2005

Effects of image speed on the acquisition and performance of a soccer skill.

My Phung Jenny. O
University of Windsor

Effects of Image Speed on the Acquisition and Performance of a Soccer Skill

By

My Phung Jenny O

A Thesis
Submitted to the Faculty of Graduate Studies and Research
Through the Faculty of Human Kinetics
In Partial Fulfillment of the Requirements for
The Degree of Master of Human Kinetics at the
University of Windsor

Windsor, Ontario, Canada
2005

Your file Votre référence
ISBN: 0-494-09790-6
Our file Notre référence
ISBN: 0-494-09790-6

1027392

Abstract

Existing sport imagery research has identified the importance of understanding the content of athletes' images (e.g., Barr & Hall, 1992; Munroe, Giacobbi, Hall, & Weinberg, 2000). Understanding 'what' athletes are imaging enables sport psychology practitioners to empirically assess the efficacy of athletes' imaging methods. As a result, practitioners are able to design the most appropriate and effective imaging interventions and programs for athletes. Though it is suggested by sport psychology practitioners that imagery be performed at 'real time' speed (i.e., imaging at a speed which approximates actual execution speed; Nideffer, 1985; Weinberg & Gould, 2003), there lacks adequate theoretical and empirical support for this claim. In the present study, the effects of three imagery conditions on the performance of a soccer dribbling task were examined. Ninety-seven male and female first-year undergraduate students were randomly assigned to one of five conditions: (1) Real time imagery; (2) Slow motion imagery; (3) Slow motion concluded with real time imagery; (4) Physical practice; or (5) Control. Performance was evaluated based on time to complete the task as well as the number of errors per task attempt. A secondary purpose of the present study was to examine the effects of the various imagery conditions on participants' self-efficacy perceptions. Participants were administered the Movement Imagery Questionnaire-Revised (MIQ-R; Hall & Martin, 1997) prior to soccer dribbling performance data collection which allowed for between-gender comparison of visual and kinesthetic imagery ability. A self-efficacy measure was constructed for the study based on recommendations made by Bandura (1997), and was administered prior to, as well as immediately after imagery or physical practice intervention. A post-experiment manipulation check assessed how closely participants felt they adhered to the experimental protocol. Results indicated that males and females did not differ in their imagery ability on either scale of the MIQ-R (visual or kinesthetic). It was also found that group membership did not affect imagery ability. Self-efficacy analysis indicated that group membership did not affect self-efficacy perceptions, nor was there a significant difference between pre- and post-intervention self-efficacy scores.

Patterns of performance times were similar across all experimental groups. All groups improved from trial 1 to trial 2, however, the most significant trial effect was between trial 3 and trial 4, the interval surrounding the intervention. Tests of simple effects over this interval revealed that all experimental groups, but not the control group decreased performance time. With respect to error frequency, chi-square analysis revealed that groups did not differ over the performance trials.

In contradiction to the widely accepted imagery guideline of imaging only at real time speed (Nideffer, 1985), results of this study suggest that the speed at which an individual images is irrelevant to the effects of imagery use on a soccer dribbling task. Furthermore, imagery use was as effective as physical practice in improving soccer dribbling performance. Limitations regarding the examination of slow motion imagery and possible implications of its use are discussed, as well as suggestions for future research.

Acknowledgements

It is not many times in your life that you are fortunate enough to work with someone who embodies so much of what you aspire to be. Dr. Krista Chandler, you have been that and so much more for me during my time here. I am certain that, despite wherever life chooses to take me, you will continue to motivate, challenge, and inspire me. Thank you for all of your support, understanding, and guidance, and for having the confidence in me to let take my own risks and make my own mistakes (from which, I assure you, I have learned!).

I would also like to acknowledge the hard work, commitment, and great insight of my thesis committee: Dr. Patti Weir, Dr. Marliese Kimmerle, and Dr. Joe Casey. Your feedback has been instrumental to my completion of this thesis project. Your efforts are deeply appreciated.

Diane Dupuis and Pat Amlin – the best moms away from home a girl could ask for! Thank you both for your patience and accommodation for my many (many!) impromptu requests and last minute room bookings. Silvia Jimenez, I can't even count the many times you've saved me from my computer illiteracy! To my data assistant, Trista Hallman, thank you for sticking out those long data collection days…I still owe you and Brian a couple of beers!

JC a.k.a. J a.k.a. buddy a.k.a. Janice Campbell. What can I say, buddy? We're like two peas in a pod...well, really only if that pod was spacious enough for each of us to have our own quarters (because *surely*, everyone likes their 'me' time)…but definitely with a lot of room in the middle for hanging out. You've taught me the value of hard work, dedication, intense planning, and last-minute flurries of working madness. Funny, though, how hard work + dedication + intense planning sometimes still equals last-minute flurries of working madness. Counter-intuitive, isn't it? Oh wait, I forgot about the procrastination. Thanks for keeping me on track, buddy.

Leisha Strachan, I may not always refer to you as the baton-twirling old lady with the eight year-old's voice (you're bound to stop twirling at *some* point), but I will always refer to you as a close friend. Thanks for all of the venting sessions, culinary adventures, and tips to success. I would have never gotten through my first year here without you (for serious)!! Race ya to a PhD?! I even gave you a head start...but only because you're old.

Lex Cleaver, thank you for your unshakable concern and support. I still have my ribbon proudly displayed (first place for being smart!) and each time I look at it I am reminded that, sometimes, you can believe in yourself and in your own abilities just by knowing that others believe in you and your abilities. Christycalder...GT's all around...who says a girl can't have it all? Thanks for reminding me that fun is fun to have. Darryl Swain...you're almost as well-rounded as I, but the superstar t-shirt still belongs to me (you do put up a good challenge though). Thanks for keeping me motivated and forcing me to be uncomfortable sometimes. Nikki Laing and Lisa Murphy...you each bring something very unique the program here. Even though I won't be here to keep you in line next year, you'd better believe that I will be keeping tabs! To all of the current grad students...best of luck, and always remember to do what you love.

Last, I'd like to thank my family for their endless support and willingness to let me follow my own path. Mom and dad, I swear, I *will* become a grown up eventually!

Table of Contents

Page

Abstract....iii

Acknowledgements....v

List of Figures....x

List of Tables....xi

Chapter

I. Introduction....1

II. Literature Review

Imagery....4

Functions of Imagery....4

Imagery Theories....6

Symbolic Learning Theory....8

Psychoneuromuscular Theory....9

Bioinformational Theory....10

Triple Code Theory....11

Imagery Use....12

Effects of Imagery Use on Self-Efficacy....12

Effects of Imagery Use on Motor Skill Learning and Performance....13

Effects of Imagery Use on Sport Skill Learning and Performance....14

Imagery Type....15

Skill Learning and Performance Theories....21

Motor Program Theory....22

Generalized Motor Programs....23

Relative Timing....24

Rationale....24

Imaging in Slow Motion....24

Concluding Slow Motion Imagery with Real Time Imagery....28

Purpose....29

Hypotheses....30

III. Methodology

Participants....31

Recruitment....31

Task....32

Measures....34
Movement Imagery Questionnaire-Revised (MIQ-R; Hall & Martin, 1997)....34
Demographic Data....34
Self-Efficacy Measure....34
Post-Experimental Manipulation Check....35
Pilot Study to Determine the Number of Imagery and Physical Practice Trials....35
Experimental Procedure....36
Imagery Conditions....36
Physical Practice Condition....37
Control Condition....38
Data Analyses....39
Preliminary Analyses....39
Primary Analyses....39
Secondary Analyses....39

IV. Results
Preliminary Analyses....40
Primary Analyses....40
Verification of Randomization....40
Performance Time....40
Error Performance....46
Secondary Analyses....46
Manipulation Check....46

V. Discussion
Imagery Ability....48
Soccer Dribbling Performance....49
Imagery – Self-Efficacy Relationship....56
Limitations....58
Implications....60
Future Directions....61

References....63

Appendices
(A) Letter of Information....71
(B) Consent Form....75
(C) Movement Imagery Questionnaire-Revised (MIQ-R; Hall & Martin, 1997)....79
(D) Soccer Task Performance Self-Efficacy Measure....83
(E) Post-Experimental Manipulation Check (2-item; PP and CC groups)....85
(F) Post-Experimental Manipulation Check (4-item; imagery groups)....87

Vita Auctoris..89

List of Figures

Figure Page

1. Munroe et al.'s Conceptual Framework of Athletes' Imagery Use............................3

2. Analytic Framework of Imagery Effects (adapted from Paivio, 1985)........................5

3. Revised Analytic Framework of Imagery Effects (adapted from Hall et al., 1998)...........7

4. Content branch of the Conceptual Framework of Athletes' Imagery Use..................19

5. Diagram of the soccer dribbling task employed in the present study.......................33

6. Group means of time performance across trials...42

7. Group means of error performance across trials...47

List of Tables

Table Page

1. Group means and standard deviations of time and error performance........................41
2. Results of Tukey's HSD pairwise comparison of collapsed group means for trial performance...44
3. Results of 5 Separate Mixed-Design ANOVAs Comparing Trial 3 and Trial 4 Time Performance...45

Introduction

Previous sport literature has established that athletes can benefit from using imagery in sport to enhance performance (e.g., Barr & Hall, 1992; Bohan, Pharmer, & Stokes, 1999; Callow, Hardy, & Hall, 2001; Denis, 1985; Driskell, Copper, & Moran, 1994; Feltz & Landers, 1983; Millard, Mahoney, & Wardop, 2001; Weinberg, 1981). Silva and Stevens (2002) suggest that imagery is often viewed as "the cornerstone of sport psychology interventions" (p. 206) as it is one of the most well known mental training tools used by recreational, amateur, and professional athletes, alike. Though a universally employed definition has yet to emerge from the literature, a commonly used definition of imagery is:

> …an experience that mimics real experiences. We can be aware of 'seeing' an image, feeling movements as an image, or experiencing an image of smells, tastes, or sounds without actually experiencing the real thing.…It differs from dreams in that we are awake and conscious when we form an image (White & Hardy, 1998, p. 389).

Thus, imagery is a volitional experience that involves the use of one or more of the senses to create, or recreate, a particular sporting skill or situation.

In the past few decades, the study of imagery use in sport has experienced a substantial upsurge. In a span ranging only 16 years, an increase of over 100% in the volume of sport imagery use studies can be found (Feltz & Landers, 1983; Martin, Moritz, & Hall, 1999). The majority of this body of imagery research has advanced explanations of the relevance of imagery use to sport performance (e.g., Hall, Mack, Paivio, & Hausenblas, 1998; Martin et al.; Paivio, 1985) and examinations of how athletes use imagery to reap performance benefits (e.g., Barr & Hall, 1992; Bohan et al., 1999; Callow et al., 2001; Mckenzie & Howe, 1997). Theoretically understanding mental imagery and its relation and use in sport are instrumental in furthering our understanding of athletic performance.

