202.0	206.8
Trial 5 cone	171.2	230.8	260.6	215.2	191.0
Average	166.4	225.6	256.6	206.0	198.1
Trial 6 no cone	156.0	233.0	265.6	205.2	181.2
Trial 7 no cone	156.0	232.6	262.6	208.4	192.6
Trial 8 no cone	162.0	222.6	268.0	207.6	192.0
Trial 9 no cone	168.2	238.0	267.4	206.2	199.0
Trial 10 no cone	163.0	227.6	273.4	189.0	191.0
Average	161.0	230.8	267.4	203.3	191.2
Overall AVE.	163.7	228.2	262.0	204.6	194.6

Participant	37	38	39	40	41	42
Trial 1 cone	192.4	177.6	201.2	208.0	214.6	183.0
Trial 2 cone	190.2	181.2	207.4	202.8	213.0	204.0
Trial 3 cone	202.0	177.0	205.8	214.0	217.2	184.0
Trial 4 cone	180.4	173.6	200.0	214.2	226.8	195.2
Trial 5 cone	181.0	179.0	209.8	228.2	222.0	192.2
Average	189.2	177.7	204.8	213.4	218.7	191.7
Trial 6 no cone	175.2	172.6	188.0	227.0	211.2	193.8
Trial 7 no cone	181.8	173.4	205.2	221.2	213.8	198.0
Trial 8 no cone	179.8	171.6	209.2	210.0	207.6	202.0
Trial 9 no cone	175.0	167.2	214.0	225.2	213.0	199.6
Trial 10 no cone	182.6	173.2	211.0	218.0	219.6	203.6
Average	178.9	171.6	205.5	220.3	213.0	199.4
Overall AVE.	184.0	174.6	205.2	216.9	215.9	195.5

APPENDIX I

Post-test SPSS output: Retention test (the IEF No Cone condition and VEF Cone condition)

Group Statistics

	Group	N	Mean	Std. Deviation	Std. Error Mean
Retention	1	105	209.7486	27.43458	2.67734
	2	105	207.6048	26.54184	2.59022

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means	
		F	Sig.	t	df
Retention	Equal variances assumed	.002	.963	.575	208
	Equal variances not assumed			.575	207.773

Independent Samples Test

		t-test for Equality of Means			
					95% Confidence Interval of the Difference
		Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower
Retention	Equal variances assumed	.566	2.14381	3.72524	-5.20025
	Equal variances not assumed	.566	2.14381	3.72524	-5.20030

APPENDIX J

Post-test SPSS output: Transfer (the IEF Cone condition and VEF No Cone condition)

Group Statistics

	Groups	N	Mean	Std. Deviation	Std. Error Mean
Transfer	1	105	210.7305	27.36662	2.67071
	2	105	206.7886	29.45706	2.87471

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means	
		F	Sig.	t	df
Transfer	Equal variances assumed	1.439	.232	1.005	208
	Equal variances not assumed			1.005	206.883

Independent Samples Test

		t-test for Equality of Means			
					95% Confidence Interval of the Difference
		Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower
Transfer	Equal variances assumed	.316	3.94190	3.92386	-3.79373
	Equal variances not assumed	.316	3.94190	3.92386	-3.79397

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