ABSTRACT

IMAGERY SPEED, TASK DIFFICULTY, AND SELF-EFFICACY: HOW FAST (OR SLOW) TO GO?

by Samuel Forlenza

The Timing element of the PETTLEP model of imagery (Holmes & Collins, 2001) suggests that real-time imagery should lead to the best performance because it is functionally equivalent. However, empirical findings to date have been mixed. The primary purpose of the present investigation was to explore how different imagery speeds affected the performance of a task at two different difficulty levels along with self-efficacy beliefs. Sixty two university students were randomly assigned to one of three imagery groups (slow-motion, real-time, or fast-motion) or to a control group. Participants completed a series a golf putts at two difficulty levels at two times (pre and post). Results indicated the imagery groups did not perform significantly different from each other or significantly better than the control group, contrasting the PETTLEP model’s predictions. However, non-significant trends emerged. Limitations such as low power and large standard deviations may have contributed to a lack of significance.
IMAGERY SPEED, TASK DIFFICULTY, AND SELF-EFFICACY: HOW FAST (OR SLOW) TO GO?

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Imagery Speed, Task Difficulty, and Self-Efficacy: How Fast (or Slow) to Go?

Imagery can be defined as “using all the senses to re-create or create an experience in the mind” (Vealey & Greenleaf, 2006, p. 307). Through imagery, people can visualize what has already happened or picture themselves doing something in the future. People may use these mental representations to figure out how to correct a past mistake, become prepared for an upcoming task, optimize their performance, or how to react in certain situations. Further, imagery is polysensory in that all the senses, not just sight, can be invoked to create a life-like and realistic picture. For example, the imagery of a figure skater may include seeing her movements (visual), hearing the sound of her skates gliding across the ice (auditory), and feeling her muscles move accordingly (kinesthetic).

**Imagery and Performance**

While anyone can create mental images, systematically using these images in a constructive manner can actually enhance performance. One group that takes advantage of the benefits of regular imagery use is athletes. For example, in a case study, imagery was shown to enhance the performance of a collegiate basketball player (Savoy, 1993). This basketball player had great potential according to her coach, but she was afraid of failure, felt inadequate, and tended to become overwhelmed by large amounts of external information and by her own distracting thoughts. In the off-season, she practiced imagery and relaxation strategies for 15 to 20 minutes at a time to develop her mental strategies for dealing with stressful situations. During the pre-season, the player used imagery along with self-talk to increase her arousal levels before practices and games. By the end of the regular season, both the athlete and her coach believed she became more confident and played tougher than before. Additionally, performance-related measures, such as number of rebounds per game and foul shot percentage, improved throughout the season (Savoy, 1993).

Furthermore, one study found an imagery training program improved foul shooting percentage encompassing a 35 game season for 10 university basketball players (Savoy & Beitel, 1996). This study was unique because it utilized an ABABAB design, where periods of no treatment (A = physical practice) were alternated with periods of treatment (B = imagery intervention). Foul shooting percentage increased immediately from A1 to B1, dropped to a constant level at A2 and B2, dropped back to baseline at A3, but improved 10% over baseline
during the final treatment time (B3) (Savoy & Beitel, 1996). Another single-subject design study examined if imagery could improve the learning of basketball tactics in 10 semi-professional, national level players (Guillot, Nadowska, & Collet, 2009). The results of this eight week intervention showed that imagery combined with physical practice lead to increased learning of a tactical strategy better than when using physical practice alone. This suggests imagery can be used alongside physical practice to help athletes execute strategy better.

Imagery also enhances basketball performance in youth athletes. Forty boys between the ages of 10 and 12 attending a sports camp participated in a study examining if imagery can help improve free throw shooting (Wrisberg & Anshel, 1989). Participants were split into four groups: imagery, relaxation, imagery with relaxation, and a control group. Participants in the imagery with relaxation group improved the most, while those in the imagery group also showed improvements over the control group, suggesting younger athletes can indeed benefit from using imagery.

Beyond basketball, imagery has been found to be useful for enhancing performance in several other sports. One study examined how imagery influenced performance of a field hockey penalty flick (Smith, Holmes, Whitemore, Collins, & Devonport, 2001). Undergraduate field hockey players were randomly assigned to one of three groups: stimulus imagery (imagery that describes the environment, such as the sight of the goalkeeper and the noise of the crowd), stimulus-response imagery (imagery that describes individual reactions to the stimuli, such as increased heart rate, feelings of confidence), or a control group. Participants in the experimental groups practiced their imagery three times per week for seven weeks. Results showed that participants in the stimulus-response group improved significantly more (47.4%) on the penalty flick than participants in the stimulus only group (31.1%), which was significantly higher than the control group’s improvement (0.5%). These results provide strong evidence suggesting imagery should not only contain multisensory pictures of the environment, but also how the individual responds to those situations.

Imagery has also been effective in improving soccer performance. A study was conducted with three professional soccer players to determine if an individualized imagery intervention would improve soccer performance (Jordet, 2005). Specifically, the imagery targeted exploratory activity, which are actions performed by players that indicate they are looking for cues relevant to future performance (e.g., environmental cues, location of teammates,
location of opponents) before receiving the ball. Visual inspection of the data revealed two of the three players showed greater frequency and improved timing of exploratory activity, suggesting imagery can help improve soccer performance.

Imagery has also been used with other psychological skills to enhance performance. Fenker and Lambiotte (1987) describe how a process-oriented psychological skills intervention that featured imagery improved the performance of a football team. Specifically, the intervention aimed to increase players’ awareness of their optimal performance states and ability to focus. The team used brief imagery sessions during practices to achieve these goals. After the season ended, most of the football players indicated the program was effective for themselves and for the team in enhancing attentional control, achieving optimal energy states, and for improving performance. Daw and Burton (1994) described the effects of a comprehensive psychological skills training program on collegiate tennis players. These players were taught goal setting, arousal regulation strategies, and imagery. Compared to a control group, the intervention group had a lower double fault percentage, lower levels of pre-match cognitive anxiety, more pre-match self-confidence, and more pre-match somatic anxiety at the intervention’s end. Furthermore, players who were highly committed to the psychological skills training package showed greater benefits than those who were less committed. Taken together, these two studies provide evidence that imagery can be used with other psychological skills to improve performance.

In summary, these studies have shown imagery to enhance performance in a variety of sports, such as basketball (Savoy, 1993; Savoy & Beitel, 1996; Guillot et al., 2009; Wrisberg & Anshel, 1989), field hockey (Smith et al., 2001), soccer (Jordet, 2005), football (Fenker & Lambiotte, 1987), and tennis (Daw & Burton, 1994). Other researchers have noted that imagery has enhanced performance in other sports including swimming, gymnastics, and figure skating (Vealey & Greenleaf, 2006). Furthermore, literature reviews on imagery strongly suggest that imagery positively influences athletic performance (e.g., Weinberg, 2008).

**Imagery and Psychological Variables**

Besides enhancing athletic performance, however, imagery can be used to enhance various psychological variables related to performance. One study, for example, found imagery can enhance self-efficacy (Short, Bruggeman, Engel, Marback, Wang, Willadsen, & Short, 2002). In this study, which examined the function and direction of imagery on a golf putting
task, 83 undergraduate students were randomly assigned to one of six experimental groups or a control group. Results showed that participants in the facilitative imagery groups (imaging positive outcomes) improved their performances and also improved their levels of self-efficacy. These effects occurred for both the skill-oriented (imaging executing the skill successfully) imagery group and the mastery-oriented (imaging feeling confident and in control of situations) imagery group.

Other studies have examined how imagery and self-efficacy are related. For example, one study examined relationships between imagery use, self-efficacy, and performance (Beauchamp, Bray, & Albinson, 2002). Fifty-one male university golfers completed measures of golfing self-efficacy, pre-competition imagery use, and performance. Results indicated significant correlations between different types of imagery use and performance and between imagery use and self-efficacy. Specifically, mastery-oriented imagery significantly predicted self-efficacy and performance, with higher levels of imagery use predicting higher levels of self-efficacy and improved performance (Beauchamp et al., 2002). Similarly, Munroe-Chandler, Hall, and Fishburne (2008) found mastery-oriented imagery use was a significant predictor of self-confidence and self-efficacy in youth soccer players. These three studies (Short et al., 2002; Beauchamp et al., 2002; Munroe-Chandler et al., 2008) suggest imagery use is associated with higher levels of self-efficacy.

Another study sought to examine if an imagery-based intervention could influence feelings of confidence and anxiety (Hale & Whitehouse, 1998). University soccer players viewed two different tapes in a random order while completely relaxed. The videotapes asked each participant to imagine himself taking the final penalty kick of the World Cup, with the outcome totally dependent on his kick. Each tape was identical, except each tape emphasized different words. The two words were “pressure” and “challenge,” and these were spoken and flashed across the screen repeatedly. Results indicated that when participants viewed and then imaged the “pressure” tape, they experienced greater intensities of cognitive and somatic anxiety and interpreted the anxiety negatively. When participants watched and then imaged the “challenge” tape, however, their cognitive and somatic anxiety levels were not as intense and they did not interpret the anxiety negatively. Furthermore, the “challenge” tape enhanced feelings of confidence, while the “pressure” tape reduced confidence. These findings suggest
imagery can affect anxiety levels, anxiety interpretations, and confidence depending on the content of the imagery.

Similarly, Page, Sime, and Nordell (1999) examined the effects of imagery on perceptions of anxiety. Forty female university swimmers listened to a recorded imagery for approximately one half-hour, and this imagery session took place two days before competition. Measures of anxiety levels and interpretation of anxiety took place one hour before competition. Results showed that while cognitive and somatic anxiety levels decreased from baseline to pre-competition, and self-confidence increased, these changes were not significant. However, the participants interpreted their anxiety as significantly more positive. This finding suggests it is possible to modify interpretations of anxiety through imagery use.

Imagery has also been found to improve attentional control (Calmels, Berthoumieux, d’Arripe-Longueville, 2004). Four French national level softball players who were identified as having concentration problems by their coach participated in a seven week imagery intervention. Participants completed three different measures of attention several times throughout the intervention: broad external attention focus (BET) (ability to integrate many stimuli at once), overloaded by external stimuli (OET) (confusion resulting from too many external stimuli), and narrow attentional focus (NAR) (ability to narrow attention as needed). Of the three softball players in the imagery group, improvements were seen on seven of the nine measures of attention. Specifically, all improved on NAR, two improved on BET, and two improved scores on OET. The control participant only showed improvement on one measure (OET), while scores worsened for the other two (NAR and BET). Additionally, participants in the imagery group felt they were more focused on task-relevant stimuli and did a better job of assessing their performances (Calmels et al., 2004). This finding suggests that imagery can be an effective means to improve an athlete’s attentional focus.