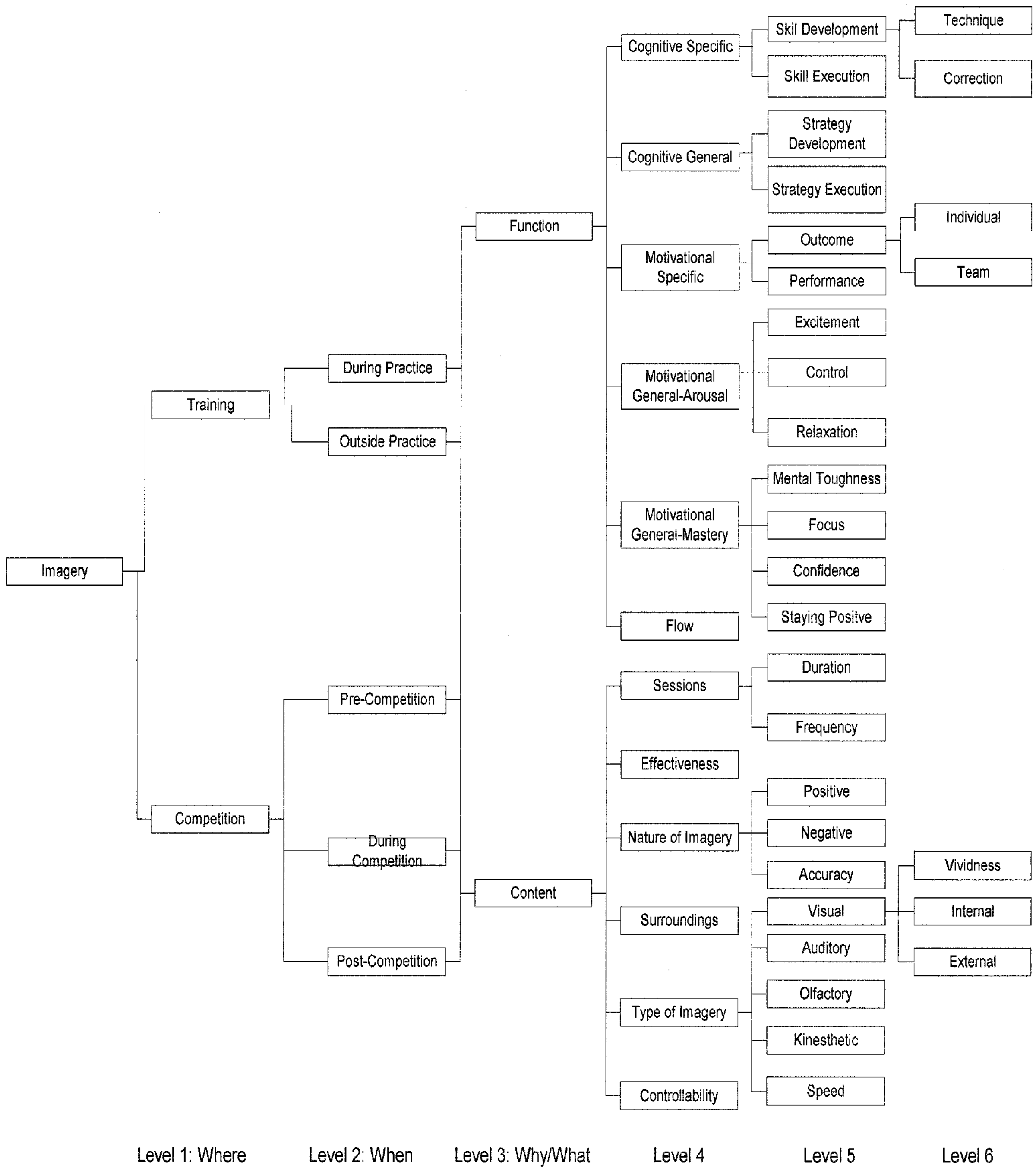
Another direction in imagery research has been to examine the content of athletes' images with the goal of increasing our understanding of exactly *what* and *when* athletes are imaging, and *where* athletes employ imagery in sport (e.g., Barr & Hall, 1992; Hall, Rodgers, & Barr, 1990; Munroe, Giacobbi, Hall, & Weinberg, 2000; Salmon, Hall, & Haslam, 1994). This line of research has yielded several interesting trends in athletes' imagery use, and has resulted in the construction of a conceptual framework of athletes' imagery use (Munroe et al., 2000; Figure 1). Researchers found athletes report using imagery more for competition than practice (though it is also used in practice and outside of sport), before competition as compared to during or after competition, and in ways that are more spontaneous and unstructured as compared to planned and regular. In addition, athletes image using various types of imagery (i.e., visual, kinesthetic, auditory, and olfactory).

Aside from the generally accepted types of imagery (i.e., visual, kinesthetic, auditory, and olfactory), which have been consistently reported by athletes in previous literature (e.g., Hall et al., 1990; Hardy & Callow, 1999), Munroe et al. (2000) found that several athletes also discussed the speed at which they were imaging (i.e., slow motion vs. faster than 'real time'). The researchers suggested that the speed of imagery may be a variable that deserves further attention in sport psychology research and emphasized this need by including the speed of imagery as an 'imagery type' in their conceptual framework.

In skill learning contexts, it is common practice for coaches and instructors to manipulate the execution speed of *physical* demonstrations of a skill to a new learner by demonstrating the skill in slow motion (e.g., a tennis instructor demonstrating a tennis serve in slow motion).

Figure 1

Conceptual Framework of Athletes' Imagery Use.
(reproduced with permission from Munroe, Giacobbi, Hall, & Weinberg, 2000).



Motor learning literature has suggested that physically demonstrating in slow motion may aid a learner in recognizing all of the important elements of a novel skill (e.g., Williams, Davids, & Williams, 1999). Regardless, the possibility of mentally *imaging* at different speeds is a topic that has received little focus in the research literature. It is suggested that imaging should occur in 'real time'; the temporal structure of the images should mimic that of actual physical execution (e.g., Nideffer, 1985; Weinberg & Gould, 2003). This suggestion, however, lacks any strong theoretical backing and few studies exist in the literature that addresses image speed in any capacity. The purpose of the present study was to examine the effects of employing imagery practice under three image speed conditions (slow motion, real time, and slow motion concluded with real time) on the performance of a soccer task.

A secondary purpose of the present study was to examine the relationship that self-efficacy holds with imagery use through the administration of pre- and post imagery self-efficacy measures. Researchers have suggested that self-efficacy may influence the relationship between imagery use and performance improvement (Bandura, 1997; Taylor & Shaw, 2002).

Results of the present study provide a unique contribution to the imagery literature, as well as providing further insights into athletes' use of imagery. Furthermore, results of the present study will allow for the development of more comprehensive imagery programs and interventions, and will aid in directing future research.

Literature Review

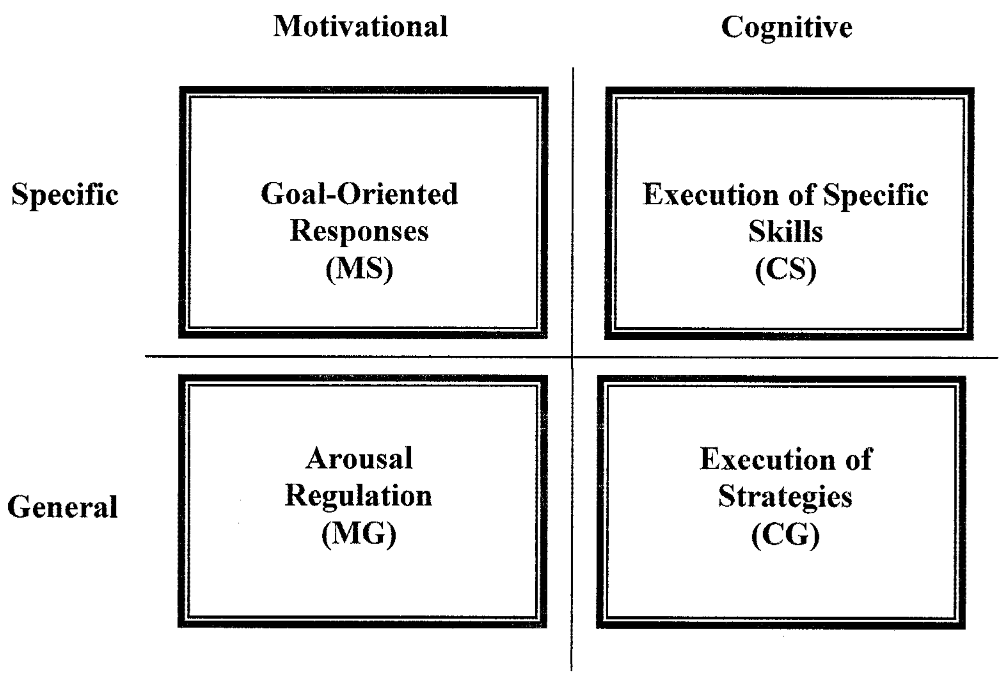
Imagery

Functions of Imagery

Paivio (1985) proposed an analytic framework that attempted to explain how imagery influenced sport and physical activity (Figure 2). Paivio posited that mental imagery had a

Figure 2

Analytic Framework of Imagery Effects.
(adapted from Paivio, 1985)



cognitive and motivational function that operated on either a specific or general level. Thus, cognitive general imagery included images of strategies, game plans, or routines (e.g., imaging a floor routine in gymnastics); cognitive specific imagery included images of specific sport skills (e.g., imaging a free-throw in basketball); motivation general imagery included images relating to physiological arousal levels and emotions (e.g., imaging feeling calm and relaxed in front of a crowd); and, motivation specific imagery included images related to an individual's goals (e.g., imaging receiving a gold medal).

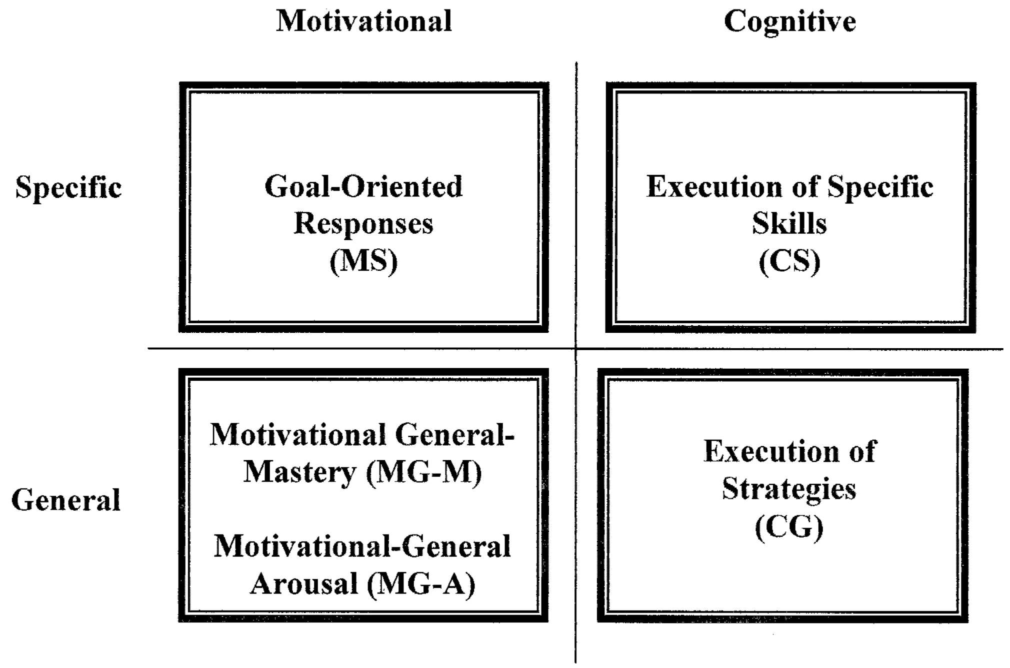
A number of years later, Hall and his colleagues (1998) further divided the motivational general function of imagery (Figure 3). The motivation general-arousal function encompassed imagery that was associated with arousal and stress, whereas the motivation general-mastery function represented imagery that involved imaging being mentally tough, in control, and self-confident. Thus, as a result of the collaborative efforts of Paivio (1985) and Hall et al., the five functions of imagery are; cognitive general (CG), cognitive specific (CS), motivational specific (MS), motivational general-arousal (MG-A), and, motivational general-mastery (MG-M). Identification of the five functions of imagery has enabled researchers, sport practitioners, coaches, and athletes to more clearly understand *why* imagery use in sport is beneficial to the athlete.

Imagery Theories

Although sport-imagery research has consistently shown that performance improvements are achievable through imagery use or intervention (for a review, see Hall, 2001), the theoretical support that has been offered to explain exactly why and how imagery use is beneficial to motor performance appears to be less clear-cut and somewhat equivocal. This is perhaps due to the fact that three of these four theories, which offer a cognitive, neuromuscular, or psychophysiological

Figure 3

Revised Analytic Framework of Imagery Effects.
(adapted from Hall et al., 1998)



explanation of how imagery 'works', were advanced prior to the major imagery research contributions of Paivio (1985) and Hall et al. (1998) wherein imagery use was delineated into five distinct functions. Although Hall notes that there currently fails to exist any one particular theory that is comprehensive enough to encompass all five imagery functions, each theory does shed some palpable insight into the mechanisms driving mental imagery and why its use can benefit performance. These theories are still employed by researchers and sport psychology practitioners and educators, and thus, it is important that the basic tenets of these theories continue to be considered until a more comprehensive theory of mental imagery is introduced.

Symbolic Learning Theory. Sackett (1934) posited that the function of imagery was to help individuals understand their movements. Symbolic Learning Theory suggests that movement patterns are 'coded' into an individual's memory system as 'mental blueprints'. The use of imagery serves to strengthen these mental blueprints by increasing an individual's familiarity with the particular blueprint, or movement pattern, being mentally recalled (Weinberg & Gould, 2003). Accordingly, the more an individual images a particular movement pattern, the more the respective mental blueprint will be reinforced in memory. Consequently, performance improvements should result as the individual continues to progress towards skill mastery. This theory also argues that skills that are more cognitive in nature (e.g., a figure skating routine) are more easily coded than skills that are considered to have a greater motoric element (e.g., the clean and jerk in weight lifting competition).