Taken together, the results of these studies suggest imagery can influence various psychological states, such as enhanced feelings of self-efficacy (Short et al., 2002; Beauchamp et al., 2002; Munroe-Chandler et al., 2008), greater self-confidence (Hale & Whitehouse, 1998; Munroe-Chandler et al., 2008), reduced intensity of anxiety (Hale & Whitehouse, 1998), better interpretations of anxiety (Hale & Whitehouse, 1998; Page et al., 1999), and improvements in attentional control (Calmels et al., 2004). Imagery, then, not only enhances performance, but can improve mental states related to performance outcomes.
**Imagery Use**

Given the documented benefits of imagery, how often do athletes actually use imagery? A study conducted by Orlick and Partington (1988) sought to address that question by assessing the mental skills of Canadian Olympic athletes. A total of 75 athletes across 17 different sports were interviewed, while an additional 160 athletes across 31 sports were given surveys. The results clearly showed imagery was a vital part of preparation for these top international athletes. An overwhelming 99% of athletes reported using imagery systematically. The imagery was used daily for preparation, to make technical corrections, to picture themselves performing well, and to see themselves achieving their ultimate goals. These well-developed imagery skills also influenced their performances. In male athletes, higher-quality imagery was associated with higher performance results and better Olympic finishes, while imagery helped female athletes feel ready and prepared for competition. In short, elite-level athletes cite using imagery frequently and regularly, which helps enhance their performance and performance-related thoughts.

Research on collegiate athletes has shown that they too frequently use imagery. Interviews with 36 university athletes revealed 81% used imagery to enhance skill execution and 94% used imagery to develop strategies (Madigan, Frey, & Matlock, 1992). Additionally, their imagery was multisensory (visual, kinesthetic, and auditory) and they used both internal and external perspectives. Interviews with 14 athletes across seven sports showed imagery was used for a variety of reasons, including cognitive purposes, motivational purposes, and to achieve flow (Munroe, Giacobbi, Hall, & Weinberg, 2000). These athletes also reported their images as being polysensory (incorporating visual, auditory, kinesthetic, and olfactory sensations) and mostly positive and accurate. A survey of collegiate athletes from 13 sports found athletes who used imagery the most also found them to be most effective (Weinberg, Butt, Knight, Burke, & Jackson, 2003). These athletes used imagery the most during difficult, high-pressure situations and when playing poorly, injured, or tired.

Attempts have been made to conceptualize why athletes use imagery and why it is effective. One notable conceptualization of imagery is Paivio’s (1985) Analytic Framework, which suggests athletes use imagery for two primary reasons: cognitive and motivational. Each of these functions of imagery occurs at both a general and specific level. Cognitive functions of imagery include strategy development and execution (cognitive general – CG) and skill
development and execution (cognitive specific – CS). Motivational functions of imagery include managing arousal levels and affect (motivational general – MG) and visualizing goal-oriented responses (motivational specific – MS).

Paivio’s (1985) framework was extended by Hall, Mack, Paivio, and Hausenblas (1998). Based on these new findings, MG imagery split into two categories: arousal (MG-A), which refers to managing arousal levels, and mastery (MG-M), which refers to performing at a high level. Other studies suggest additional functions of imagery may exist, such as for achieving flow (Munroe et al., 2000), pain management, healing, and injury prevention (Driediger, Hall, & Callow, 2006).

The findings from these studies suggest both elite level athletes and college level athletes use imagery in a variety of situations and for many reasons (Orlick & Partington, 1988; Weinberg et al., 2003). Some of these reasons include enhancing skill and strategy execution, and to enhance motivation (Hall et al., 1998; Paivio, 1985). Athletes also report using multiple senses while imaging and find imagery rehearsal to be an effective form of mental practice (Madigan et al., 1992).

**Imagery and Task Characteristics**

The effectiveness of imagery, however, may be influenced by different characteristics of the task being performed. Early research identified that imagery led to significant improvements on the performance of cognitive tasks, but little or no improvement on the performances of motor tasks. For example, Ryan and Simons (1981) showed imagery did not improve balance times on a stabilometer (motor task), while significant improvements were made on completion of a maze (cognitive task). A follow-up study concluded that imagery use led to greater benefits for a low-motor cognitive task (completing a maze, which is a cognitive task, using only one hand at a time) compared to a high-motor cognitive task (completing a maze using both hands simultaneously, which requires greater motor coordination) (Ryan & Simons, 1983). This early research suggested that performance improvements from imagery happened for cognitive reasons.

A more recent study compared imagery effectiveness on open and closed skills and found that the imagery group performed significantly better on the performance of a closed skill (tennis serve) compared to a control group (Coelho, de Campos, da Silva, Okazaki, & Keller, 2007). However, no significant differences were found between the imagery and control groups on the
Meta-analyses on the effectiveness of mental practice found imagery was effective on a variety of tasks (Feltz & Landers, 1983). The overall effect size was 0.48, indicating mental practice of a motor skill enhances motor skill performance to a moderate degree. However, the effect size for cognitive tasks (1.44) was significantly larger than the effect sizes of both motor tasks (0.43) and strength tasks (0.20). This suggests that while imagery does improve performance on motor and strength tasks, the greatest gains of imagery use will be on cognitive tasks (Feltz & Landers, 1983). A more recent meta-analysis found similar results, where cognitive tasks showed more improvements than motor tasks (Driskell, Copper, & Moran, 1994). However, most sports skills are not pure motor skills and they have cognitive elements to them. Therefore, imagery seems to enhance the performance of sports skills predominantly through their cognitive components (Ryan & Simons, 1983).

How difficult or complex a task is to perform may also influence performance, although the relationship between imagery and task difficulty has not been explored fully. On the performance of a primarily cognitive task, Ryan and Simons (1983) manipulated the degree of motor involvement. They found mental practice improved performance on the low-motor task but showed no improvement on the performance of a high-motor task, although studies on task difficulty and imagery are lacking.

There has been research in related areas. For example, Prezuhy and Etnier (2001) examined the attentional patterns of horseshoe pitchers at two different levels of task difficulty (taller stake, shorter stake). Participants’ accuracy went down as task difficulty increased (stake became shorter). Reaction times also increased as difficulty increased, indicating more attention was being allocated to the difficult task. Another study examined the relationship between expertise, task difficulty, and eye movement (Williams, Singer, & Frehlich, 2002). Skilled and unskilled billiards players had their eye movement and gaze behavior tracked while performing three different billiards shots of various difficulties. For both skilled and unskilled players, performance decreased as difficulty increased. Additionally, the more complex the shot was, the more time the participants spent looking at the shot.
Although the relationship between task difficulty and imagery has not been studied, imagery has been shown to improve performance on a variety of tasks in many different contexts (e.g., Feltz & Landers, 1983; Weinberg, 2008). Therefore, it is plausible that imagery use may reduce performance decrements that result from increases in task difficulty.

**Characteristics of Imagery**

In addition to examining how imagery functions, some researchers have investigated the factors that strengthen the quality of imagery. Characteristics of imagery such as whether the image is positive or negative, or the perspective used, can influence how well imagery works (Weinberg, 2008). For example, studies that have examined imagery direction (whether the images are positive or negative) have concluded that positive imagery facilitates performance while negative imagery hurts performance. For example, Woolfolk, Parrish, and Murphy (1985) found that for a golf putting task, participants using positive imagery showed significantly greater improvements in performance compared to a control group. Participants using negative imagery, meanwhile, lead to a significant drop in performance.

Similarly, Beilock, Afremow, Rabe, and Carr (2001) found suppression imagery should be avoided. Suppression imagery is imaging the skill being performed successfully while avoiding potential errors. For the golf putting task used in this study, participants using suppression imagery were instructed to image the ball landing in the hole, but not past or in front of it. Results showed that participants’ imagery in the suppression imagery groups contained high amounts of negative images. Further, an overcompensation effect occurred, where players who imaged the ball landing short then hit the ball long, and vice-versa. Again, participants in the positive imagery group improved their performance, suggesting negative imagery should be avoided.

Imagery perspective has been a well-studied characteristic. Early research in the field concluded an internal imagery perspective (imaging your performance from one’s own eyes) was superior to an external imagery perspective (imaging by watching your performance from a third person point of view). Specifically, Mahoney and Avener (1977) surveyed and interviewed elite gymnasts, all of whom reported using mental imagery. Specifically, it was found that better performances were correlated with an internal imagery perspective, rather than an external perspective.
However, subsequent research was equivocal. For example, in a study on competitive figure skaters, Mumford and Hall (1985) found no significant differences between internal and external imagery groups on the performance of a novel figure. Additionally, all skaters believed the imagery improved their confidence and helped their performances, regardless of perspective. Results of a six week imagery training program showed similar results for 64 high school cricketers (Gordon, Weinberg, & Jackson, 1994). Both the external and internal imagery groups improved at about the same amount, although the participants admitted it was easier to use an internal perspective. Ultimately, however, it has been suggested athletes should use whichever perspective suits them best. As Hardy (1997) argues, the research suggesting that internal imagery should be used instead of external imagery has not been replicated. Instead, imagery should attempt to include the kinesthetic sense, as this has been shown to strengthen the effectiveness of imagery regardless of perspective used.

The PETTLEP Model

Recently, Holmes and Collins (2001) identified seven characteristics of imagery that they felt were crucial to its effectiveness. They feel that if all seven characteristics are present, the imagery will be of a higher quality, thus strengthening the benefits of imagery use. If some characteristics are not present, however, the quality of the imagery will be lowered, thus reducing its effectiveness.

This model of imagery is known as the PETTLEP model, which stands for Physical, Environment, Task, Timing, Learning, Emotion, and Perspective (Holmes & Collins, 2001). In essence, the PETTLEP model is a checklist of seven characteristics that all good imagery should include. PETTLEP is a functional equivalence theory, which simply means that the closer the imagery approximates real life, the greater the effect. It is theorized that imagery works to enhance performance by activating the same or similar neural networks that real life activates. It follows, then, that the more equivalent imagery is to real life, the greater the neural activation, and the better the results.

The first item functionally equivalent imagery should take into consideration is the Physical component (Holmes & Collins, 2001). The Physical component includes being an active imagery participant. By this it means the person utilizing imagery should alter their physical state to approximate real life. For example, a hockey player imaging while holding onto a hockey stick, wearing skates, and being at the ice rink would create a strong physical
component to the imagery. Imagery should include the Environment in which the action will take place. Athletes imaging should take into consideration where they will be performing to familiarize themselves with the nuances of each location to feel more comfortable with the environment. For example, a golfer would want to image the specific course to be played on, along with the expected weather conditions. As with the environment, the Task should be taken into consideration when imaging. Imagery should be different for each task, but also tailored to the expertise of the athletes. For example, while beginning racquetball players may focus only on the next shot, advanced racquetball players may think several shots ahead and adjust their movements accordingly.

Timing refers to how quickly the athletes images performing a movement. Since the PETTLEP model utilizes functional equivalence theory, the amount of time it takes to imagine performing a task should equal the amount of time it takes to actually perform that same task. Therefore, the PETTLEP model advocates the use of real-time imagery. Good imagery interventions should take Learning into consideration. As one learns how to perform a skill better, one’s imagery should reflect those advances. For example, the imagery of a novice tennis player who is just learning to serve might focus on the steps to hitting a good serve. As the player learns, however, the player will start to focus on spin and placement, reflecting their progress (Holmes & Collins, 2001).

Many times, imagery sessions are preceded by relaxation. However, most athletic events, from practice to competition, are not performed in a relaxed state, including a range of emotions, from relaxation to excitement to tension to joy. Following this, Emotion should be included with imagery. Emotion attaches meaning to an event, and if that emotion is incorporated into imagery sessions, the resulting effects may become even greater. Lastly, imagery should primarily take place from an internal Perspective. Interactional perspectives may be used if the athlete is at a high enough skill level (e.g., switching from internal to external and back), but an internal perspective allows for greater functional equivalence (Holmes & Collins, 2001). As noted previously, however, the literature suggests there is no difference between internal and external imagery (e.g., Hardy, 1997).