In addition to the Symbolic Learning Theory's failure to address all of the functions of imagery, it focuses only on the individual who is learning a skill. The theory does not explain how an expert performer – one who has mastered the particular skills for his or her given sport – benefits from using imagery (Hall, 2001). A further criticism by Hall lies in the ambiguity of the

Symbolic Learning Theory's operational definition. Hall argues that it is difficult to objectively determine the size of the cognitive component of any given motor task. In other words, the Theory offers no quantification of a specific size of cognitive demand that a motor skill or task must possess in order to be considered a 'cognitive' as compared to a 'purely motor' task. This creates a problem when attempting to apply the theory into practice (i.e., does a particular motor skill contain a great enough cognitive component for imagery practice to be effective?).

Psychoneuromuscular Theory. Psychoneuromuscular Theory (Jacobson, 1930) states that neural pathways are activated when mentally imaging a skill and that these neural pathways are identical to those activated when actually (physically) performing the particular movement (though the corresponding nerve impulses are much smaller in magnitude as compared to that which occurs during physical execution). Vealey and Walter (1993) further add that muscle synergies are developed or strengthened via imagery use; imaging a particular movement trains the relevant muscles to fire in the correct sequence, which would suggest that the benefits of mentally practicing a movement is akin to that of physical practice.

Empirical support of the Psychoneuromuscular Theory is evident through measurement of electomyographical (EMG) activity of relevant muscles. During imagery of a skill, muscles relevant to that particular skill are activated (e.g., Harris & Robinson, 1986; Slade, Landers, & Martin, 2002). Feltz and Landers (1983), however, have criticized the validity of this support arguing that many times, a lack of appropriate controls were used during data collection. Additional research that ensures appropriate controls and that measures frequency and duration of EMG activity (as well as amplitude) is needed. Furthermore, the Psychoneuromuscular Theory also fails to encompass all five functions of imagery (Hall, 2001).

Bio-informational Theory. Lang's (1979) Bio-informational Theory suggests that mental images are comprised of two main parts: stimulus propositions and response propositions. Stimulus propositions are the characteristics of the skill or scenario to be imaged, while response propositions are the physiological and affective responses that the individual experiences when imaging that particular skill or scenario. For example, a baseball player may imagine the fans, the opposing team's pitcher and defense, and the bat and ball (stimulus propositions) as well as imagining feeling the bat in his hands and the cognitive and somatic anxiety he feels as he gets ready to step into the batter's box (response propositions).

The important addition that the Bio-informational Theory makes that the previous theories tend to overlook is consideration of the impact that affective responses have on the efficacy of imagery use. The Bio-informational Theory posits that imaging a skill or scenario with the particular response propositions associated with execution of that skill or scenario – even if they are considered debilitative or negative responses – can help an individual improve his performance to a greater extent than if he were to only image the stimulus propositions alone. By mentally replicating the actual task, *including* the associated feelings and emotions, an individual is more closely imaging the task as it would occur in real life.

While the Bio-informational Theory represents an improvement over both the Symbolic Learning and Psychoneuromuscular Theories, it is not without criticism. Although it is conceivable that the Bio-informational Theory makes inference to the motivational functions of imagery (when considering response propositions), Hall (2001) suggests that the link is too weak to consider the Theory as encompassing all imagery functions. Furthermore, Hall adds that the Theory also fails to connect the relationship that imagery holds with respect to linking action to other forms of information processing (e.g., language).

Triple Code Theory. Perhaps one of the more comprehensive theories of imagery to-date is Ahsen's (1984) Triple Code Theory (ISM). This theory is similar to Lang's (1979) Bio-informational Theory, however, Ahsen's Theory offers a third element to its operational definition. Ahsen suggests that an image is composed of three sources of information that are coded by the individual. The image (I) is similar to Lang's stimulus propositions in which effective images are vivid and realistic and closely replicate the object, skill, or scenario as it would occur in real life. The second source of information involves the individual's somatic responses (S; similar to Lang's response propositions) in which imaging a task results in psychophysiological changes to an individual. These can include somatic responses such as an increase in heart rate, sweaty palms, or other physiological responses to anxiety or arousal. The third source of information is the meaning of the image (M), which addresses the need to consider individual differences with respect to imagery use. Ahsen states that every image imparts a meaning and that no two people, even if provided with the same imagery script, will have the exact same imagery experience (Weinberg & Gould, 2003). Triple Code Theory states that the most effective images are vivid and realistic, evoke psychophysiological response, and impart significance, or meaning, to the individual.

As seen in each of the previous theories, limitations of the Triple Code Theory include an inability to encompass all five of the functions of imagery. Much like Lang's (1979) Bio-informational Theory, it is possible to *infer* inclusion of the five functions, however, there is no direct explanation of how the three sources of information of the Triple Code Theory (ISM) are related to, or influence, each of the five functions of imagery.

Despite their limitations, each of these theories does suggest that motor performance can be improved through the employment of imagery techniques. Furthermore, empirical research has been provided to support each of the aforementioned imagery theories (cf. Weinberg & Gould, 2003), thus suggesting that certain aspects of each of the theories do partially explain the imagery-performance relationship, but that these aspects alone are not sufficient enough to completely address all functions of imagery as they relate to performance. Further exploratory research is warranted to examine other possible explanations of why imagery use can facilitate athletic performance improvement.

Imagery Use

Effects of imagery use on self-efficacy. Bandura (1986) notes that imaginal experiences are a source of self-efficacy. Furthermore, Callow and colleagues (2001) have suggested that images of successful skill execution may be considered as a form of personal mastery, which according to Bandura is the most influential source of self-efficacy. With the delineation of imagery into its five distinct functions, studies examining MG-M imagery have concluded that the use of MG-M imagery by athletes generally correlate with higher levels of self-efficacy, as MG-M imagery includes images of being confident and in control (e.g., Beauchamp, Bray, & Albinson, 2002; Moritz, Hall, Martin, & Vadocz, 1996; Vadocz, Hall, & Moritz, 1997). Research has also found that the administration of MG-M imagery intervention can result in increases self-efficacy perceptions (e.g., Callow et al., 2001; Hall, 2001). However, some researchers have suggested that other imagery functions may also influence an athlete's self-efficacy perceptions (e.g., Callow et al., 2001; Martin & Hall, 1995; McKenzie & Howe, 1997). Results from examination of this relationship between self-efficacy and other imagery functions have been inconclusive.

In particular, studies employing the effects of CS imagery intervention on self-efficacy have produced equivocal results. Garza and Feltz (1998) and Short and colleagues (2002) found that CS imagery use resulted in an increase in the self-efficacy of figures skaters (Garza & Feltz) and subjects performing a golf putting task (Short et al.). Conversely, Martin and Hall (1995), who also employed a golf-putting task in their study, concluded that CS imagery intervention did not have an effect on participants' self-efficacy perceptions. Furthermore, McKenzie and Howe (1997) found that their subjects performing a dart-throwing task exhibited within group differences with respect to the effect of CS imagery intervention on self-efficacy. These researchers reported that some subjects showed increases in self-efficacy, some showed no change, and interestingly, some subjects even showed a decrease in self-efficacy perceptions.

It has recently been suggested that these differences in the effects of various imagery interventions on self-efficacy may have been partially influenced by the meaning that subjects imparted onto the imagery being employed (Short, Monsma & Short, 2004). If, for example, a study employed a CS imagery intervention but many of the study participants interpreted the images they were instructed to use as being of a 'confidence-boosting' nature, that particular study would likely conclude that the CS imagery intervention resulted in an increase in self-efficacy perceptions. Despite lack of a clear-cut understanding of the exact nature of the imagery-self-efficacy relationship, relatively few studies have focused on teasing out the relationship that each respective imagery function holds with self-efficacy.

Effects of imagery use on motor skill learning and performance. The majority of existing between-participants, pre- to post-test comparison studies have yielded results that support the notion that mental imagery use is more effective than no practice at all. It should be recognized, however, that mental imagery use alone is not as effective in eliciting motor skill performance improvements as is physical practice alone (e.g., Bohan et al., 1999; Creelman, 2003). Creelman examined the effects of imagery practice as compared to physical practice on the learning and performance of a novel discrete motor skill (i.e., big toe abduction). Creelman concluded that the employment of mental imagery was effective in producing performance improvements (though not as effective as physical practice). Similarly, Bohan et al. reached the same conclusion employing a joystick displacement task. It is important to recognize the cognitive demand differences in the tasks used in Creelman's and Bohan and colleagues' respective studies. Sackett's (1934) Symbolic Learning Theory suggests that skills that contain a greater cognitive component (e.g., Bohan et al.'s joystick displacement task) tend to benefit more from imagery practice than those skills that are more motoric (e.g., Creelman's big toe abduction task). The results of these two studies demonstrate, however, that regardless of the size of the cognitive demand of the task, statistically significant improvements in task performance are still possible through the employment of mental imagery.

Effects of imagery use on sport skill learning and performance. The effects of imagery use on learning and performance have also been extensively examined in the sport skill context. Hall (2001) notes that the research literature generally suggests that imagery use can have a beneficial influence on sport skill performance. Beauchamp and colleagues (2002) examined the effects of the use of pre-competition MG-M imagery on golf performance within a group of 51 varsity golfers. The researchers found that the use of MG-M imagery accounted for significant variance in golfers' performance, with better performances belonging to those golfers who employed more frequent pre-competition MG-M use.

Other studies in the sport literature that have employed a four-group design (which include a physical practice group, imagery practice group, control group, and a combination group that receives both physical practice and mental imagery) have indicated that the combination of physical practice and mental imagery produced as great, if not greater improvements in motor performance from pre- to post-test than any one practice condition alone (e.g., Millard et al., 2001). Millard and colleagues found that when learning a kayak wet exit drill (a novel, serial skill), subjects who employed a combination of physical and mental imagery practice significantly outperformed subjects who practiced using mental imagery alone or those who received no practice at all. The physical practice group in Millard and colleagues' study showed the greatest improvement among all experimental groups.

Furthermore, Meta-analyses conducted on the efficacy of imagery use on motor learning and performance by Driskell and colleagues (1994) and Feltz and Landers (1983) revealed small, yet statistically significant, effect sizes of 0.53 and 0.48, respectively. Several other reviews of the mental imagery literature have consistently concluded that individuals can benefit from employing imagery when learning and performing a motor skill (e.g., Denis, 1985) and that imagery use is generally effective for improving athletic performance (e.g., Weinberg, 1981). It is now widely accepted that positive performance benefits can be obtained through the employment of mental imagery use in sport.

Imagery Type

Imagery studies in sport have begun to focus on exactly how athletes use imagery in sport. This research has attempted to answer questions regarding what, when, where, and why athletes employ imagery use in sport (e.g., de Almedia, 1999; Barr & Hall, 1992; Hall et al., 1990; Hall et al., 1998; Martin et al., 1999; Munroe et al., 2000). Much of this existing sport-imagery research has attempted to determine the most effective imagery techniques that athletes can employ to enhance sport performance (e.g., Hall et al.; Hardy & Callow, 1999).

In order to determine the most effective imaging strategies for athletes, some researchers have examined the concept of 'what' athletes are imaging (e.g., Hall et al., 1990; Munroe et al., 2000). As a result of this body of research, imagery perspectives and several types of imagery have been identified in the literature. Imagery perspectives include internal and external perspectives, while generally accepted types of imagery encompass each of the body's five senses; sight (visual), feel (kinesthetic), hearing (auditory), smell (olfactory), and taste (Hardy & Callow, 1999). When imaging from an internal perspective, an athlete 'sees' herself performing from within her own body, through her own eyes (Cox, 2002). Conversely, when imaging from an external perspective, the athlete imagines 'watching' herself perform, similar to watching a videotape of her own performance (Hardy & Callow). Although earlier imagery perspective research suggested that elite level athletes preferred to image using an internal perspective (e.g., Mahoney & Avener, 1977), more recent research has suggested that athletes at all levels use both internal and external perspectives when imaging (e.g., Hall et al.; Munroe et al.). Hardy and Callow have suggested that imaging from an external perspective may be most beneficial for those athletes who participate in sports in which form is an important evaluative factor (e.g., gymnastics).

Of the types of imagery employed by athletes, available research seems to suggest that visual and kinesthetic imagery are the most frequently used (e.g., Hall, 2001; Munroe et al., 2000). Kinesthetic imagery involves 'feeling' the movements of a skill when imaging (Cox, 2002). For example, a slalom ski racer may feel the snow under his skis and the wind against his body when imaging a run. It is important to note that when considering an athlete's use of different types of imagery (e.g., internal and external imagery perspective, kinesthetic imagery type) and the efficacy of these different imagery types, imagery ability of the subjects should also be taken into consideration (Hall).

Several studies have examined, as either the primary focus of study or as an additional variable, the imagery ability of various athlete populations (e.g., Moritz et al., 1996; Vadocz et al., 1997) using the Movement Imagery Questionnaire – Revised (MIQ – R; Martin & Hall, 1997). The MIQ-R is an 8-item questionnaire that assesses an individual's visual and kinesthetic imagery ability. Moritz and colleagues found that high sport-confident roller-skaters demonstrated greater imagery ability than low sport-confident roller-skaters, while Vadocz et al. concluded that those athletes (roller-skaters) who demonstrated greater imagery ability reported using imagery more frequently. Weinberg and Gould (2003) note that imagery ability is perhaps the most powerful factor influencing imagery's effectiveness, with more efficacious imagery being experienced by those individuals having higher imagery ability. Martin and colleagues (1999) strengthen this suggestion regarding the efficacy of imagery use in their Applied Model of Imagery Use. The Model recognizes that imagery ability serves a moderating role between imagery use and effectiveness. Additional empirical research using the MIQ-R is warranted as well as research that examines the relationship between imagery ability and imagery efficacy.

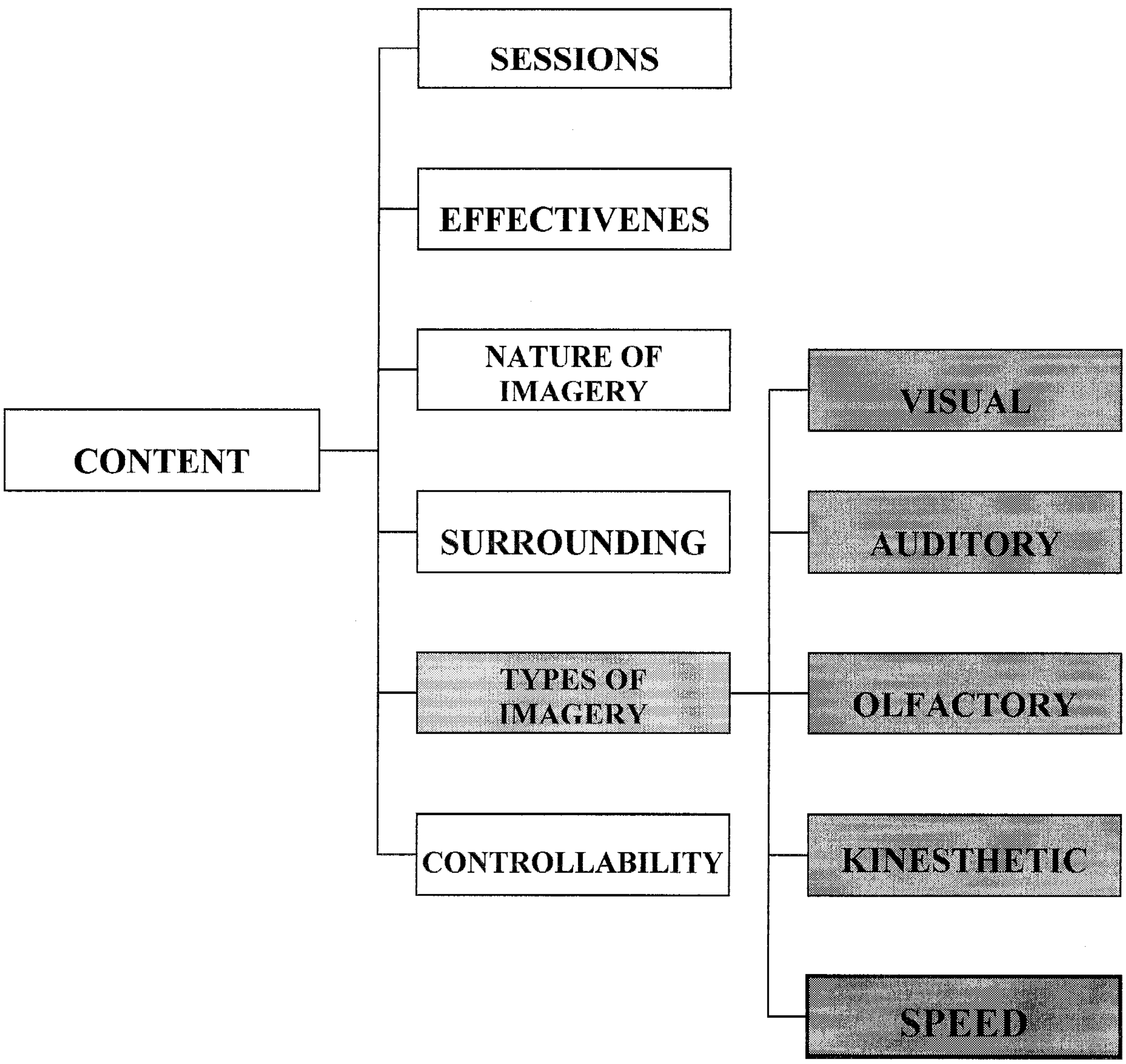
Aside from the various types of imagery that an athlete may employ, athletes may also differ in their use of imagery. Athletes may use imagery at different times, for different purposes, and in different contexts. Hall and colleagues (1990) conducted a study involving 381 male and female participants from six sports competing at various competitive levels. The researchers administered the Imagery Use Questionnaire (IUQ; developed specifically for the study). The IUQ collected information on what, when, where, and why athletes were imaging. Hall and colleagues found that athletes used both internal and external imagery perspectives with approximately the same frequency, as well as using kinesthetic imagery. The researchers also noted that athletes reported using imagery more in competition than in practice and that the athletes' imagery sessions tended to be spontaneous and unstructured.

In a qualitative study by Munroe and colleagues (2000), researchers administered in-depth interviews with 14 varsity-level athletes (both males and females) from seven different sports, and asked the athletes to identify and describe their imagery use (the 'four Ws of imagery use'; where, when, why, and what). By employing an open-ended interview approach, Munroe et al. were able to expand on Hall and colleagues' (1990) study by allowing athletes the freedom to expand on their thoughts and techniques regarding their imagery use. With respect to 'what' athletes were imaging, Munroe and colleagues found that the content (e.g., 'what') of athletes' imaging could be divided into six branches. These branches included sessions, effectiveness, nature of imagery, surroundings, type of imagery, and, controllability (Figure 4). Focusing specifically on the branch of 'type of imagery', it was found that athletes reported using visual, kinesthetic, auditory, and olfactory imagery, which is consistent with that reported by athletes in previous literature (e.g., Hall et al.).

Munroe and colleagues also noted that several athletes discussed the speed at which they were imaging (e.g., slow motion vs. faster than 'real time'). This finding suggests that despite the imagery application-based suggestion of imaging only in real time (i.e., at an image speed that is identical to that of actual physical execution; Nideffer, 1985; Weinberg & Gould, 2003), athletes may be employing imagery use at image speeds other than real time. Furthermore, although the suggestion to image in real time is widely accepted and advocated by many sport psychology practitioners, there has not been any specific theoretical support advanced as to *why* it is best to image in real time. Munroe and colleagues suggest that the speed of imagery may be a variable that deserves further attention in sport psychology research, and further emphasized

Figure 4

Content branch of the Conceptual Framework of Athletes' Imagery Use.
(adapted with permission from Munroe, Giacobbi, Hall, & Weinberg 2000)



this need by including the speed of imagery as an 'imagery type' in their subsequent conceptual framework of athlete's imagery use.

In 1986, Andre and Means administered an imagery intervention program with a group of university-aged males learning a relatively familiar closed motor skill (a Frisbee toss). Imagery speed was manipulated such that groups were guided (via group audiotape sessions) through either slow motion- or standard (real time) imagery sessions. A control group was also employed that did not receive an imagery intervention. The researchers hypothesized that the group receiving the slow motion imagery intervention would show the greatest performance improvements (from pre- to post-test). The researchers justified their hypothesis by relating their reasoning to the efficacy of certain 'psychotherapeutic' techniques such as relaxation, hypnosis, and meditation that emphasized, "...an exaggerated slowing down of the client's information processing" (p.124). The researchers further rationalized (based on a position paper written by the secondary author) that by slowing down and focusing on the skill during mental practice, participants in the slow motion imagery group would experience more vivid images and image more detailed execution of the skill, thereby resulting in improved performance. Conversely, results of the study found that though performance did improve in both imagery conditions, greater improvement was seen in the real time imagery group.

The recent work of Munroe and colleagues (2000) suggests that there is a need for further exploration into the various types of imagery employed by athletes, and in particular, into the possibility of imaging at different image speeds. Additional research is needed to explore whether more types of imagery exist, as well as how and in what context athletes at various competitive levels employ these imagery types. Also warranted is the examination of how the employment of different types of imagery (e.g., internal and external perspectives, image speed, kinesthetic imagery, etc.) impact upon the novice athlete's acquisition and performance of skills relevant to his particular sport.

Skill Learning and Performance Theories

As an athlete repeatedly performs the particular skills relevant to her sport (as seen when practicing or during game situations), she moves along a continuum of the skill-learning process that ranges from 'cognitive' through to 'autonomous' (Fitts & Posner, 1967). Early in the learning process, an athlete's performance is characterized by attempts to become familiar with the movements associated with the skill (Schmidt & Wrisberg, 2000). As a result, a large cognitive demand is placed on the athlete who is trying to perform the skill being learned. As the athlete becomes more proficient at the skill, the volitional cognition required to perform the skill is progressively reduced until skill mastery is reached and performance of the skill reaches a state of automaticity (i.e., the autonomous end of the skill-learning continuum is reached).

Examination of the expertise literature would suggest that true expert status is not obtained until an athlete has logged 10 years, or 10,000 hours, of deliberate practice (i.e., practice wherein the specific goal is to improve performance; Ericsson, Krampe, & Tesch-Römer, 1993). However, more in-depth examination of the skill-learning process reveals that the acquisition, refinement, and mastery of several smaller motor performance sub-components (e.g., muscle synergies and motor programs) that are crucial to movement execution are required early in the learning process in order for skill-learning to progress (Singer, 1982). It is important to distinguish between issues of motor learning and those of motor control when discussing these motor performance sub-components. Singer has suggested that motor learning is concerned with constructs and variables related to improvement and the learning of a motor skill (e.g., developing a motor program), whereas motor control issues appear to involve the development of certain internal processes that are required for successful execution of a skill (e.g., muscle synergies).

A novice-level athlete's skill learning will largely concern the creation and storage into long-term memory of specific muscle synergies and motor programs for related sport-skills. By the time the athlete reaches an intermediate level of skill proficiency, these muscle synergies and motor programs have been created, automated, and stored into memory (e.g., Schmidt & Wrisberg, 2000; Singer, 1982). At this time, the athlete is able to begin to shift his or her focus of learning from learning how to perform the skill correctly to learning how to perfect the skill (i.e., progress towards mastery) or, at least perform it more efficiently.

Motor Program Theory

Schmidt and Wrisberg (2000) suggest that for an individual to attempt to consciously regulate every possible combination of muscle and joint activity of which she is capable would be virtually impossible. It appears that many movements that are executed on a regular basis (e.g., walking, running, throwing, etc.) can be executed by an individual without having to devote much thought as to exactly *how* to perform each particular task. Schmidt (1975) states that this 'prestructured movement' is resultant of the existence of a motor program for a given movement task. A motor program is a set of prestructured motor commands. When activated, these motor commands trigger the required muscle and joint actions necessary for execution of the given movement. For example, the motor program for throwing a baseball would include a set of motor commands that address arm position and movement, leg position and movement, and torso position and rotation. This set of commands essentially defines and structures the movement to be produced (Schmidt & Wrisberg).

Generalized Motor Programs

The major limitation of motor program theory is that it fails to address the flexibility that is seen within various movements (Schmidt, Heuer, Ghodsian, & Young, 1998; Schmidt & Wrisberg, 2000). For example, a change in foot and leg displacement and speed (i.e., amplitude and velocity) can mean the difference between stopping a rolling soccer ball and kicking it. Although the set of motor commands used to initiate stopping the ball versus kicking the ball is the same, the amplitude and velocity of the movement change depending on the desired outcome (i.e., stop the ball or kick it).