In sum, the PETTLEP model recommends imagery interventions should take into consideration seven key characteristics. The more of these characteristics that are included in the
imagery, the more functionally equivalent the imagery will be to the actual movements, and therefore, it is predicted that the more effective the imagery will be in enhancing performance.

Empirical investigations of the PETTLEP approach have yielded favorable results for the model. Two studies comparing imagery utilizing PETTLEP principles to traditional imagery found the PETTLEP imagery lead to better improvements on the performance of motor tasks (Smith, Wright, Allsopp, & Westhead, 2007). The first study compared sport-specific PETTLEP imagery to traditional imagery and traditional imagery while standing and wearing uniforms (clothing imagery group). Participants in the PETTLEP imagery group had significantly greater scores on a field hockey penalty flick than the clothing imagery group, which performed significantly better than the traditional imagery group. In the second study, imagery using PETTLEP was compared to physical practice and stimulus imagery on the performance of a gymnastics move (full turning straight jump on beam). The physical practice and PETTLEP groups performed significantly better than the stimulus imagery and control groups, and there were no significant differences between physical practice and PETTLEP imagery. These results provide support for using functionally equivalent PETTLEP imagery.

Another study testing the effectiveness of dynamic imagery of a slalom ski course found results that are applicable to the PETTLEP model, even though it was not a direct test of the model (Callow, Roberts, & Fawkes, 2006). The dynamic imagery experimental group conducted their imagery sessions in the snow while wearing equipment, standing in a race position, and moving their bodies in conjunction with where they pictured themselves being on the slalom course. The state imagery experimental group, meanwhile, conducted their imagery sessions indoors without standing in a race position or wearing equipment. Results indicated that the dynamic imagery group produced more vivid imagery and scored higher on a measure of confidence than the static imagery group. Although performance was significantly better compared to the control group, it was not significantly better compared to the static imagery group. However, the dynamic imagery group performed the course .73 seconds faster than the static imagery group. While this finding may not have yielded statistical significance, races are won by tenths and sometimes hundredths of seconds, so this finding yields practical importance.

Research has also shown that imagery following PETTLEP guidelines combined with physical practice produces greater improvements in performance than either imagery or physical practice alone. In a study utilizing an imagery intervention to enhance a golf shot (bunker shot),
participants in the imagery with PETTLEP plus physical practice group performed significantly better than participants in both the imagery and physical practice groups (Smith, Wright, & Cantwell, 2008). Similarly, imagery with PETTLEP plus physical practice led to significantly greater improvement in performance of a strength task (bicep curl) compared to the imagery only group. The imagery plus physical practice group also performed better than the physical practice only group, but this difference was not significant. (Additionally, the traditional imagery group in this study did not improve more than the control group) (Wright & Smith, 2009). The results of these two studies suggest applying the PETTLEP characteristics to imagery alongside physical practice to maximize performance enhancement and that imagery using PETTLEP principles produces significantly better performance than traditional imagery.

PETTLEP imagery has been found to enhance performance on other types of tasks, not just sport tasks. For example, Wright and Smith (2007) found that PETTLEP imagery significantly improved performance on a cognitive task (video game) more than traditional imagery. Further, while a physical practice group also performed significantly greater than the traditional imagery group, the PETTLEP imagery group maintained their times at a retention test while the other groups worsened their times. PETTLEP imagery was also found to enhance the performance of blood pressure measurement in nursing students compared to a control group (Wright, Hogard, Ellis, Smith, & Kelly, 2008).

Taken together, it appears that imagery with PETTLEP characteristics is effective in enhancing performance in a variety of motor, strength, and cognitive tasks. However, further research on the components that comprise PETTLEP imagery is encouraged to establish the model as a reliable and practical guide for implementing imagery interventions. One aspect of the PETTLEP model that has not received much attention in the imagery literature has been the Timing element, or imagery speed.

**Imagery Speed**

Imagery speed is the rate or timing of imagery. In essence, *imagery speed* refers to how quickly or slowly the imagery is being performed by the participant. According to the PETTLEP model, which is based on functional equivalence theory, it should take about the same amount of time to visualize an action as it does to perform that action (Holmes & Collins, 2001). Since motor imagery accesses the same motor representations as actual physical practice, the imagery being performed should be as close as possible to the actual performance. In essence, imagery
times should mimic times it takes to perform the action. Thus, the PETTLEP approach favors real-time imagery, or imagery performed at approximately the same speed as the actual motor task. For example, if it takes a sprinter 22 seconds to run the 200 meter dash, the sprinter should take approximately 22 seconds to visualize the race each time imagery is used.

The recommendation for real-time imagery use is echoed by other researchers. Vealey and Greenleaf (2006) suggest the timing of imagery should be the same as the actual skill being imagined. Morris et al. (2005) suggest imagery speeds other than real-time can hinder imagery effectiveness and ultimately hurt performance. Syer and Connolly (1984) recommend that imagery be performed at the same speed as the actual skill itself since the goal is to replicate the skill visually. Changing imagery speed can change how quickly one performs the action. They go on to recommend avoiding fast-motion imagery, or visualizing tasks quicker than it normally takes to complete them.

However, Syer and Connolly (1984) suggest there are times when slow-motion imagery can be utilized. Slow-motion imagery is simply visualizing a particular skill or task at a slower rate than it takes to actually perform the skill or task. They argue that the times slow-motion imagery should be used are when a person is first establishing a mental rehearsal program and when trying to break a bad habit or change technique. Keeping the imagery slow when first starting to visualize allows the person to ask for feedback to ensure the imagery is being done correctly. This is particularly useful when learning a brand new skill. Using slow-motion imagery allows a person to focus on specific aspects of the movement when having a problem, such as a short backswing on a forehand, and to then visually correct the problem (Syer & Connolly, 1984). Additionally, Holmes and Collins (2001), acknowledge that slow-motion imagery may be useful when learning certain motor movements. Although the dominant recommendation is for real-time imagery, it seems there are certain situations when slow-motion imagery may have its uses.

Given it is argued athletes should use real-time imagery when they visualize performing, the question is, do they actually do this? A large sampling of competitive and recreational athletes across a variety of sports completed the Imagery Speed Questionnaire (ISQ), which asks athletes how much of one imagery speed they use compared to another speed on different functions in different stages of learning (O & Hall, 2009). Items on the ISQ asked participants to rate how much they use imagery for a particular function on a scale from 0 (never) to 10
(always) and to then break down their imagery use into a ratio of fast-motion to real-time to slow-motion imagery. For example, participants rated how much they used imagery when “first learning a new skill” from never to always, then indicated how much of that imagery use was slow-motion, real-time, or fast-motion. The ratio of slow-motion, real-time, and fast-motion imagery must equal the indicated amount of imagery use. In essence, if an athlete marked a 9 on imagery use for a particular skill, the amount of slow-motion, real-time, and fast-motion imagery must add up to 9.

Results indicated athletes use a mix of imagery speeds for different functions. Athletes reported using real-time and slow-motion imagery approximately the same amount and significantly more than fast-motion imagery when learning new skills, new strategies, and developing new skills. When imaging being mentally tough, regulating arousal levels, developing strategy, or performing an already mastered skill, athletes used real-time imagery significantly more than slow-motion imagery, which was used significantly more than fast-motion imagery. Athletes reported using real-time imagery the most when visualizing a mastered skill or achieving goals, while both slow-motion and fast-motion imagery were used significantly less and about at the same rate. Lastly, athletes used real-time imagery significantly more than fast-motion imagery, which was used significantly more than slow-motion imagery on mastered strategies (O & Hall, 2009).

Results also indicated that athletes used different images speeds through the stages of learning. The three stages of learning are the cognitive stage (the skill is first introduced and learning begins), the associative stage (adjust movements to perform them properly), and the autonomous stage (performing the skill is automatic). Athletes reported slow-motion imagery was used significantly more for cognitive general (CG) (strategy execution) and cognitive specific (CS) (skill execution) imagery while in the early stages of learning. Real-time imagery was used significantly more for motivational reasons and when in the final stage of learning for CG and CS imagery. Further, real-time imagery use increased parallel to the progression through the stages of learning, while slow-motion imagery use decreased through the progression. When fast-motion images were used, it was typically in the last stage of learning for CG and CS imagery (O & Hall, 2009).

Overall, athletes reported voluntarily using all three imagery speeds for all functions of imagery at all stages of learning. While real-time imagery was used the most overall, slow-
motion imagery was used most frequently when learning a new skill or strategy, while fast-motion imagery was used most frequently when visualizing mastered skills and strategies (O & Hall, 2009). The results of this study suggest that athletes use all imagery speeds at varying amounts for different functions. However, this study did not ask athletes why they used one speed more than another on each function, nor did the study measure the effectiveness of the various imagery speeds on performance.

However, a previous study did manage to shed light on why one imagery speed may be used as opposed to another. Competitive skydivers were interviewed to describe and analyze how they use mental imagery (Fournier, Deremaux, & Bernier, 2008). Results of these interviews suggested that the function of the imagery (why the imagery is being used, e.g., learning) determines the content (what is being imaged, e.g., the environment and outcome) and characteristics (how the image is pictured, e.g., its vividness and speed) of that imagery. When the goal of the imagery was to learn new sequences, the imagery was conducted at a slower pace “to understand the sequence” (p. 740). Once the sequences were understood, real-time imagery was used “to get as close as possible to the actual jump” (p. 740). When the goal of the imagery was to manage stress or increase arousal, fast-motion imagery was used “to get immersed in the move” (p. 740) and pumped up. These results suggest that the speeds at which athletes visualize themselves performing a task may be influenced significantly by the reasons they have for creating those images in the first place.

Taken together, these two studies (Fournier et al., 2008; O & Hall, 2009) suggest athletes use slow-motion, real-time, and fast-motion imagery across a variety of situations for different functions and purposes. While the general recommendation is to use real-time imagery the majority of the time and slow-motion imagery sparingly, athletes seem to employ imagery at all speeds. Since athletes use various imagery speeds, the next question, then, is whether different imagery speeds have different effects on performance.

Empirical investigations on the effects of different imagery speeds on motor performance have received limited attention throughout the years, and the studies have yielded mixed results. An early study conducted by Andre and Means (1986) tested the effectiveness of slow-motion imagery against real-time imagery on the performance of a Frisbee golf putt (or disc golf putt). Participants were instructed to visualize their performance in three blocks of five minutes for five nights. Participants’ imagery in the second and third blocks was to be in slow-motion, while
imagery in the first block was to be in real-time to provide a reference point for speed. Results revealed no significant differences between the experimental groups (real-time imagery, slow-motion imagery) and placebo control group. However, the real-time imagery group (10.94%) improved more than the slow-motion imagery group (5.62%).

Although this finding suggests slow-motion imagery is not as effective as real-time imagery, limitations of the study may limit conclusions. One limitation was that participants reported their slow-motion imagery was only marginally slower than their real-time imagery. Another limitation was that the imagery audiotape may have been too structured and controlling, preventing participants from taking ownership over their imagery. Last, the task was of the all-or-nothing type (the disc was either in the basket or not in the basket) and the imagery used may not have been effective for that particular kind of task. Different results may have been obtained if a more sensitive performance measure were used (Andre & Means, 1986).