The concept of a 'generalized' motor program (GMP) eliminates the limitation of the more simplistic motor program theory. Schmidt and Wrisberg (2000) suggest that a GMP "defines a pattern of movement rather than a specific movement" (p. 140). Thus, the general structure of the movement including all of its crucial movement elements is stored as a set of commands. The generality of the motor program allows for 'parameterization' of the motor program such that it can be adapted to suit various outcome demands.

Schmidt and Wrisberg (2000) refer to the different variables that can be modified within a GMP as 'parameters'. Of particular relevance to the present context are the parameters of movement time and amplitude. GMP theory holds that an individual is able to change the movement time or amplitude of a particular movement without significantly altering the pattern of the movement. This suggests that physical execution of a task can be carried out at various speeds (i.e., duration of skill execution) or amplitudes while still maintaining the integrity of the GMP. For example, a golfer hitting an iron from 75 yards out (i.e., away from the pin) would use the same GMP as he would use to hit a tee shot from 500 yards out. The difference in the two swings would be a function of the parameterizations of the movement's amplitude and time.

For the shorter shot with the iron, the golfer would slow his swing down (i.e., elongate movement duration) and decrease the amplitude of his swing (i.e., swing the club with less force and velocity). Similarly, the long drive off of the tee would require parameterization such that movement duration was shortened and amplitude increased (which would ultimately generate a more powerful swing and, therefore, a longer drive).

Relative timing. In the motor control domain, Schmidt (1985, 1988) explained that an important invariant feature of a GMP is the relative timing of the movements required of the skill for which the GMP defines. Similar to the temporality requirement of muscle synergies (e.g., Lee, 1984), relative timing in GMP theory suggests that the temporal structure of the various parts of a movement change as a unit when the timing of the entire movement is changed. Regardless of changes to movement amplitude or time, relative timing of a movement ensures that the fundamental temporal structure, or the 'rhythm' of the movement, remains the same. Using the previous golf swing example, if the golf swing were to be broken down into smaller 'components' of the golf swing (i.e., back swing, swing phase, and follow through), one would expect to see the same ratios exist with respect to movement duration between each of the golf swing's component movements in the tee shot as compared to those of the shot from only 75 yards out.

Rationale

Imaging in Slow Motion

Though types of imagery have been identified and established through previous research, the results of Munroe et al.'s (2000) study seem to suggest these concepts warrant further investigation. In particular, the possibility of imaging at different speeds is a topic that has managed to remain virtually unaddressed in the literature and one that requires additional research.

Drawing from popular culture medium, many modern-day films often depict sport scenes that unfold in slow motion. It is often these scenes that viewers remember most explicitly from any particular film. For example, most sport enthusiasts are able to vividly recall the opening credits of *Raging Bull* (Chartoff, Polaire, Savage, Winkler, & Scorsese, 1980) where a hooded Robert De Niro as former middleweight boxing champion Jake LaMotta is seen shadow-boxing. The scene is played in slow motion. *Hoosiers* (DeHaven, Pizzo, & Anspaugh, 1986) captivated audiences during its final game scene, where a game winning free-throw attempt took seconds to play out, also, in slow motion.

Similarly, sporting news and review programs on television such as *SportsCentre* (Milliere, 2004) or *Sportsnetnews* (Rogers Sportsnet Inc., 2003) often include a 'highlight' section at the end of the show's broadcast. These highlights are often played in slow motion, thereby allowing the viewer to fully appreciate the excellence of the skills and plays being reviewed. Perhaps when individuals recall these 'great plays', be it in casual conversation or as a method of preparing for an athletic game or situation of their own, it is possible, and even plausible, that these individuals mentally recall or image the play in slow motion as they had originally seen it or best remembered it from the film or sporting program. Furthermore, because these individuals relate successful performances and perfect skill execution to visions that unfold in slow motion, it is entirely possible that these individuals may employ slow motion imagery when imaging themselves in various sport situations.

The employment of slow motion imagery may also occur during the skill learning process where an individual is attempting to familiarize himself with the various movement requirements of a particular skill. This use of slow motion is evident when considering the modeling performed by coaches and instructors. Motor learning literature recognizes that modeled movements may have to be slowed down to be registered by a learner due to human information-processing limitations (Williams et al., 1999). Often times slow motion video is used to allow learners the opportunity to register all parts of a skill. Seeing a particular skill in slow motion allows a learner to observe the many different movements required of the body for successful execution. Although a large portion of the support for the efficacy of slow motion modeling is either theory-driven or anecdotal in nature, some empirical literature has provided support for the benefits of slow motion modeling (e.g., Roshal, 1961, as cited in Williams et al.). Roshal found that slow motion video modeling was useful for rope-knotting tasks that subjects deemed as 'difficult'. In accordance with the generally accepted view that slow motion modeling can be beneficial for the skill learning process, it is possible that the employment of slow motion imagery may also improve learning and performance of a skill.

The results of Andre and Means' (1986) study would, however, suggest that the employment of real time imagery is more beneficial than that of slow motion imagery. Yet, their results are not surprising if basic motor learning theory is considered. Arguably, one of the most important tenets in motor learning theory is that it is crucial to practice 'target skills in target contexts' (Schmidt & Wrisberg, 2000). When learning a skill (i.e., the 'target' skill), an individual should practice in an environment that is most closely representative of the environment or context in which he is expected to perform that skill (i.e., the 'target' context). By imaging in slow motion only, the slow motion group may not have been approximating the target context as closely as were the real time imaging group. Not surprisingly, when motor learning theory is considered, this would lead to better skill learning and improvement in the latter group. By imaging in real time, the real time imagery condition participants were more closely able to practice the target skill in the target context.

One could suggest that it is the combination of slow motion imagery with real time imagery that would be most beneficial to athletes. Practicing 'target skills in target contexts' (Schmidt & Wrisberg, 2000) would suggest that real time imagery is the most effective imaging method. The argument for the benefits of imaging at different speeds, and particularly in imaging using a combination of slow motion and real time imaging, however, is driven by a combination of existing sport psychology theory and theory from the motor learning and motor control domains.

As outlined earlier, imagery serves both cognitive and motivational purposes (Hall et al., 1998; Paivio, 1985). It could be argued that the cognitive functions of imagery would be further enhanced if the athlete incorporated slow motion imagery into his imagery practice (in conjunction with real time imaging). By imaging in slow motion, an athlete is 'seeing' himself perform every minute detail of the game strategy (CG) or skill movement (CS) perfectly. This reasoning is in line with that of Andre and Means (1986) which suggested that by imaging in slow motion, an individual would be able to image execution of a particular skill more vividly and in greater detail, thereby increasing the performance benefits of imagery use.

Furthermore, it is possible that imaging in slow motion may also impact the efficacy of the MG-M function of imagery, which would indirectly influence performance. Bandura (1997) has suggested that self-efficacy may be a mediating variable of the effects of imagery use on performance. Bandura defines self-efficacy as subjective judgments regarding what an individual can do with the skills he possesses in a particular situation. By seeing each detail of the movement in slow motion, the athlete is reassuring himself that he is capable of executing the skill properly (MG-M). It is plausible that this reassurance would lead to an increase in self-efficacy and perceived competence, which would ultimately result in better skill performance. When image speed is considered, this indirect effect of MG-M imagery on performance may be less pronounced imaging in real time than at a slower speed, and particularly for discrete skills (i.e., skills that are relatively short and have a definitive beginning and end; Schmidt & Wrisberg, 2000).

In the literature, higher self-efficacy, perceived competence, and motivation levels have all been positively linked to successful sport performances (e.g., Bandura, 1997; Biddle, 1993; Duda, Chi, Newton, Walling, & Catley, 1995). Thus, it would seem that the benefits of using slow motion imagery would also show a positive relationship with sport performance.

Concluding Slow Motion Imagery with Real Time Imagery

The importance of concluding slow motion imagery with real time imagery is based on motor control theory. In the motor control domain, Shumway-Cook and Woollacott (2000) note that muscle synergies and motor programs of elite level athletes have reached a level of 'automaticity'; athletes can perform the skills relevant to their sport without having to devote much attentional capacity to skill execution because the synergies and motor programs have been permanently stored into memory. If an athlete were to image only in slow motion, however, then it would be possible that these muscle synergies and motor programs would be negatively affected since the athlete is, in essence, practicing the skill incorrectly.

These errors would be occurring at the temporal level where muscle synergies (the timing and order of the movement of specific body parts and initiation of certain body processes) would be 'thrown off' because the action is taking much longer when imaged in slow motion than it would when it was physically executed. Furthermore, it is possible that a single motor program could become divided into several smaller motor programs. When imaging only in slow motion, a single fluid movement (e.g., a baseball swing) is mentally replayed so slowly that it essentially becomes several discrete movements (e.g., weight transfer, arm action, follow through arm action). Each movement is sequentially linked to the previous movement, but still independent of each other. This would result in a choppy, and perhaps, even spastic execution of the skill if the skill were to be physically attempted.

However, as mentioned above, motor learning and control theories suggest that the motor program and muscle synergies of a learned skill are permanently stored into long-term memory (Shumway-Cook & Woollacott, 2000). Therefore, concluding slow motion imagery with real time imagery would successfully restore temporal structure and timing of skill movement. By concluding with real time imagery, muscle synergies and motor programs are mentally recalled and reinforced; thus, the athlete would be able to reap the enhanced benefits of imaging in slow motion without suffering any detrimental performance effects.

Purpose

To date, there has been only one study in the literature that has examined the concept of slow motion imagery (Andre & Means, 1986). It must be noted that in the literature review of this study, absent was the mention of previous slow motion imagery studies or related established theories. Similarly, following an extensive literature search for the present study, it does appear that such studies and related theories fail to exist in the current body of imagery knowledge. A handful of studies have examined the duration of images and compared image duration to the duration of physical execution of the same task (e.g., Calmels & Fournier, 2001; Orliaguet & Coello, 1998; Reed, 2002), but results have been inconsistent and the reasoning for the differences seen in imaged versus actual execution duration have been equated to differences in skill level of the participants (i.e., less-skilled participants required more information processing time to image the task).

As a result, there does appear to be a large gap, or more accurately aligned with the allusion of Munroe and colleagues (2000) – an *untraveled branch* of 'imagery type' – that has yet to be thoroughly researched. Thus, the primary purpose of the present study was to examine the effects of three imagery practice conditions: real time imagery, slow motion imagery, and slow motion concluded with real time imagery on the acquisition and performance of a serial motor skill (soccer dribbling). A physical practice condition and a control (no physical or imagery practice) condition was also employed. A secondary purpose of this study was to explore the effect of imagery use on self-efficacy, as it has been suggested that self-efficacy is the mediating variable of the effects of imagery on performance (e.g., Bandura, 1997; Taylor & Shaw, 2002). This effect was assessed via pre- and post-imagery trial block administration of a self-efficacy scale.

Hypotheses

There were seven hypotheses made regarding the results of the present study: 1) All groups will show a statistically similar pattern of change in performance over the six recorded trials; 2) The physical practice group will exhibit the greatest performance change from pre- to post-intervention (as compared to the three imagery conditions and the control condition); 3) The slow motion concluded with real time imagery group will exhibit the greatest performance change from pre- to post-intervention compared to all other imagery conditions; 4) The real time alone imagery group will exhibit greater performance changes from pre- to post-intervention compared to the slow motion alone condition; 5) All experimental groups will exhibit greater performance changes as compared to the control group (i.e., no imagery intervention); 6) Among all experimental groups, self-efficacy scores will show the greatest increase from pre- to post-intervention in the group that receives physical practice, and; 7) Self-efficacy scores will show a greater increase from pre- to post-intervention in those groups that receive imagery treatments as compared to the control group.

Methodology

Participants

Participants were 102 university-aged males and females (33 males, 69 females; mean age = 18.1 years) from the 'Principles of Mental Skills Training' Human Kinetics course (95-211) at the University of Windsor. Participation on an organized soccer team (at any recreational or competitive level) was the only eligibility requirement of participants.

Recruitment

Students (N = 177) in 95-211 were offered a 2% bonus mark for their participation in the study. To earn the bonus mark, each student who chose to participate was required to remain a study participant for the duration of the data collection phase. This stipulation as well as further details of the compensation were outlined in the 95-211 course syllabus, letter of information (Appendix A), and consent form (Appendix B). For those students who chose not to participate in the study, an opportunity to earn the 2% bonus mark was also made available through completion of a short journal article review.