A more recent study found slow-motion and real-time imagery to be equally effective, however. On performance of a soccer-dribbling task, it was found that the real-time imagery, slow-motion imagery, and slow-motion plus real-time imagery groups all improved their times and reduced the number of errors made (O & Munroe-Chandler, 2009). While participants in the control group improved their times at a rate similar to those in the imagery groups, the error rate did not drop a significant amount, suggesting the imagery was partially effective in enhancing performance. These results suggest that slow-motion and real-time imagery use each enhance performance to a similar degree, which contrasts the findings of Andre and Means (1986), where slow-motion imagery did not lead to as great an improvement as real-time imagery.

Other studies have found an assimilation effect when varying imagery speed, which occurs when recall of a movement matches the speed at which it was performed originally. A study comparing fast-motion imagery and slow-motion imagery on the amount of time it took to complete a series of sequential rhythmic steps (feet and body move in a certain order) found the slow-motion imagery group performed the task slower, hurting performance, while the fast-motion imagery group performed the task quicker, improving performance (Boschker, Bakker, & Rietberg, 2000). Another study found participants in the fast-motion imagery group performed upper body sequences (arms move in a certain manner and order) and lower body sequences (feet and body move in a certain order) at a quicker and therefore better rate, participants in the slow-motion imagery group did not differ from the control group on their performance,
indicating no improvement (Louis, Guillot, Maton, Doyon, & Collet, 2008). Results of a follow-up study showed that participants in the fast-motion imagery group improved the quickness they executed a judo kata (a series of performed movements in the martial arts), while participants in the slow-motion imagery group executed the kata at a slower rate. These changes were neither good nor bad, as the researchers only studied whether imagery speeds altered subsequent rates of movement (Louis et al., 2008).

The results of these studies suggest that slow-motion imagery will lead to performing the task slower while fast-motion imagery will lead to performing the task faster. In essence, the slow-motion imagery is assimilated into the performance, causing the execution speed to drop, while the fast-motion imagery is assimilated into the performance and causes the speed of execution to increase. However, in each of these studies (Boschker et al., 2000; Louis et al., 2008), while participants performed the task in real-time to establish a reference point, there was no real-time imagery experimental group, so these studies only compared slow-motion imagery with fast-motion imagery. No comparisons can truly be made on the effectiveness of slow-motion, fast-motion, and real-time imagery simply because there were no real-time imagery groups. For example, the study by O and Munroe-Chandler (2009) found that both the real-time and slow-motion imagery groups improved their performance on a soccer-dribbling task through performing it at a quicker rate and with fewer errors. While this conflicts with the results of Boschker et al. (2000) (slow-motion imagery decreased performance of rhythmic step) and Louis et al. (2008) (slow-motion imagery decreased performance of body sequences), the lack of real-time imagery groups in the latter two studies prevent direct comparisons from being made.

In sum, the results of empirical studies on the effectiveness of imagery speed on motor performance provide no clear answers. Slow-motion imagery was as effective as real-time imagery in one study (O & Munroe-Chandler, 2009), ineffective in two studies (Andre & Means, 1986; Louis et al., 2008), and harmed performance in two other studies (Boschker et al., 2000; Louis et al., 2008). Fast-motion imagery was effective in improving performance in two studies (Boschker et al., 2000; Louis et al., 2008), but due to a lack of real-time imagery groups, it is unknown how those performance gains would have compared to gains from real-time imagery. What is clear, however, is a need for further research on this area.

Purposes
The PETTLEP model argues real-time imagery should produce the best results, but athletes report using different imagery speeds, and empirical investigations on the effectiveness of these speeds are inconclusive. These investigations have primarily relied on gross motor tasks, while no research has examined the effects of imagery speed on the performance of a fine motor task (e.g., Boschker et al., 2000; Louis et al., 2008; O & Munroe-Chandler, 2008).

Furthermore, no research has compared the effectiveness of different imagery speeds on different task difficulties. Previous research has identified task difficulty as a future direction of study to explore if different imagery speeds are useful in different contexts (O & Munroe-Chandler, 2008). Therefore, the primary purpose of the present investigation was to examine how slow-motion imagery, real-time imagery, and fast motion imagery influences the performance of a fine motor task at two different task difficulties.

In addition, no studies have examined the effects of imagery speed on any psychological variables. Previous research has identified imagery as a significant contributor to feelings of self-efficacy (Short et al., 2002; Beauchamp et al., 2002; Munroe-Chandler et al., 2008). Therefore, the secondary purpose was to examine how different imagery speeds influence self-efficacy levels on the performance of a task at two different difficulties.

Method

Participants

Participants were 64 students enrolled in kinesiology and health courses at a Midwestern university. However, one student was excluded as an outlier and one student was excluded because of a low MIQ-R score (see below). Therefore, the final sample comprised 62 students ($M_{age} = 21.97, SD = 6.10$). Approximately two-thirds of the sample were female ($n = 40, 65\%$), while the rest were male ($n = 22, 35\%$). Participants predominantly self-reported themselves as being Caucasian ($n = 57, 92\%$), while the rest self-reported as being Asian ($n = 2, 3\%$), Black ($n = 2, 3\%$), or Latino ($n = 1, 2\%$). Most participants were in their junior ($n = 14, 23\%$) and senior ($n = 27, 44\%$) years, while first years ($n = 9, 15\%$), sophomores ($n = 7, 11\%$), and graduate students ($n = 3, 5\%$) comprised the remainder. Two (3\%) participants did not report their class year.

Participants had a variety of prior golf experience, ranging from none ($n = 18, 29\%$) to more than five years of playing experience ($n = 15, 24\%$). A plurality of participants indicated they had had some, but not extensive (i.e., less than five years) playing experience ($n = 29, 47\%$).
Additionally, most participants \((n = 44, 71\%)\) reported having prior experiences with imagery before participating in the experiment. Of those who indicated previous experiences, most reported using imagery in other sports \((n = 31, 70\%)\). Other participants reported using imagery previously in golf \((n = 6, 14\%)\), learning about it in class \((n = 5, 12\%)\), using imagery in other contexts \((e.g., \text{design, medicine, meditation}) (n = 3, 7\%)\), and using it for coaching \((n = 1, 2\%)\). Two participants \((5\%)\) reported having used imagery as a result of meeting with a sport or performance psychologist.

**Study Design**

The study design for this project was a randomized groups design, with a repeated measures component incorporated to assess the effects of time. In particular, participants were randomly assigned to a no-imagery control group or to one of three experimental groups \((\text{fast-motion imagery, real-time imagery, slow-motion imagery})\). Each participant completed the golf putting task at two difficulty levels \((7’ \text{ putt and 14’ putt})\). Each participant also completed the golf putting task at two different times, a pretest and a posttest following the intervention. The statistical design that was used to analyze the obtained data was a \(4 \times 2 \times 2\) (imagery condition \(\times\) task difficulty \(\times\) time) mixed model MANOVA with repeated measures on the third factor. The dependent variables were two measures of task performance \((\text{average distance from the hole and number of putts made})\).

**Measures**

*Demographic Questionnaire.* Participants completed a simple demographic questionnaire, which asked them to self-report their gender, age, race/ethnicity, class year, and prior golf experience.

*Imagery Ability.* Participants completed the Movement Imagery Questionnaire – Revised \((\text{MIQ-R; Hall & Martin, 1997})\) to ensure all participants had a general level of movement imagery ability. The MIQ-R asks participants to perform movements and then use visual or kinesthetic imagery to picture themselves performing the same movement. Participants rate on a 7-point Likert scale ranging from 1 \((\text{very hard to see/feel})\) to 7 \((\text{very easy to see/feel})\) the ease of which they are able to “see” or “feel” the images. The original MIQ displayed adequate psychometric properties \((\text{Hall, Pongrac, & Buckholz, 1985})\). Cronbach’s alphas for each subscale were acceptable \((\text{visual} = .87, \text{kinesthetic} = .91)\) indicating internal consistency, while test-retest reliability was also high \(.83 \text{ for each subscale})\). The correlation between the two
subscales was moderate (.58), indicating each of the subscales are related, yet distinct. The revised version of the MIQ (the MIQ-R) displayed significant correlations between the visual subscales (-.77) of the MIQ and MIQ-R and between the kinesthetic subscales (-.77) of each, indicating the revision’s validity (Hall & Martin, 1997). Further research using the MIQ-R found it displayed adequate reliability, with each subscale showing high alpha coefficients (visual = .87, kinesthetic = .86) (Abma, Fry, Li, & Relyea, 2002).

Participants who scored lower than an average of 16 on the subscales were excluded from the study. A score of 16 represents marking an average of 4 or “neutral” for each answer, indicating average imagery ability. Therefore, scores lower than 16 indicate it may not be easy for participants to manipulate their imagery. A score of 16 has also been the cut-off in previous imagery research (e.g., Smith et al., 2008; O & Munroe-Chandler, 2008).

**Self-Efficacy.** To measure participants’ level of self-efficacy for the putting task under all conditions and all levels of task difficulty, a self-efficacy scale was used. After completion of the pretest and intervention or control condition, participants rated the level and the strength of their certainty for which they believed they could perform progressively harder tasks. Specifically, participants were asked if they believed they could perform a given task by marking either “yes” or “no.” The level of self-efficacy was the number of times the participants selected “yes.” Participants rated the strength of that choice using a 0% (*I am certain I cannot do this*) to 100% (*I am certain I can do this*) scale. Each question contained the stem, “Rate your confidence that you can…” followed by the individual item. Each item to rate was progressively more challenging. Participants started by rating the certainty with which they believed they could sink one putt, then rate the certainty with which they believed they could sink two putts, and so on, with the last question asking the certainty with which they believed they could sink all seven of their putts at each difficulty level (Feltz, Short, & Sullivan, 2008).

**Post-Experimental Questionnaire.** Following completion of the experiment, participants completed a questionnaire as a manipulation check. This assessed whether experimental procedures were followed and if outside knowledge was used to complete the tasks. Questions asked which task was more difficult, prior experience with imagery, whether the imagery was helpful or easy to use, if the imagery changed how they were feeling, if they used imagery as recommended, which perspective was taken, and if any other mental strategies were used.
Participants in the control group completed a similar post-experimental questionnaire. Since they were not instructed to use any imagery, all questions about the nature of imagery were removed. In their place, questions asked if they used imagery at any point during the experiment and if so, whether they found it helpful.

**Experimental Conditions**

For participants in the experimental group, the lead researcher defined imagery as “a mental practice technique that uses the senses to create or re-create an experience in the mind.” An example was given of how a golfer on a golf course might use imagery (e.g., a golfer may visualize hitting a perfect swing, seeing the ball go into the hole, feeling a warm breeze, and hearing the sound of the putter hitting the ball). Participants were instructed to include all relevant aspects of performance in their imagery (e.g., task, environment, emotion, multiple senses) and to keep their imagery positive (i.e., the ball going into the hole). Participants were instructed to hold the putter while performing imagery and were allowed to stand wherever they desired along the putting green. Participants were allowed to image from either perspective since research has not found significant performance differences between the perspectives (Mumford & Hall, 1985; Hardy, 1997). Additionally, participants were allowed to move into their putting stances if they wished and to image with their eyes open or closed.