Students who expressed interest in participating in the study were provided a letter of information, which was distributed to the potential participants in a subsequent 95-211 class. Students who decided to take part in the study then signed up for testing times at the end of the following 95-211 class. Each participant was required to attend one of three possible sessions (prior to his or her data collection session) wherein the Movement Imagery Quesitonnaire -

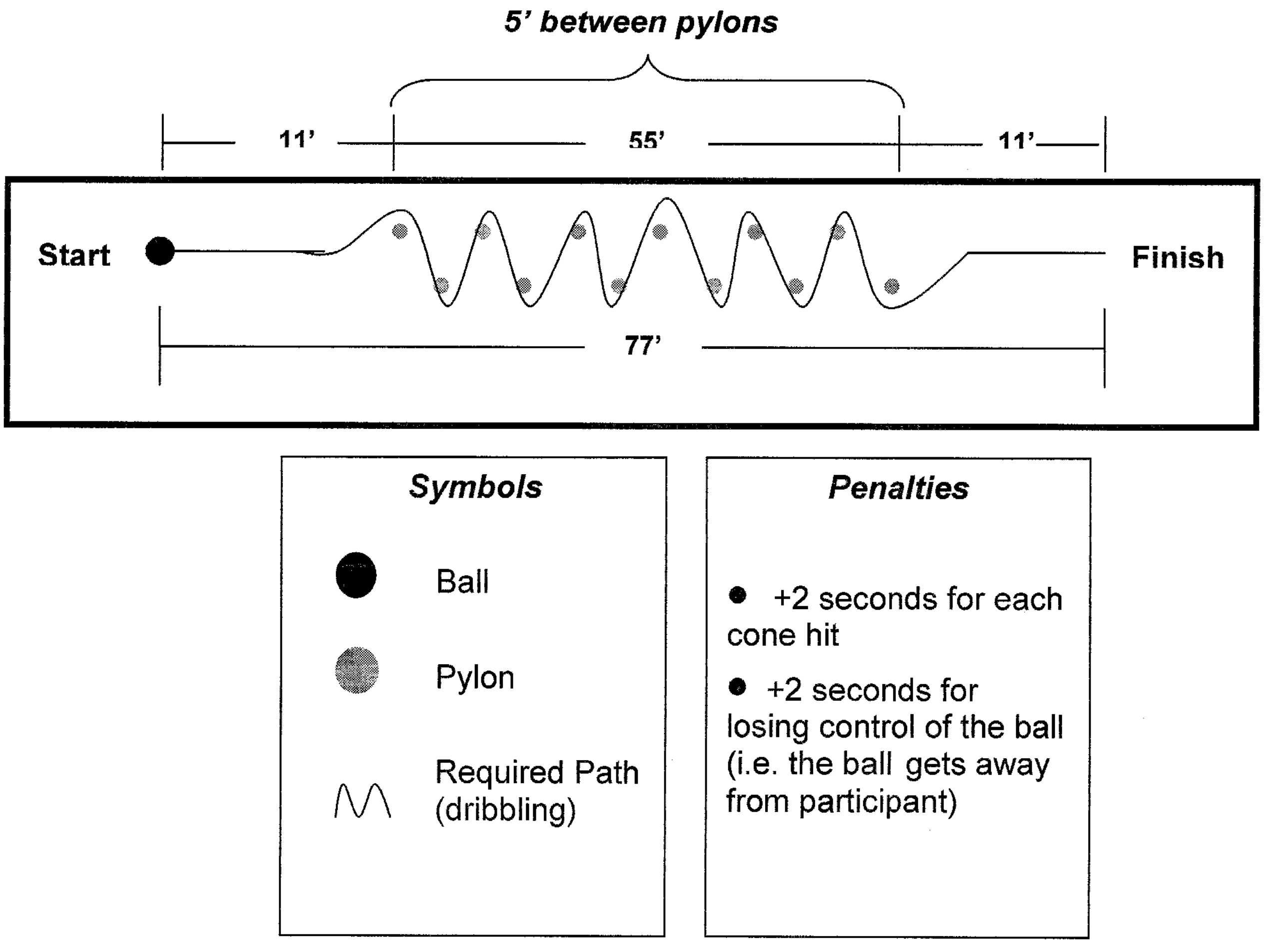
Revised (MIQ-R; Hall & Martin, 1997) was administered by the researcher. The MIQ-R allowed the researcher to collect data on each participant regarding his or her imagery ability, such that any possible relationships that participants' imagery ability held with the learning and/or performance of the soccer task could be explored. Upon completion of the MIQ-R testing session, the researcher arranged individual times with each participant where he or she met with the researcher for the administration of the different experimental conditions as well as the soccer data collection. At the data collection sessions, each participant performed the soccer task trials individually. Only the researcher and a data collection assistant were present.

Task

The task used in this study was a serial motor skill consisting of dribbling a soccer ball. The task (e.g., distance dribbled and number of pylons) was scaled down from a previous imagery study (Blair, Hall, & Leyshon, 1993). The participants were asked to execute the task as quickly and as accurately as possible. In order to ensure that participants focused on both speed and accuracy (as opposed to just speed alone), time penalties were levied for errors that occurred during execution. The time penalties were also adopted from Blair and colleagues. A diagram of the soccer task with explanation of the time penalties can be seen in Figure 5. The selection of a continuous motor skill (dribbling a soccer ball) extended the work of Andre and Means (1986) who employed a discrete motor skill in their study (a frisbee disc toss). The soccer task also contained both cognitive (deciding how to efficiently weave the soccer ball between pylons) and motoric (actually executing the skills) components. As suggested earlier, imagery is most effective for skills that contain a cognitive as well as a physical component (e.g., Hall, 2001).

Figure 5

Diagram of soccer dribbling task employed in the present study.
(dimensions adapted from Blair et al., 1993)



Measures

Movement Imagery Questionnaire – Revised (MIQ-R; Hall & Martin, 1997). The MIQ-R is an 8-item questionnaire which assesses an individual's visual and kinesthetic imagery ability (Appendix C). Participants were asked to first physically perform, and then visually or kinesthetically image four different movements. Each movement involved an arm-, leg-, or whole body movement. Participants then rated how well they felt they were able to visually or kinesthetically image the movement on a 7-point Likert scale, where 1 = 'very hard to see/feel' and 7 = 'very easy to see/feel'. Hall and Martin suggest that the MIQ-R is an acceptable revision of the original Movement Imagery Questionnaire (MIQ; Hall & Pongrac, 1983), as a high correlation was found between the visual and kinesthetic subscales of the MIQ and the MIQ-R (r =.77, p<.001 for both subscales). More recently, Abma, Fry, Li, and Relyea (2002) have shown that the MIQ-R has demonstrated more than adequate reliability and validity with alpha coefficients above .86 for both the visual and kinesthetic subscales.

Demographic data. Demographic data was obtained from each participant at the MIQ-R administration session. Information regarding age, gender, and previous soccer experience was collected.

Self-efficacy measure. Self-efficacy was measured in a manner recommended by Bandura (1997). A self-efficacy measure was developed for this study that assessed both the level and the strength of each participant's beliefs in his/her ability to successfully perform the soccer task (Appendix D). Items were based on the question: "I believe that I can perform the soccer task as fast or faster than my average practice time without making any errors on x of the next 3 trials". This question was repeated three times where x = 1, 2, and 3, progressively. The participants were asked to rate their self-efficacy in their ability to reach the goal outlined in the item based on a percentage scale, where 0% = "I am very certain I cannot do this", 50% = "I am unsure; it could go either way", and, 100% = "I am very certain I can do this". Participants were allowed to rate their self-efficacy anywhere along the 0%-100% scale.

Post experimental manipulation check. On completion of the data collection session, each participant was asked to complete a manipulation check. The purpose of the manipulation check was to determine whether participants employed any other mental strategies while performing the soccer task, or if they employed imagery use on their own (without being asked to do so by the researcher). For the physical practice and control group participants, a 2-item manipulation check was administered (Appendix E). A 4-item manipulation check was given to imagery condition participants, with the additional items being related to participants' use of imagery relative to their particular experimental condition (Appendix F).

Pilot study to determine the number of required imagery and physical practice trials

Prior to the data collection phase, the researcher conducted a pilot test of the soccer task in order to determine the appropriate number of imagery and physical practice task trials required (i.e., to determine when practice effects begin to plateau). Five participants recruited from the Human Kinetics undergraduate program at the University of Windsor (95-211 students) each performed 30 trials of the soccer task. The researcher recorded each pilot participant's movement time (i.e., time to complete the task) after having factored in time penalties incurred for errors. This data was used to determine, on average, how many trials elapsed before practice effects began to level off (7 trials). The plateau was operationalized as the first three successive data points which fell within one standard deviation of the mean final trial time (across the 30 trials and all pilot participants). The third successive data point was taken as the number of imagery/physical task trials.

Experimental Procedure

Prior to data collection, all participants were randomly assigned to one of four treatment conditions or to a control group using a block randomization schedule and each participant had already attended one of the three designated MIQ-R administration sessions. Upon arriving at the individual data collection site, the participants were given the consent form. This form provided each participant with general information regarding the purposes of the study, as well as providing information regarding compensation, withdrawal, and how to obtain a copy of the study results. Once signed, the researcher verbally reminded the participants that they were free to withdraw from the study at any time, as well as of the stipulations of the compensation. The participants were then given as much time as necessary to physically warm up.

The data collection began with the researcher verbally explaining the soccer dribbling task to the participants. The researcher then obtained a baseline measure of the participants' performance of the soccer task consisting of three trials. Participants rested between trials while they walked from the end of the soccer task back to the starting point. Baseline self-efficacy was then measured through administration of the self-efficacy measure.

Imagery conditions. Following the baseline self-efficacy measure, participants in the imagery conditions were introduced to the concept of imaging in sport. They were verbally given a definition of imagery (White & Hardy, 1998) and were told that imagery has been shown to be an effective technique for practicing motor skills.

The imagery condition participants were then asked to image themselves executing the soccer task for seven trials. Depending on the specific imagery condition, the participants were instructed to image executing the soccer task in real time (RT; i.e., actual execution time, being each participant's average baseline trial time), slow motion (SM; i.e., at a rate approximately

50% slower than real time), or in slow motion concluded with imaging execution of the task in real time (SM+RT; i.e., five of the trials in slow motion, and the final two trials in real time). The approximate 3:1 ratio of slow motion imagery to real time imagery was an arbitrary value selected by the researcher. Assuming that the motor program for the soccer skill would have been stored into long-term memory by the participants (see Schmidt & Wrisberg, 2000), it was not necessary that the *actual amount* of real time imagery performed by each participant be equal to the amount of slow motion imagery performed. The crucial factor is that slow motion imagery was *concluded* with real time imaging in order to fulfill the requirements of the combined imagery condition.

For the first three imagery trials, the participants were asked to start a stopwatch when they commenced their imaging and stop the stopwatch when they finished imaging a single execution of the soccer task so that the researcher could ensure that the participants were imaging at the required image speed (i.e., real time or slow motion). Feedback (knowledge of results) was provided to the participants as to whether or not they were imaging at the required image speed. An imaged execution of the soccer task was considered as having been imaged in real time if the time taken to mentally image the execution was within a 15% range of the participants' own baseline response time (i.e., up to 15% faster or slower than the average baseline response time was acceptable and considered imaging in real time). Breaks were given between imaging each trial that approximated the time it would take to walk from the endpoint location of the soccer task back to the starting point (this was timed during physical baseline trials).

Physical practice condition. Participants in the physical practice (PP) condition were allowed to physically practice the soccer task for seven trials (as determined through the pilot testing), with rests being considered as the walk from the endpoint location of the soccer task back to the starting point. For the first three physical practice trials, feedback was provided to the participants regarding their current performance time.

Control condition. The participants in the control condition (CC) were asked to play a card game, 'memory', with the data collection assistant. The card game is set up by evenly spreading out 52 playing cards face down (in rows and columns). The premise of the game is to match pairs of playing cards (face value) by flipping over two cards each turn. If the two flipped cards do not match, those two cards are returned to their original face-down positions and it becomes the opponent's turn. If the two flipped cards match, the player continues his or her turn until he or she flips two cards that do not match. The goal of the game is to match more pairs of playing cards than the opponent.

The time spent in the control condition was calculated by taking the duration of each control group participant's respective average baseline response time, plus additional time added to factor in the 'rest' time received by the other groups, and multiplying that time value by seven. Involving the control participants in a game of 'memory' ensured that the participants were not spontaneously imaging themselves executing the soccer task, or employing any other cognitive performance enhancing technique between task trials (e.g., self-talk). As well, the time allotment of the control condition ensured that the control participants spent approximately the same amount of time between physical task trials in their 'control' condition as all other participants did in their respective conditions.

Following administration of the imagery, physical practice, or control condition, participants completed the self-efficacy measure for the second time, and immediately following, physically performed a single block of three soccer task trials with the same rest condition given between trials. Immediately after completion of the last block of trials, the post experimental manipulation check was administered. Participants were then debriefed, thanked for their participation and then released.

Data Analyses

Preliminary analyses. Before conducting the main analyses concerning the primary and secondary purposes, a preliminary analysis was conducted using two separate one-way ANOVAs to determine whether statistically significant differences in imagery ability (as measured by the MIQ-R) existed between genders. A MANOVA was also employed to examine whether between-group differences (i.e., between the RT, SM, SM+RT, PP and CC groups) existed in imagery ability.

Primary analyses. A one-way ANOVA was conducted on trial 1 scores to confirm randomization of the participants into the five groups employed in the study. A non-significant omnibus F would indicate that groups displayed similar physical soccer dribbling performances and thus confirm randomization. The analysis of time performance employed a 5x6 (group x trial) mixed-design ANOVA, with post hoc analysis being carried out using Tukey's HSD procedure. Tests of simple effects were performed to further explore group differences in performance time change via five separate 5x2 (group x trial) mixed-design ANOVAs. The analysis of error performance utilized a chi-square test of fixed proportions to determine whether groups committed errors with the same frequency over the course of the six performance trials.

Secondary analyses. Following the primary analyses, a mixed-design ANOVA was performed to determine whether statistically significant differences existed between the pre-imagery/physical practice self-efficacy scores and the post-imagery/physical practice self-efficacy scores.

Results

Preliminary Analyses

Results of two separate one-way ANOVAs revealed no significant differences in imagery ability between the two genders (p >.05 for both the visual and kinesthetic scales). All subsequent analyses were therefore conducted with the genders collapsed. MANOVA results revealed that the five groups in the present study did not significantly differ with respect to their imagery ability (p >.05 for both the visual and kinesthetic scales).

Primary Analyses

Five of the original sample of 102 participants failed to complete the data collection phase. They were dropped from the remaining analyses leaving a sample of 97 participants (65 females, 32 males; M_{age} = 18.1 years).

Verification of randomization. A one-way ANOVA (at p =.05) determined that trial 1 performance times did not significantly differ between groups, thus confirming randomization of the participants into the four experimental conditions and the control condition.

Performance time. A 5 x 6 (group x trial) mixed-design ANOVA was conducted on performance time. Group membership was the between-groups independent variable, trial the within-groups independent variable, and performance time the dependent variable. Means and standard deviations for the six performance trials of the five groups are presented in Table 1.

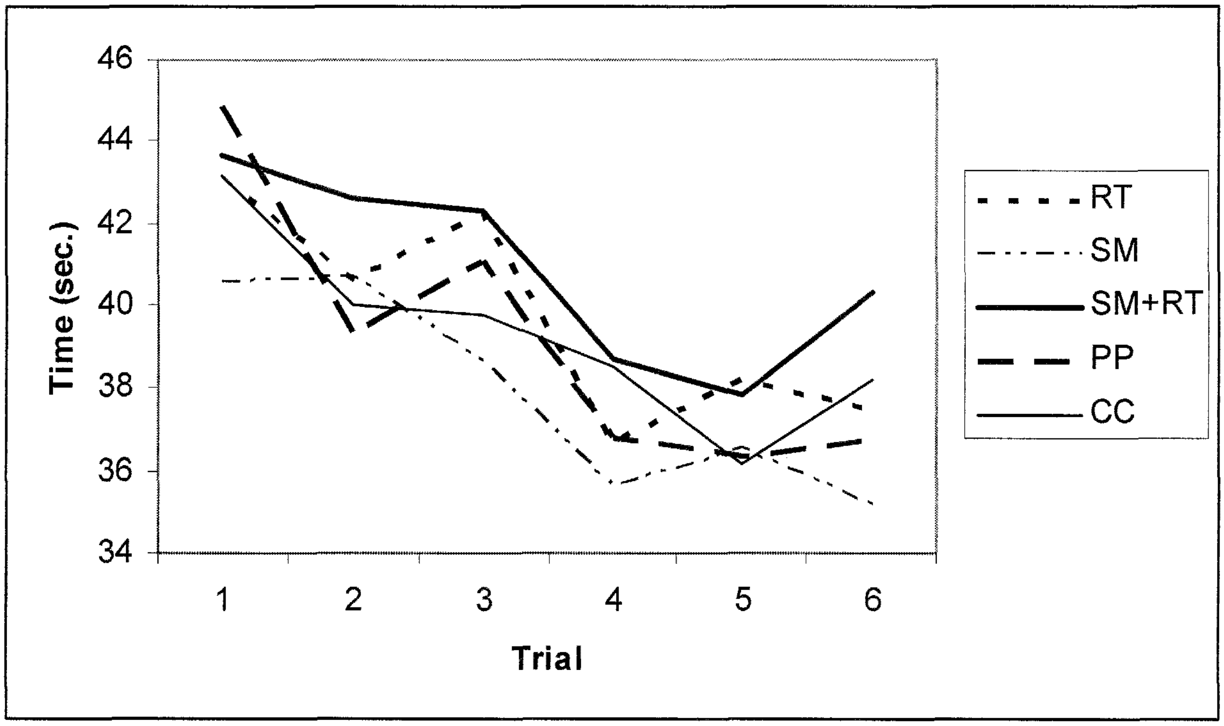
Time performance across trials by group can be found in Figure 6. There were non-significant group and interaction (group x trial) effects (p >.05). This indicated that group membership did not have an overall effect on performance time, thus confirming hypothesis one that predicted that all groups would show a statistically similar pattern of performance change over the six trials. A significant main effect of trial ($F(1, 92) = 77.228$, p <.0001, $\eta^2 = .456$), and

Table 1
Time and error scores of performance for the five experimental groups over the six performance trials (3 baseline and 3 post-intervention)

Group		Trial 1	2	3	4	5	6
				Time (sec.)			
RT							
	M	43.12	40.59	42.25	36.65	38.18	37.44
	SD	8.02	8.27	8.38	6.35	7.83	6.54
SM							
	M	40.55	40.71	38.65	35.60	36.52	35.15
	SD	10.76	9.64	7.90	6.81	7.69	7.32
SM+RT							
	M	43.67	42.62	42.27	38.70	37.84	40.29
	SD	8.62	8.51	6.82	6.46	7.29	9.45
PP							
	M	44.83	39.23	41.05	36.77	36.36	36.74
	SD	9.98	7.50	8.81	9.03	7.42	8.89
CC							
	M	43.18	39.97	39.73	38.51	36.19	38.18
	SD	9.68	7.87	7.23	7.06	6.09	9.38
				Errors			
RT							
	M	1.84	1.21	1.37	0.37	0.89	0.68
	SD	1.50	1.08	1.17	0.50	1.29	0.89
SM							
	M	1.35	1.90	1.70	0.90	1.00	0.80
	SD	1.53	1.74	1.56	0.97	1.12	1.01
SM+RT							
	M	1.95	1.74	1.74	0.95	0.53	1.32
	SD	1.35	1.59	1.41	1.13	0.91	1.77
PP							
	M	2.56	1.22	2.22	0.94	0.72	1.06
	SD	1.82	1.22	1.83	1.35	1.02	1.31
CC							
	M	1.43	1.24	1.14	1.00	0.71	1.10
	SD	1.86	1.22	1.23	1.14	1.06	1.97

Figure 6

Group Means of Time Performance across Trials



subsequent post hoc analysis employing Tukey's HSD test (p =.05), revealed that across all groups average trial 1 performance time were significantly slower than all other trials (i.e., trials 2-6), and trial 2 and 3 performance times significantly slower than all post-intervention trials (i.e., trials 4-6). Trials 2 and 3, as well as trials 4-6 performance times, respectively, were found not to differ significantly from each other. Results of the Tukey's HSD analysis are presented in Table 2.

All pre-intervention times (i.e., trials 1-3) were significantly slower than all post-intervention trials (i.e., trials 4-6). In order to further explore these significant differences in pre- as compared to post-intervention performance time, a 5 x 2 (group x trial) mixed-design ANOVA was conducted using trials 3 and 4 as the within-group independent variables. Trial 3 represented the final pre-intervention performance trial and trial 4 the first post-intervention trial. A significant interaction effect would indicate that group membership had an effect on the changes in performance time from trial 3 to 4.

Results of the 5 x 2 mixed-design ANOVA revealed a significant interaction effect between group and trial ($F(4, 92) = 3.278, p = .01, \eta^2 = .125$). Simple main effects analysis employing five separate mixed-design ANOVAs (p = .01) indicated that all of the imagery groups as well as the PP group showed a significant improvement in performance time from trial 3 to trial 4 (Table 3), and thus it was concluded that all experimental groups responded similarly to the intervention. These findings lead to the rejection of hypotheses two, three, and four, which made predictions regarding expected significant differences in the magnitude of performance changes between the experimental groups. The simple effects analysis also indicated that only the CC group failed to show any significant improvement between pre- and post-intervention performance time ($p > .01$). This resulted in confirmation of hypothesis five,

Table 2

Results of Tukey's HSD pairwise comparison of collapsed group means for trial performance

Trial	1	2	3	4	5	6
1	--	*0.000	*0.001	*0.000	*0.000	*0.000
2	--	--	1.000	*0.000	*0.000	*0.000
3	--	--	--	*0.000	*0.000	*0.000
4	--	--	--	--	0.999	0.993
5	--	--	--	--	--	0.930
6	--	--	--	--	--	--

*$p < .05$

Table 3

Results of 5 Separate Mixed-Design ANOVAs
Comparing Trial 3 and Trial 4 Time Performance

Group	D*f*	F	Mean Square	*p*
RT	1.000	42.217	297.304	*.000
SM	1.000	17.581	93.330	*.000
SM+RT	1.000	11.982	121.362	*.003
PP	1.000	14.840	165.123	*.001
CC	1.000	2.521	15.873	.128

*p <0.01 (Bonferroni adjusted)

which predicted that all experimental groups would demonstrate a greater positive performance change from pre- to post-intervention than the CC group.

Error performance. Due to the relatively small numerical values recorded for error performance (mean trial errors for groups ranged between 0.37 and 2.56 errors; Figure 7), a chi-square test of fixed proportions was conducted with all errors being collapsed across trials for each group. The group frequencies were found not to be significantly different, χ^2 (4, $N = 97$) = 6.479, $p = .166$, and thus it was concluded that the frequency of the number of errors committed across the trials did not differ between the groups. This finding provided support for hypothesis one, which predicted that all groups would demonstrate a statistically similar pattern of change over trials. The finding did not support hypotheses two to five, which made predictions regarding expected group differences in magnitude of performance changes.

Secondary Analyses

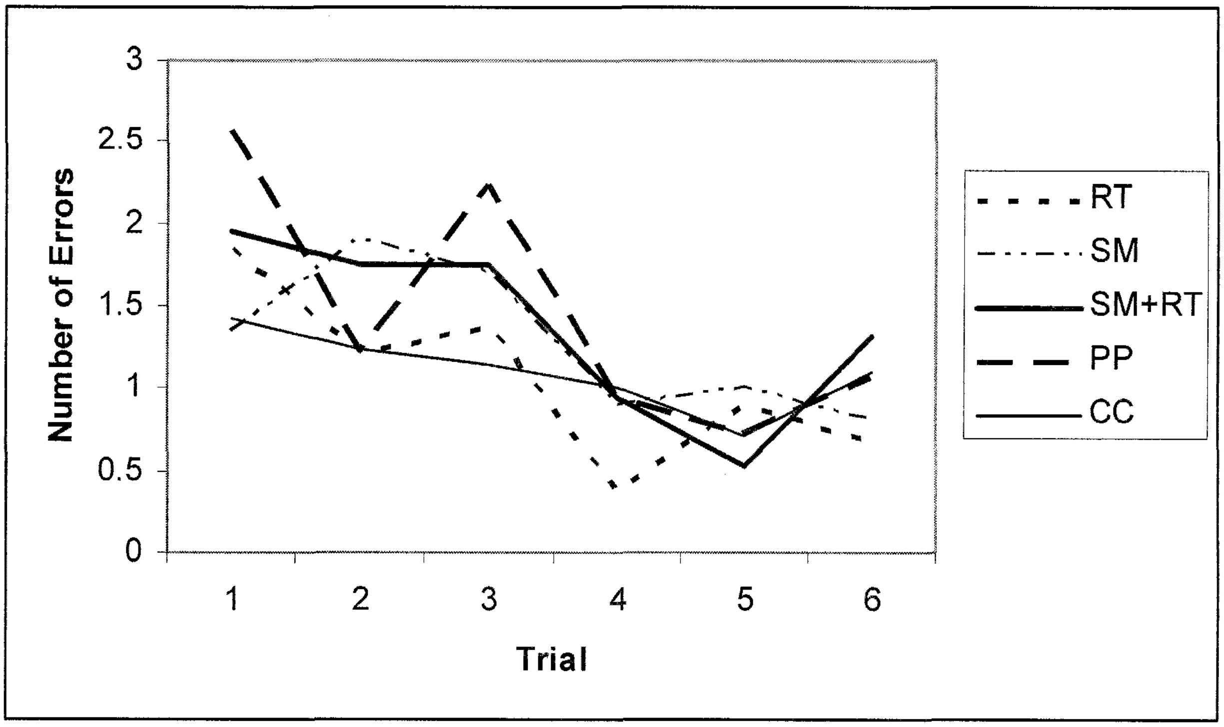
Mixed-design ANOVA results showed no significant effect across all experimental conditions on self-efficacy ($p > .05$), thus rejecting hypotheses six and seven regarding expected group differences.