During the pretest, the researcher recorded the average length of how long it took participants to complete the task, starting with their pre-shot routine and ending with the ball coming to a rest. Participants were informed of this average, and then instructed to use imagery in either real-time, slow-motion, or fast-motion. All participants were told to include their pre-shot routine as part of the task. A consistent pre-shot routine is essential for the performance of tasks such as a golf wedge shot, basketball free throw, and water polo penalty shot (McCann, Lavallee, & Lavallee, 2001; Czech, Ploszay, & Burke, 2004; Marlow, Bull, Heath, & Shambrook, 1998). Therefore, since consistency of a pre-shot routine influences subsequent performance, it was important to image not only the actual golf putt, but also the preparatory actions leading up to each putt.

Participants in the real-time imagery group were instructed to visualize for about the same amount of time it took them to actually perform the task. Participants in the slow-motion imagery group were instructed to visualize the task at a slower speed (50% slower was suggested). Participants in the fast-motion imagery group were instructed to visualize the task at
a faster speed (50% faster was suggested). For example, if it took someone 30 seconds to complete the task, they were instructed that their imagery should take about 30 seconds if they were in the real-time group, about 15 seconds if they were in the fast-motion group, or about 45 seconds if they were in the slow-motion group. The suggested slower/faster speeds were not required rates, but instead gave the participants an idea of what to aim for (e.g., O & Munroe-Chandler, 2008).

Participants imaged themselves performing the task a total of seven times. The lead researcher provided feedback (knowledge of results) after each imagery trial and informed the participants if they went too fast, too slow, or at about the right speed.

Task

All participants completed the golf putting task at two difficulty levels and at two different times, thus resulting in a within-subjects repeated measures design. The number of trials used to measure participants’ performance was determined by pilot testing (described below). To avoid the possibility of order effects, a counterbalanced procedure was used, with the study participants randomly assigned to complete the two levels of task difficulty in different orders.

The task was a golf putt performed on a combination of two putting mats, totaling about 16 feet in length. The mats overlapped slightly, enabling the ball to roll smoothly from one to the other. Participants were asked to putt the ball into the hole from marked starting locations at 7 feet and 14 feet away from the hole. Participants were instructed their primary objective was to sink the putt, but if they missed, to have the ball stop as close to the hole as possible, as if they were actually putting on a golf course. Two performance measures were taken: number of putts holed and average distance from the hole, with the best score obtainable on a putt being zero (putting the ball into the hole) (Ramsey, Cumming, & Edwards, 2009).

Participants were instructed to use a pre-shot routine before each putt. Before the pretest, the researcher asked participants if they had a pre-shot routine. For those who said they did not, the researcher modeled a sample pre-shot routine for them to follow. The pre-shot routine was adapted from two sources, a routine used previously with golfers and non-golfers, and a five-step readying strategy (McCann et al., 2001; Singer, 2002). The sample pre-shot routine was as follows:

1. Check the lie of the ball.
2. Address imaginary ball next to real ball.
3. Ready self by going into optimal stance.
4. Picture a line from the ball to the hole.
5. Take a deep breath.
6. Perform a practice swing.
7. Address real ball to be hit.
8. Ready self by going into optimal stance.
9. Picture a line from the ball to the hole.
10. Take a deep breath.
11. Perform the real swing.

Participants were allowed to personalize this routine (e.g., two practice swings instead of one), but their routine had to include those elements. They were also allowed to practice the routine (without hitting the ball) until they knew it. The participants who already had a pre-shot routine were asked to perform it for the researcher. If the routine contained the above elements, they were allowed to keep it as is. If the routine did not contain the above elements, they were instructed to add the missing component (e.g., check the lie of the ball before going into the routine).

Pilot Testing

Before the data collection phase, pilot testing was conducted. Its first purpose was to establish the appropriate number of trials of golf putts at each difficulty level. The second purpose was to establish the appropriate number of practice imagery trials. Six participants were recruited for these purposes.

Upon arriving, participants completed the informed consent. They were given instruction on the pre-shot routine and completed five blocks of three putts at each difficulty level, meaning they completed 15 putts at 7’ and 15 putts at 14,’ in counterbalanced order. While they were putting, the researcher recorded the amount of time it took them to perform the task (start of pre-shot routine to the ball coming to a rest) with a stopwatch. After completing all trials, the average amount of time it took the participant to complete the task was computed and this served as the reference point for how long it took them to perform the task.
The lead researcher then defined imagery to the participants (described previously). Once explained, participants then completed five blocks of three practice imagery trials at the speed to which they were randomly assigned (real-time, slow-motion, or fast-motion). The researcher recorded imagery times with a stopwatch and gave feedback to the participants about how long they are imaging in order to help them image at the appropriate time.

Upon completion, participants were thanked and allowed to leave. Afterwards, the researchers visually inspected when performances of the task began to plateau, and it was determined this occurred at the start of the third block of trials (Trial 7). Therefore, participants in the experiment completed seven putts at each difficulty level, and received seven practice imagery trials.

**Data Collection Procedures**

After receiving permission from the Institutional Review Board, the experimenter went to various kinesiology and health classes to recruit students for participation, having first asked permission from the professor or instructor. Students were told an experiment is being conducted on the effects of different types of mental practice on the performance of a golf putting task. The researcher explained that participation would be voluntary and that the total length of the experiment would be approximately 45 minutes. A sign-up sheet asking for names and email addresses was passed around if they wished to participate or wanted more information. Once a list of volunteers was obtained, the lead researcher sent follow-up emails to the students. Upon agreeing to enter the study, the researcher and student arranged a time for participation. Students were informed that their results would be kept confidential, as well as their contact information. The lead researcher also placed several recruitment fliers within the kinesiology and health academic building along with the researcher’s contact information.

The experimental procedure is outlined as follows (Table 1). When the participants arrived at the lab, they completed the consent form, demographic questionnaire, and MIQ-R. The lab space was a reserved racquetball court on the lowest floor of an academic building. This provided a private space for the experiment to take place. Participants were randomly assigned to one of the three experimental groups (fast-motion imagery, real-time imagery, slow-motion imagery) or the control group.

After completion of the initial forms, participants were asked if they already had a pre-shot routine, and were allowed to practice the sample routine if they did not. Once the pre-shot
routine was memorized, participants completed the pretest, which was the first set of seven golf putts at each difficulty (7’ and 14’) in counterbalanced order. Before the pretest, participants were told their scores would be compared to group norms and that they should do their best. This was done to ensure participants took the task seriously and put forth their best effort each time.

During the pretest, the researcher recorded the length of time it took for the participant to perform one trial with a stopwatch. Participants were told the stopwatch will start when they step up to the matt to begin their pre-shot routine and stop when the ball comes to a rest. The averaged time of all trials served as the reference point for imagery speed for participants in the experimental groups. After the ball came to a rest, the researcher marked whether it was in or out of the hole, and if the ball did not go in the hole, measured the distance from the hole using a tape measure.

Participants in the experimental groups performed seven practice imagery trials at the speed to which they were randomly assigned. After each trial, the researcher provided feedback about the speed of their imagery so the participants had a better approximation of how quickly or slowly they were imaging. After the practice imagery trials, participants were explained that they would be completing the task again, only with one imagery trial at the appropriate speed before each putt. Therefore, during the posttest, participants imaged the putt once before moving into their pre-shot routine and putting the ball. Before the posttest, however, participants completed the self-efficacy measure to gauge how confident they were in performing the task with imagery. Participants completed two self-efficacy measures, one for the set of 7’ putts and one for the set of 14’ putts. Efficacy levels may be different for each difficulty, which necessitated measuring self-efficacy for each length separately. These measures were completed at the same time to prevent the performance of the posttest from being broken up into two sections.

Participants then completed the posttest, which was the same as the pretest, with the exception of participants using imagery before each shot. During the posttest, the researcher measured imagery times, performance times, and performance. Following completion of the posttest, participants completed the post-experimental questionnaire.

The control group followed a similar procedure. After completing the informed consent, MIQ-R, and demographic measures, participants completed the pretest. After this, they were
given several golf articles to read from for seven minutes, which was about the same amount of
time it took participants in the experimental group to do all of the practice imagery trials. After
reading the articles, participants completed the self-efficacy measure, the posttest, and then a
post-experimental questionnaire.

Following completion of the post-experimental questionnaire, participants in both groups
were thanked and debriefed. Specifically, participants were informed their scores would not be
compared to group norms and were told the true purpose of the experiment.

Statistical Analyses

To assess the effects of imagery type and task difficulty on study participants’
performance, a 4 x 2 x 2 (imagery condition x task difficulty x time) repeated measures mixed
model MANOVA was conducted. The dependent variables were number of putts holed and
average distance from the hole. Significant main or interaction effects were further examined
using post-hoc means comparison testing.

To examine the effects of imagery condition and task difficulty on participants’ level and
strength of self-efficacy, a 4 x 2 (imagery condition x task difficulty) MANOVA was conducted
with self-efficacy level and strength serving as the dependent measures.

Finally, two one-way ANOVAs were performed comparing the amount of time spent
imagining in each of the experimental groups as a manipulation check. Specifically, the mean
differences and percent changes between the average pretest performance time and average
imagery time were examined.

Results

Descriptive Statistics

Descriptive statistics are provided for all performance measures (Table 2). Of note are
the high standard deviations on the performance measures, which indicate large amounts of
variability within the sample. This most likely reflects the make-up of the participants, who
varied greatly in prior golf experience.

Descriptive statistics were calculated for all self-efficacy measures, including 7’ level (M
= 4.08, SD = 1.42, range = 1-7), 7’ strength (M = 67.28, SD = 14.18, range = 30.00-98.75), 14’
level (M = 2.85, SD = 1.49, range = 1-7), and 14’ strength (M = 56.57, SD = 18.02, range =
19.00-85.00). Descriptive statistics were also calculated for average pretest performance times
(M = 22.52, SD = 7.77, range = 11.94-49.56), average posttest performance times (M = 23.94,
$SD = 8.55$, $range = 6.93-49.16$), and average imagery times ($M = 23.32$, $SD = 11.13$, $range = 5.79-47.04$).

_Preliminary Analyses_

**Group Differences.** Six one-way ANOVAs were used to test for initial group differences among the experimental and control groups during the pretest. No significant differences emerged across groups on MIQ-R scores indicating all groups had the same level of imagery ability. There were also no significant group differences on any performance measures during the pretest, indicating all groups performed the same. Finally, there were no significant differences on average performance time, indicating all groups initially performed the task using the same amount of time,

**Manipulation Checks.** To serve as a manipulation check, two one-way ANOVAs were used to test if the three experimental groups differed on their imagery speeds. Recall that the researcher suggested to participants in the fast-motion and slow-motion groups that their imagery should be approximately 50% faster and 50% slower than their initial performance times, respectively, while participants in the real-time imagery group should image for approximately the same amount of time.

Average imagery times differed significantly across the three imagery groups, $F(2, 44) = 28.37, p < .001$. Tukey post-hoc comparisons of the three groups indicated that the slow-motion group ($M = 31.92$) was significantly different from the fast-motion group ($M = 12.01$), while the real-time group ($M = 24.88$) was also significantly different from the fast-motion group.

Additionally, percent changes in imagery speeds differed significantly across the three imagery groups, $F(2, 44) = 82.96, p < .001$. Tukey post-hoc comparisons of the three groups indicated that the slow-motion group ($M = 50.69\%$), real-time group ($M = 3.39\%$), and fast-motion group ($M = -45.65\%$) were all significantly different from each other, $p < .001$.

The direction of means indicate the imagery speed manipulation was generally successful in the expected directions. Mean differences indicated that participants in the fast-motion group imaged at a significantly faster speed than participants in the slow-motion and real-time groups. Percent changes indicated that participants were able to image at the speed to which they were randomly assigned when compared to their average pretest performance times. That is, participants in the slow-motion group were able to image about 50% slower, participants in the
fast-motion groups were able to imagery about 50% faster, and participants in the real-time imagery group kept their imagery about the same length of time as their actual performance.

To serve as a manipulation check for task difficulty, two paired samples t-tests were conducted comparing the mean scores of the 7’ putts and the 14’ putts with average distance from the hole and number of putts made serving as the dependent measures. Results of the t-test on average distance from the hole indicated participants performed significantly better on the 7’ putts ($M = 10.89$) compared to the 14’ putts ($M = 20.69$), $t (61) = -10.57$, $p < .001$. Results of the t-test on number of putts made indicated participants performed significantly better on the 7’ putts ($M = 2.43$) compared to the 14’ putts ($M = 1.15$), $t (61) = 6.84$, $p < .001$.

These results indicate the task difficulty manipulation was successful in the expected direction as indicated by scores on both performance measures. On average, participants were able to putt the ball closer to the hole from 7’ away than from 14’ away. Additionally, participants made more putts from 7’ away than from 14’ away.

**Main Analyses**

*Imagery Speed and Performance.* The primary purpose of the present investigation was to explore the relationship between imagery speed and performance on a task at two different difficulty levels. A 4 x 2 x 2 (imagery condition x task difficulty x time) mixed model MANOVA was conducted with repeated measures on time. Imagery condition was a between-subjects variable while task difficulty was a within-subjects variable. Examination of the results from the MANOVA revealed a significant main effect for task difficulty, Wilks’ $\lambda = .33$, $F (2, 57) = 58.27$, $p < .001$, which is consistent with the results of the previously reported paired samples t-test on task difficulty.

There were no other significant main effects and no significant interaction effects. The lack of significant interaction effects indicates participants in all conditions had similar performances. Although not significant, inspection of mean differences reveals the slow-motion and real-time imagery groups always improved their scores from the pretest to the posttest, while participants in the fast-motion imagery and control groups improved their performance twice, but also worsened their performance twice. Table 3 reports means, standard deviations, and mean differences for all performance measures.

*Imagery Speed and Self-Efficacy.* The secondary purpose of the present investigation was to explore the relationship between imagery speed and self-efficacy beliefs about an
upcoming performance. A 4 x 2 (imagery condition x task difficulty) MANOVA was conducted to test if the level and strength of participants’ self-efficacy differed by group. Results of the MANOVA revealed a significant main effect for task difficulty on level and strength of self-efficacy, $F(2, 57) = 50.07, p < .001$. Results of a follow-up paired samples t-test revealed that participants had a significantly higher level of self-efficacy on the 7’ putts ($M = 4.08$) compared to the 14’ putts ($M = 2.85$), $t(61) = 8.96, p < .001$. Participants also had a significantly higher strength of self-efficacy on the 7’ putts ($M = 67.28$) compared to the 14’ putts ($M = 56.57$), $t(61) = 6.40, p < .001$.

No other significant interaction effects or main effects emerged. The lack of significant interaction effects indicates participants in all experimental conditions had similar self-efficacy beliefs about their future performances. Table 4 reports means and standard deviations for all self-efficacy measures.

**Follow-Up Analyses**

**Assimilation Effects.** Previous research has found that when manipulating imagery speed, assimilation effects occur (Boschker et al., 2000; Louis et al., 2008). An assimilation effect is when imaging a movement at a different speed causes one to perform the movement at a rate similar to what was imagined (e.g., imaging a task at a slow speed leads one to perform the task at a slower rate).

To test if an assimilation effect occurred, a 4 x 2 (imagery condition x time) repeated measures ANOVA was conducted to see if group differences emerged between the average performance time of the pretest and the average performance time of the posttest. Results indicated a significant interaction effect, $F(3, 58) = 9.27, p < .001$. However, Tukey post-hoc comparisons of the four groups were not significant. Two one-way ANOVAs on the pretest average performance time and posttest average performance time were also not significant. These results indicate an assimilation effect did not occur in the present investigation.

**Post-Experimental Questionnaire Results**

Results of the post-experimental questionnaire confirmed the results of the quantitative manipulation check, indicating that the manipulation was successful. Overall, 87% of the participants stated that the 14’ putt was more difficult than the 7’ putt. Additionally, all participants in the experimental groups indicated that they used the imagery as instructed to by the researcher (100%). Of the participants in the experimental groups, 89% found the imagery
helpful and 70% found the imagery easy to use. Participants predominantly reported using an internal perspective (60%), with the rest using an external perspective (15%) or both perspectives (25%).

For participants in the experimental groups ($n = 47$), 85% indicated on an open-ended question that their imagery changed how they were feeling. Most of these changes were positive. Of the participants who had their feelings change ($n = 40$), they reported feeling more confident ($n = 14$), having better focus or concentration ($n = 11$), feeling more relaxed or calm ($n = 10$), feeling less anxiety or pressure ($n = 3$), having better technique or execution ($n = 3$), feeling more prepared ($n = 1$), and having a more positive attitude ($n = 1$). Some participants reported negative changes, such as increases in anxiety ($n = 4$), overthinking each shot ($n = 1$), changing their timing ($n = 1$), and having a hard time clearing their mind ($n = 1$).

However, nearly one-third of participants in the imagery groups reported using other mental strategies via open-ended questions (30%, $n = 14$). The most common mental strategy used was self-talk ($n = 11$), while other strategies (i.e., goal setting, relaxation, increasing motivation) were used less often ($n = 5$). Additionally, most participants in the control group indicated on an open-ended question they used imagery at some point during the experiment (73%, $n = 11$). Of the participants who indicated they did use imagery at some point, they typically used imagery during their routine ($n = 6$), found it helpful ($n = 6$), and used it to see the ball going in the hole ($n = 5$). These results indicate that some of the results may have been influenced by the use of other mental strategies in the experimental groups and by imagery use in the control group.

Discussion

The primary purpose of this study was to explore the effects of different imagery speeds on the performance of a golf putting task at two different difficulty levels. One aspect of the PETTLEP model that has recently begun to receive attention in the literature is the Timing or speed element of imagery (Holmes & Collins, 2001). The PETTLEP model argues that real-time imagery should produce better results compared to slow-motion imagery or fast-motion imagery because real-time imagery is more functionally equivalent to reality than slow-motion or fast-motion imagery. However, empirical investigations have been mixed (Andre & Means, 1986; Louis et al., 2008; O & Munroe-Chandler, 2008), and no prior studies have compared the effects
of all three speeds at once. Additionally, task difficulty has yet to be studied in imagery research, and this study also explored imagery’s effects at different task difficulty levels.

Additionally, while previous research has identified that imagery can enhance psychological variables related to performance, no previous studies on imagery speed have explored the relationship between imagery speed and any psychological variables. Therefore, the secondary purpose of this study was to explore the effects of different imagery speeds on self-efficacy beliefs about a future performance.

**Manipulation Checks**

Quantitative methods ensured participants in the experimental groups were able to image at the speeds to which they were randomly assigned. Previous research in imagery speed has not used quantitative manipulation checks. Instead, participants have been asked if they felt they imaged at the correct speed (Andre & Means, 1986; Boschker et al., 2000; O & Munroe-Chandler, 2008). In addition to the quantitative methods employed here, all participants stated they used imagery as instructed, while most of them stated the imagery was helpful and easy to use. These findings indicate it is possible to include quantitative measures along with open-ended questions to ensure participants imaged at the correct speed.

However, a number of participants in the imagery groups reported using other mental strategies, most commonly self-talk. This may have interfered with their imagery use. Additionally, most participants in the control group reported using imagery at some point during the experiment. This suggests that the no-imagery control group did in fact use imagery, limiting the overall effectiveness of the imagery manipulation.

The task difficulty manipulation was successful in the intended direction. Participants performed significantly worse on the 14’ putts compared to the 7’ putts, and most participants reported the 14’ putt as being more difficult than the 7’ putt.

**Performance Results**

Performance results are discussed in terms of imagery versus control differences and then differences between the imagery speed conditions.

**Imagery and Performance.** Analyses of the four performance variables yielded no significant findings, indicating the imagery groups did not perform better than the control group. This finding conflicts with most imagery research (Feltz & Landers, 1983; Blair, Hall, &
Leyshon, 1993; Weinberg, 2008; Wright & Smith, 2009) that finds imagery use leads to significant performance improvements.

One reason this study found no significant improvements may have been due to the small sample size. A small sample size increases the difficulty of finding significant differences because of a lack of power. Another reason could be that the use of outside strategies by participants interfered with the manipulations. Some participants in the imagery groups used other psychological strategies, while most participants in the control group used imagery. The use of these strategies was not part of the manipulation, which may have limited the effects of the intervention, leading to no significant differences between the imagery groups and control groups.

Some imagery studies, however, find that imagery use does not lead to significant improvements or significant differences from the control group. For example, O & Munroe-Chandler (2008) found that participants in every group improved times on a soccer dribbling course, including the control group. While the improvements from pretest to posttest were significant, there were no significant differences across groups, suggesting all groups improved at the same rate.

*Imagery Speed and Performance.* Regarding imagery speed, results indicated the four experimental groups did not significantly differ from each other. This means that different imagery speeds did not lead to statistically significant differences in performance. This is consistent with some past research. For example, Andre & Means (1986) found that different imagery speeds did not lead to statistically significant differences in improvement on a disc golf putt. However, they found real-time imagery use (10.94%) and slow-motion imagery use (5.62%) lead to slight improvements in performance, while the no-imagery control group (-1.57%) slightly worsened its performance.

Similar non-significant improvements occurred in the present investigation. Participants in the slow-motion and real-time imagery groups always improved their scores from the pretest to the posttest on all four performance measures, while participants in the fast-motion imagery and control groups only improved their scores from the pretest to the posttest on two performance measures and worsened their scores on the other two (Table 3). The range of improvement for the slow-motion group was 5% to 37%, while the range of improvement for the
real-time group was 1% to 38%. Meanwhile, the fast-motion group performed from 35% worse to 27% better and the control group performed from 30% worse to 20% better.

Although not significant, the findings have some limited relevance due to the exploratory nature of the study. It appears that participants using slow-motion and real-time imagery performed more consistently, since they always improved, while participants in the fast-motion imagery and control groups performed more inconsistently. Additionally, the percent improvements indicate that participants in the slow-motion and real-time imagery groups improved to a larger extent than participants in the fast-motion imagery and control groups.

Previous research has also come across this dilemma of statistical significance versus applied or practical significance. For example, Weinberg, Stitcher, and Richardson (1994) randomly assigned players on a lacrosse team to a goal setting condition where specific goal setting strategies were discussed or to a do-your-best goal condition. While their results yielded no significant differences, the goal setting group had higher mean scores on all four performance measures. Additionally, it was reported that the coaching staff felt the goal setting program was highly effective in improving performance, giving the results applied significance despite the lack of statistical significance.

In the present investigation, the performance results were not statistically significant. However, it appears that slow-motion and real-time imagery lead to more consistent performance improvements compared to fast-motion and no imagery. From an applied perspective, these differences can still be meaningful and useful. While the improvements may not have been statistically significant, an intervention that results in putting the ball closer to the hole and outright making more putts has some applied value. Specifically, although the mean improvements were small, small improvements can often make a large difference in golf. For example, during the 2009 season, the best putter on the PGA Tour had a putting average of 1.726, while the 125th best putter had a putting average of 1.786, a difference of only 0.06 (PGA Tour Statistics). Furthermore, during 2009, the best average round score was 68.84. The 4th best average round score was one stroke higher, at 69.88, but the 104th best average round score was only two strokes higher at 70.84 (PGA Tour Statistics). On the LPGA tour for the 2009 season, the best putter had a putting average of 1.75, while the 100th best putter had an average of 1.85, a difference of only 0.10 (LPGA Tour Statistics).
Based on those numbers, it is easy to see how small improvements can make a large difference. The difference between the best putters on the PGA Tour and LPGA Tour is well less than one stroke, while the difference between having the best average round score and the hundredth best round score is only two strokes on the PGA Tour. In the present investigation, participants in the slow-motion and real-time imagery groups made more putts from 7’ away (0.18 and 0.80, respectively) and from 14’ away (0.35 and 0.20, respectively) on the posttest compared to the pretest. While seemingly small, those improvements could be the difference between being an excellent putter versus an average putter and are quite large compared to differences of 0.06 and 0.10 on the PGA and LPGA tours, respectively. In essence, while the results in this study were not statistically significant, an argument can be made for their practical significance. Therefore, the practical significance of the findings may be worthy of attention due to some limitations in this investigation which may have prevented statistical significance from being reached.

Theoretical Implications

The PETTLEP model (Holmes & Collins, 2001) suggests that real-time imagery should lead to the best performances due to a higher degree of functional equivalence, and other researchers echo this sentiment (e.g., Syer & Connolly, 1984; Morris et al., 2005). However, it has been suggested that slow-motion imagery may be beneficial to use at certain times. For example, both Holmes and Collins (2001) and Syer and Connolly (1984) suggest slow-motion imagery may be useful when learning new motor skills. Additionally, athletes have reported using slow-motion imagery to help them learn new skills (Fournier et al., 2008; O & Hall, 2009).

The current investigation found no significant differences in performance, although both slow-motion and real-time imagery lead to non-significant performance improvements on a more consistent basis compared to fast-motion imagery. These results conflict with most imagery research in general and the PETTLEP theory specifically. According to the PETTLEP model (Holmes & Collins, 2001), the real-time imagery group in this study should have improved a significant amount, and improved more than the other imagery groups. However, that did not occur. Instead, only non-significant performance improvements occurred for both real-time and slow-motion imagery. Overall, then, it appears these findings do not support the PETTLEP model of imagery (Holmes & Collins, 2001).
These findings also seem to confirm the recommendation by Syer and Connolly (1984) to avoid fast-motion imagery. All differences were non-significant, but participants in the fast-motion imagery group performed worse on two measures and better on two measures. These inconsistent differences suggest fast-motion imagery may not be as reliable as real-time or slow-motion imagery.

**Self-Efficacy Results**

Similar to the performance results, analysis of the self-efficacy measures revealed no significant group differences, indicating the imagery groups did not significantly differ in their level and strength of self-efficacy beliefs from the control group. This seems to conflict with past empirical research that has found imagery use to be linked with higher self-efficacy beliefs (Beauchamp et al., 2002; Short et al., 2002; Munroe-Chandler et al., 2008). Furthermore, the lack of significant group differences indicates that different imagery speeds did not lead to different self-efficacy beliefs.

Although efficacy was not significantly different across groups, neither were performance results. Self-efficacy has been linked with improved performance (Short et al., 2002), so it would follow that a lack of self-efficacy would be linked with no significant performance improvements, which is what was observed in this investigation. Therefore, these results appear to support self-efficacy theory. Furthermore, consistent with self-efficacy theory, participants had better scores and higher self-efficacy on the 7' putts compared to the 14' putts.

Of note are the results of the post-experimental questionnaire. Of the 47 participants in the experimental groups, 14 indicated that their imagery use made them feel more confident. (Additionally, 11 people reported the imagery made them more focused, 10 people reported feeling more relaxed, and 3 people each reported feeling less anxiety and having better technical execution). Given the documented benefits of imagery on efficacy beliefs and confidence (e.g., Hale & Whitehouse, 1998; Short et al., 2002), the results of this open-ended question seem to be consistent with past research. Without any prompting, 30% of the participants in the imagery groups reported feelings of enhanced confidence.

However, given that the efficacy beliefs of participants in the experimental groups did not differ from the efficacy beliefs of participants in the control group, it could be argued that in this study, imagery did not help to improve feelings of efficacy to a significant degree. One reason for this could be the relatively inexperienced sample, with approximately 75% of the sample...
having some-to-no prior experience with golf. Perhaps their inexperience prevented them from feeling very confident they could make more putts on the posttest.

Task Difficulty

Results revealed that participants performed significantly better on the shorter 7’ putts than on the longer 14’ putts. This was true for both performance measures of average distance from the hole and number of putts successfully made. Paralleling these results, the post-experimental questionnaire revealed that 87% of the sample believed the 14’ putt was more difficult than the 7’ putt. This is consistent with past research that has found that as task difficulty or task complexity increases, performance decreases (Ryan & Simons, 1983; Prezuhy & Etnier, 2001; Williams et al., 2002). Additionally, participants had a higher level and strength of self-efficacy on the 7’ putts than on the 14’ putts.

While no studies have directly examined the effects of imagery on task difficulty with sport skills, Ryan and Simons (1983) manipulated the degree of motor involvement on a cognitive task. They found mental practice lead to improvements on a low-motor task (use of one hand at one time) compared to the control group, but not on a high-motor task (use of both hands at one time), which may mean that if a task is too difficult, the effectiveness of imagery decreases. The results of this study are somewhat consistent with the findings of Ryan and Simons (1983), in that the imagery groups did not perform significantly better than participants in the control group on the more difficult task.

Although not significant, of note is that all four groups improved their performance from the pretest to the posttest on average distance from the hole for the 14’ putts, while only the slow-motion and real-time imagery groups improved their performances from 7’ away. This finding may be explained by the fact that since participants initially did worse on the 14’ putts compared to the 7’ putts, they had greater room for improvements. Because their initial performance on the pretest was so poor, participants were able to putt the ball closer to the hole on the posttest as a result of practice effects.

Assimilation Effects

Previous research has found that assimilation effects may take place when using fast-motion or slow-motion imagery. For example, Boschker and colleagues (2000) found that slow-motion and fast-motion imagery lead participants to perform a series of rhythmic steps at slower and faster speeds, respectively. Other studies found similar results on the performances of
sequential body movements and a judo kata (Louis et al., 2008). O and Munroe-Chandler (2008) did not find an assimilation effect, but that was most likely due to the nature of their soccer dribbling task, which had a temporal goal.

The results of the present investigation did not uncover any significant assimilation effects, indicating participants’ imagery did not change their performance times. The present findings are consistent with past research that has not found any assimilation effect (O & Munroe-Chandler, 2008). However, these results conflict with other past research that has found assimilation effects take place for both slow-motion and fast-motion imagery (Boschker et al., 2000; Louis et al., 2008).

It is unclear why no assimilation effects were observed in the present investigation. While participants’ performances were timed, there was no temporal goal, as with O & Munroe-Chandler (2008). The only time participants were given feedback on their performance times was when they were informed of the average length of time it took them to perform the pretest. Results of other studies (Boschker et al., 2000; Louis et al., 2008) finding an assimilation effect would suggest that one would occur in this study, but that was not the case. One possible explanation could be that participants were able to perform their pre-shot routine and putt consistently on both the pretest and posttest, and that different imagery speeds did not impact how long it took them to go through the task.

Practical Applications

These findings suggest a few applied uses, although it is recommended that more research be conducted. First, these results suggest slow-motion and real-time imagery may help improve performance on a golf putting task, although these findings must be interpreted with caution as they were not statistically significant. This study is in line with past research that has found imagery can enhance golf putting performance (e.g., Beilock et al., 2001; Ramsey et al., 2008), but potentially adds that slow-motion imagery may be useful as well.

Second, fast-motion imagery should be avoided, at least for this kind of performance. In this study, fast-motion imagery lead to inconsistent changes in performance. Performance was sometimes better, sometimes worse. As such, it does not seem that fast-motion imagery is useful for this kind of task. However, this was the first study to compare all three imagery speeds on performance at once, so more research is needed to confirm the finding that fast-motion imagery is not helpful. Additionally, fast-motion imagery may be more useful for altering feeling states.
(e.g., increase arousal levels) as opposed to performance, as suggested by past research (Fournier et al., 2008).

Third, this was the first imagery speed study to use a fine motor task, as previous studies have utilized larger gross motor tasks. As such, these results may be generalizable to other fine motor tasks. However, it is necessary to conduct more research to see if in fact similar results emerge on the performance of other fine motor tasks, and to see if significant differences emerge.

Limitations

Several limitations exist which may limit the generalizability of the findings. One possible limitation to this study could be a lack of power. That is, there was a relatively low number of subjects within each of the experimental groups (n = 15 to 17 participants per group). According to Cohen (1992), with an alpha level of .01, power = .80, and an estimated large effect size (.40), the number of participants needed per group would be 25. Thus, the current study's group size could be considered low. However, the results of the 4 x 2 x 2 (imagery condition x task difficulty x time) mixed model MANOVA that was conducted to test the main study analysis revealed very small effect sizes (eta-squared values ranged from .02 to .09) for all but the task difficulty effect. These small effect sizes, combined with the small F-values, suggest that increasing the sample size would likely not increase the probability of finding significance (Morgan, Leech, Gloechner, & Barrett, 2004). Nevertheless, future researchers might be advised to use group sample sizes of 25 or higher.

Perhaps a bigger issue in this study regarding the lack of significance in the comparison of the mental imagery conditions is the large standard deviation seen within the sample. Specifically, the standard deviations for the two performance measures (average distance from the hole and number of putts made) were, in most cases, almost as large as the sample means. Such large variance in performance within the mental imagery conditions makes it considerably more difficult to detect differences between the treatment conditions (Thomas, Nelson, & Silverman, 2005; Tabachnick & Fidell, 2007).

These large standard deviations were most likely a result of the wide range in experience of the sample. Most of the sample had either never golfed before or only had a small to moderate amount of golfing experience. However, some participants had more extensive golf experience, meaning that participants’ skill levels varied considerably. Thus, future researchers
might consider ways to reduce such inter-individual variability within the groups. For example, setting a certain amount of golf experience or skill as a prerequisite would have reduced the variability, so all the participants would have a more similar skill level, reducing inter-individual variability.

Another way to increase power in a study is to apply stronger treatment (Thomas et al., 2005; Tabachnick & Fidell, 2007). For example, the number of practice imagery trials could have been increased. Additionally, the use of outside strategies by participants in the experimental and control groups may have prevented the treatment from being as strong as it could have been. Thirty percent of participants in the imagery groups reported using other mental strategies, with the most popular being self-talk. The use of these other strategies may have contaminated the experimental groups’ performances because they were trying to utilize strategies other than imagery, which was not intended to be part of the experiment.

Furthermore, 11 of the 15 participants in the control group reported using imagery at some point during the experiment, with many of them indicating the imagery was helpful and used on every shot. The use of imagery by the control group indicates it was not a no-imagery control group, as intended. One reason for this may be due to the rise in popularity of sport psychology techniques in the past several years. Indeed, most of the participants (71%) reported having prior experiences with imagery, usually from use in other sports. Given that, it is plausible to suggest that since they have had exposure to imagery before, participants felt comfortable using it in a new performance setting. However, this may have limited the effectiveness of the imagery manipulations in this study. This also indicates that in future research, it may be necessary to use a no-imagery distraction control group to prevent participants from using imagery spontaneously.

Another way to increase the strength of the treatment would be to have a more experienced sample. As one learns new skills, the blueprint for those skills becomes increasingly refined as they are practiced more. Novices, however, are still trying to figure out their mental blueprint. Therefore, when asked to manipulate their mental blueprint by imaging at different speeds, experts are going to have a better quality manipulation compared to novices. By eliminating people who have never golfed before, the strength of the treatment would increase because that would mean that only people with strong blueprints are left. In essence, eliminating less experienced golfers would increase the quality of imagery manipulations.
**Future Research Directions**

There are many possible questions that future researchers can address. First, given the variability of prior golf experience in the sample, it may be beneficial to compare the effects of different imagery speeds based on level of expertise. Perhaps experts may benefit from the use of fast-motion imagery because they already have a firmly established mental blueprint of how to perform the action, whereas novices would benefit from slow-motion imagery since they are trying to create a mental blueprint (Syer & Connolly, 1984; O & Hall, 2009).

Second, one could compare the effects of imagery speeds on the performance of a novel task versus a learned task. The task in this study was relatively novel, in that it is highly unlikely anyone has ever encountered this type of set-up before. The skill itself (golf putting) was encountered by most participants before, but the way the putting mats were set-up was new. It has been suggested that slow-motion imagery may be more useful for learning new tasks or skills so as to create a mental blueprint for correct performances (Syer & Connolly, 1984; Holmes & Collins, 2001; Fournier et al., 2008), so it would be interesting to see if slow-motion imagery has significant benefits on new tasks compared to well-learned tasks.

Researchers should also attempt to use a variety of different tasks to enhance the generalizability of the findings to different sport skills. The two previous imagery speed studies that measured performance as an outcome used two different gross motor skills, disc golf and soccer dribbling (Andre & Means, 1986; O & Munroe-Chandler, 2008, respectively). This study was the first imagery speed study to utilize a fine motor task, golf putting. Future studies may want to use other tasks from different sports to see if the effects are specific to one type of task or can be useful on many tasks. For example, a golf putt is a slower movement, while a softball pitch is a fast, explosive movement. It may be that fast-motion imagery is more useful for a softball pitch since faster is better, but that slow-motion imagery is more useful for a golf putt so one does not rush through the shot.

More attempts should be made to understand if imagery speeds alter psychological states related to performance. This study found no significant differences on self-efficacy. However, results from an open-ended question indicated that many participants reported becoming more confident, focused, and relaxed. Additionally, previous research has indicated that athletes used fast-motion imagery to increase their arousal level (Fournier et al., 2008). Future experimental
studies may want to include measures of psychological states to determine if and to what extent these changes do occur.

A fifth potential avenue for future research could be to observe assimilation effects and then to explore potential practical uses of those effects. Many times if athletes become too anxious or overwhelmed, they may try to rush their performance, which ultimately ends up hurting their performance. Slow-motion imagery may be useful for helping the athlete slow down their actual movements, reducing their anxiety and stopping them from getting ahead of themselves. For example, if a golfer has a tendency to speed through her pre-shot routine on anxiety producing putts, causing her to miss more, using slow-motion imagery for an assimilation effect may cause her to perform the routine at a slower pace. However, this potential application needs empirical testing before it can be used.

Sixth, it would be of use to explore the relationship between imagery and task difficulty. More levels of difficulty (e.g., easy, medium, hard) would be necessary to explore fully how imagery is related to performance at increasingly difficult tasks. For example, as the length of the golf putt increases, does the effectiveness of imagery decrease? At what point, if any, does imagery become ineffective? Those questions could have potential implications for sport psychology practitioners.

Lastly, and perhaps most importantly, when it comes to imaging at different speeds, it may be useful to determine exactly how fast is fast and how slow is slow. In one study, participants were simply told to image at a slower rate (Andre & Means, 1986). Louis and colleagues (2008) had their participants actually perform the tasks at faster and slower speeds so participants could feel the differences in speed when imaging. However, there was no indication of how quickly or slowly participants actually imaged. Boschker and colleagues (2000) had their participants perform the task two times as fast or two times as slow (50% faster and 100% slower), but again, no indication was made at exactly how fast or slow their imagery was. O & Munroe-Chandler (2008) suggested to participants to image at a 50% slower rate. In the present study, participants were asked to imagery either 50% slower or faster.

It would be interesting to learn exactly how slowly or quickly athletes image when told to alter their imagery speed for two reasons. First, from a researcher’s perspective, it would make sense to attempt to determine if athletes’ preferred fast/slow speed as opposed to an assigned speed is effective to enhance performance or change mood states. Conversely, from an applied
perspective, it would be useful to know at what rate participants should image in order to achieve the maximum benefit (e.g., 100% vs. 50% vs. preferred). Since there has been little consistency across imagery speed studies as to exactly which rate to image, it may make it harder to move forward with imagery speed research if researchers are having participants alter their imagery speed in different ways.
References


Table 1.

*Data Collection Procedure*

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<tr>
<td>9</td>
<td>Post-Experimental Questionnaire</td>
</tr>
<tr>
<td>10</td>
<td>Debriefing</td>
</tr>
</tbody>
</table>
Table 2

*Performance Descriptive Statistics*

<table>
<thead>
<tr>
<th>Performance</th>
<th>Pretest</th>
<th>Posttest</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$M \ (SD)$</td>
<td>Min</td>
</tr>
<tr>
<td>7’ AD</td>
<td>10.77 (8.40)</td>
<td>0.00</td>
</tr>
<tr>
<td>7’ # Hole</td>
<td>2.31 (1.73)</td>
<td>0</td>
</tr>
<tr>
<td>14’ AD</td>
<td>21.86 (9.43)</td>
<td>4.17</td>
</tr>
<tr>
<td>14’ # Hole</td>
<td>1.13 (1.24)</td>
<td>0</td>
</tr>
</tbody>
</table>

*Note. AD = Average Distance from the Hole in Inches; # Hole = Number of Putts Successfully Holed.*
### Table 3

**Means, Standard Deviations, and Mean Differences for Performance Measures**

<table>
<thead>
<tr>
<th>Group</th>
<th>Pre</th>
<th>Post</th>
<th>Difference&lt;sup&gt;a&lt;/sup&gt;</th>
<th>Pre</th>
<th>Post</th>
<th>Difference&lt;sup&gt;b&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>7’ AD</td>
<td>7’ # Hole</td>
<td></td>
</tr>
<tr>
<td>SM</td>
<td>11.44 (10.32)</td>
<td>9.59 (6.02)</td>
<td>-1.85</td>
<td>2.53 (2.27)</td>
<td>2.71 (2.14)</td>
<td>+0.18</td>
</tr>
<tr>
<td>RT</td>
<td>11.71 (9.11)</td>
<td>11.55 (11.57)</td>
<td>-0.16</td>
<td>2.07 (1.75)</td>
<td>2.87 (2.00)</td>
<td>+0.80</td>
</tr>
<tr>
<td>FM</td>
<td>9.35 (5.56)</td>
<td>9.52 (6.31)</td>
<td>+0.17</td>
<td>2.20 (1.57)</td>
<td>2.80 (1.57)</td>
<td>+0.60</td>
</tr>
<tr>
<td>C</td>
<td>10.47 (8.23)</td>
<td>13.58 (9.19)</td>
<td>+3.11</td>
<td>2.40 (1.24)</td>
<td>1.80 (1.42)</td>
<td>-0.60</td>
</tr>
<tr>
<td></td>
<td>14’ AD</td>
<td>14’ # Hole</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SM</td>
<td>21.47 (9.24)</td>
<td>20.33 (13.00)</td>
<td>-1.14</td>
<td>0.94 (1.25)</td>
<td>1.29 (1.83)</td>
<td>+0.35</td>
</tr>
<tr>
<td>RT</td>
<td>20.78 (8.18)</td>
<td>17.27 (9.95)</td>
<td>-3.51</td>
<td>1.00 (1.00)</td>
<td>1.20 (1.32)</td>
<td>+0.20</td>
</tr>
<tr>
<td>FM</td>
<td>19.43 (9.03)</td>
<td>18.39 (10.79)</td>
<td>-1.04</td>
<td>1.73 (1.49)</td>
<td>1.13 (1.25)</td>
<td>-0.60</td>
</tr>
<tr>
<td>C</td>
<td>25.82 (10.79)</td>
<td>21.95 (7.80)</td>
<td>-3.87</td>
<td>0.87 (1.24)</td>
<td>1.07 (1.16)</td>
<td>+0.20</td>
</tr>
</tbody>
</table>

**Note.** AD = Average Distance from the Hole in Inches; # Hole = Number of Putts Successfully Holed; SM = Slow-Motion Imagery; RT = Real-Time Imagery; FM = Fast-Motion Imagery; C = Control No Imagery.

<sup>a</sup> Negative differences indicate improvements in performance (closer to the hole).

<sup>b</sup> Positive differences indicate improvements in performance (greater number in hole).
Table 4

*Means and Standard Deviations of Self-Efficacy Measures by Group*

<table>
<thead>
<tr>
<th>Self-Efficacy</th>
<th>Slow-Motion</th>
<th>Real-Time</th>
<th>Fast-Motion</th>
<th>Control</th>
</tr>
</thead>
<tbody>
<tr>
<td>7’ Level</td>
<td>4.24 (1.68)</td>
<td>4.00 (1.41)</td>
<td>3.87 (1.25)</td>
<td>4.20 (1.37)</td>
</tr>
<tr>
<td>7’ Strength</td>
<td>72.09 (14.33)</td>
<td>65.33 (15.30)</td>
<td>66.29 (15.04)</td>
<td>64.78 (11.89)</td>
</tr>
<tr>
<td>14’ Level</td>
<td>3.06 (2.02)</td>
<td>2.87 (0.74)</td>
<td>2.67 (1.35)</td>
<td>2.80 (1.61)</td>
</tr>
<tr>
<td>14’ Strength</td>
<td>62.97 (14.32)</td>
<td>49.49 (17.02)</td>
<td>55.61 (23.27)</td>
<td>57.37 (15.64)</td>
</tr>
</tbody>
</table>

*Note.* Level = Level of Efficacy Beliefs; Strength = % Strength of Efficacy Beliefs.