Manipulation Check

Following recommendations from previous imagery research (e.g., Cumming & Ste-Marie, 2001; Short et al., 2002; Taylor & Shaw, 2002), a post-experiment manipulation check was employed in the present study. The results of the check established that most all imagery group members (90%; 52 out of 59 members) felt that they imaged at the required image speed, for the specified number of trials. The remaining seven imagery group members noted that they felt they imaged too quickly for the first few trials of the imagery intervention. The check also revealed that imagery group members (93%; 55 out of 59 members) did not feel that they

Figure 7

Group Means of Error Performance across Trials



employed imagery at any other time (i.e., spontaneously) during the experiment. All imagery group members, with the exception of one member, felt that the imagery practice helped their dribbling performance. It was ascertained through the manipulation check results that it was unlikely that the use of additional cognitive strategies (e.g., goal setting, self-talk) influenced the results of the present study, as only 12% of the study participants (12 out of 97 participants) reported employing any additional cognitive strategies above what was required of them (additional strategies noted included imagery, goal setting, self-talk, concentration, and focus).

Discussion

The aim of the present study was to investigate the effects of three imagery practice conditions: real time imagery, slow motion imagery, and slow motion concluded with real time imagery on the acquisition and performance of a serial motor skill (soccer dribbling). A secondary purpose of this study was to explore the effect of imagery use on self-efficacy. Preliminary analyses determined that neither gender nor group membership had any effect on imagery ability. Results of the main analysis found that patterns of performance times were similar across all experimental groups. However, it was ascertained through post hoc analysis that all groups, except for the control group, decreased trial performance time from pre- to post-intervention. No significant changes in self-efficacy were found between or within groups.

Imagery Ability

As hypothesized, results indicated that no differences existed between genders with respect to imagery ability. An important caveat, however, is that the gender distribution of the present study was largely unequal, with the number of female participants holding a 2:1 ratio over males in the present sample (65 females, 32 males). As a result, these imagery ability results must be interpreted with some degree of caution.

Regardless of the unequal gender distribution in the present sample, gender's effect on imagery ability remains an important variable that should be considered in future research. Although Hall (2001) states that there lacks adequate empirical research in the sport domain that would support the notion that differences in imagery use exist between genders, this conclusion refers to differences that exist between genders with respect to *frequency* of imagery use. Existing sport imagery frequency studies that have considered gender have generally collapsed gender and not considered it in subsequent analyses (e.g., Munroe, Hall, Simms, & Weinberg, 1998; Salmon et al., 1994).

Some sport imagery studies have found strong correlations between frequency of imagery use and imagery ability, in that high ability imagers tend to report using imagery more often (e.g., Moritz, et al., 1996; Vadocz et al., 1997). Due to this correlation, one could argue that if frequency of imagery use is similar between males and females, it would be logical to assume that imagery ability would also be similar between the genders. With this being said, it does not appear that adequate empirical sport-imagery research has spoken directly to possible gender differences with respect to imagery ability.

The present study also found no significant between-group differences to exist in imagery ability, on either the visual or kinesthetic scale of the MIQ-R (Hall & Martin, 1997). This finding indicates that, with respect to the subsequent effects of the imagery interventions, no one imagery group was advantaged (nor disadvantaged) due to higher (or lower) imagery ability.

Soccer Dribbling Performance

The present study made several predictions regarding soccer dribbling performance. It was predicted that although all groups would show a similar pattern of change in performance, the physical practice group would demonstrate the greatest performance changes from pre- to post-intervention among all groups followed, in order, by the slow motion concluded with real time imagery group, the RT imagery group, the SM imagery group, and the control group.

All groups showed a similar pattern of change over the six recorded trials, thus confirming hypothesis one. This finding is consistent with existing imagery literature that discusses the functional equivalence that exists between mental imagery and physical practice (e.g., Decety, 1996; Jeannerod, 1994; Vealey & Walter, 1993). The functional equivalence hypothesis is largely based on Jacobson's (1930) Psychoneuromuscular Theory of imagery. Jacobson posited that the neural pathways of the brain that are activated when mentally imaging a particular movement or skill are identical to those that are activated when physically performing that same movement or skill. The functional equivalence hypothesis (Decety) further suggests that the series of cognitive steps required to perform an action (i.e., recalling the relevant motor program, modifying the program, and transmission of execution commands to the motor cortex) are identical between mental imagery and actual physical execution. According to this hypothesis, the one difference in cognitive processing between mental imagery and physical practice is the omission of the command for actual physical execution when mentally imaging. Assuming functional equivalence between mental imagery and physical practice, it is not surprising that in the present study, those groups who employed CS imagery versus those who physically practiced the soccer dribbling task exhibited similar patterns of performance over the five trials.

Nideffer (1985) suggests that employing images at a real time speed more accurately approximates the actual performance environment, and as a result, an athlete employing real time imagery will be better practiced in dealing with the stressors associated with that environment. Nideffer further adds that these stressors may cause increases in anxiety and decrease an individual's attentional control, which would ultimately influence performance negatively. Weinberg and Gould (2003) also suggest that imaging in real time allows for an easier transition from mental to physical practice.

Despite this universally accepted imagery application guideline of imaging at real time speed (e.g., Nideffer, 1985; Weinberg & Gould, 2003), the lack of significant differences in performance changes between the three imagery conditions in the present study suggested that the *speed* at which participants imaged was irrelevant to the effect of imagery on soccer dribbling learning and refinement (i.e., there was no significant difference in *how* the three imagery groups' performances changed across trial). These results provide some empirical evidence that question the necessity of adhering to Nideffer's imaging guideline. In order to strengthen justification for further empirical investigation into the utility of Nideffer's real time imaging suggestion, the present study also examined whether significant differences existed in the magnitude of groups' performance changes from pre- to post-intervention by means of post hoc analyses (tests of simple effects). With respect to time, all four experimental groups (the RT, SM, SM+RT, and PP groups) showed a significant improvement in performance time from pre- to post-intervention. Error analysis revealed that between group differences did not exist with respect to the frequency of errors committed over the six performance trials.

The finding that all imagery groups significantly improved their performance is consistent with sport imagery literature in that the use of imagery can bring about performance improvements (e.g., Barr & Hall, 1992; Bohan, et al., 1999; Callow, et al., 2001; Denis, 1985; Driskell, et al., 1994; Feltz & Landers, 1983; Millard, et al., 2001; Weinberg, 1981). The present study posited that the employment of slow motion imagery would allow participants to 'see' the task in greater detail, which would thereby result in more accurate formation of a mental representation of the soccer dribbling task. Rationale for this speculation came largely from modeling literature in the motor learning domain, which suggests that, especially for novel tasks, slowing down demonstration of a skill assists a learner in identifying all of the important aspects of that skill required for successful execution (e.g., Williams et al., 1999). Application of this practical suggestion is evident in most all learning situations. For example, it is common practice for coaches and instructors to demonstrate a novel skill in slow motion, as well as have learners initially physically practice the novel skill at a slower pace than it would be executed in actual performance or competition. Recently, in the sport psychology domain, Lavallee, Kremer, Moran, and Williams (2004) have lent support to this skill acquisition imaging suggestion. Lavallee and colleagues briefly discuss the possibility that slow motion images may allow the learner to more accurately visualize the body and joint actions required of the skill as well as create a feeling of calmness and confidence when physically performing the skill.

Although not supported in the present study, the argument for the advantage of concluding slow motion images with real time images was based on motor learning and control literature (Schmidt, 1985; 1988, Shumway-Cook & Woolacott, 2000). It was suggested that the possible detrimental effects of employing slow motion images – segmentation of the generalized motor program (GMP) for the skill into several separate GMPs – could be avoided by concluding slow motion imagery with real time imagery. Interestingly, explanation of why between-group differences (among the imagery groups) were *not* evident may be partially derived from the same literature that was originally used to argue that between group differences *would* exist (i.e., GMP theory).

Although GMP theory is generally used to explain physical skill learning and performance (e.g., Schmidt & Wrisberg, 2000), the theory seems applicable to mental imagery as literature has acknowledged similarities in functionality, muscle activity, and use of mental processes between mental and physical practice (e.g., Hall, 2001; Jacobson, 1930; Slade, et al., 2002; Vealey & Walter, 1993). Once a skill is learned, the GMP for the skill is stored into long-term memory (Schmidt & Wrisberg). This GMP has an invariant feature known as 'relative timing', which holds that the temporal structure of a skill will remain unchanged, even when the skill is performed at different magnitudes or velocities (i.e., the skill can undergo 'parameterization').

The criterion for inclusion in the present study was that each participant had been involved in some form of organized soccer. All participants were required to have been familiar with the skill used in this study (dribbling a soccer ball – a basic soccer skill) prior to data collection. Accordingly, it would be argued that they had already formed, and stored into long-term memory, a GMP for the skill. Therefore, the speed at which participants imaged the skill was irrelevant given that slowing down the image when mentally practicing the skill was simply a *parameterization* of the skill.

This explanation using GMP theory is strengthened when Sackett's (1934) Symbolic Learning Theory is considered. Symbolic Learning Theory posits that through imagery, mental blueprints for skills are created, stored, and, when mentally practiced, strengthened. When tenets of the two theories are combined, one could explain the lack of between-group differences between the imagery groups with respect to soccer performance. Performance improved because the mental blueprint for the skill was being practiced (Symbolic Learning Theory). However, between-group differences in the imagery conditions were not evident only as a function of parameterization (GMP theory). More specifically, all groups imaged themselves successfully executing the soccer dribbling task, with the only imaging difference between the groups being a parameterization of movement duration.

The performance of the PP group, in relation to that of the other groups in the present study, is inconsistent with existing literature. Imagery research that has employed three-group experimental designs has consistently reported that physical practice alone, as compared to imagery practice alone or no practice at all, results in greater performance improvements (e.g., Bohan et al., 1999; Creelman, 2003; Hall, 2001). The present study does not support this view in that all imagery groups improved their soccer dribbling performance to the same degree as the PP group.

This inconsistency may be due to the requirement for study inclusion. The assumption made was that this prior participation in some form of organized soccer would ensure at least some familiarity with the soccer dribbling task. This did seem to be the case, as none of the participants asked for a definition or explanation of how to dribble a soccer ball during the data collection phase. Furthermore, from observation of participants' actual soccer dribbling it did appear that all participants had had some prior soccer dribbling experience. Despite this experience, many of the participants still exhibited a great deal of difficulty dribbling the soccer ball around the set of pylons effectively (i.e., few subjects moved 'smoothly' through the pylons). The scale of the task was designed such that the task would be difficult to perform even for participants who had mastered the skill of soccer dribbling. More specifically, the spacing of the pylons was set such that the task was not impossible, but left very little room for imprecision in dribbling speed and accuracy. The scale of the task was adapted from a previous imagery study (Blair et al., 1999) wherein the researchers anecdotally reported that all participants in their study, who ranged in soccer experience from 'beginner' to 'National/International', found the task challenging to complete successfully.

Some motor learning has suggested that the use of mental imagery may be most beneficial to skill performance in the earlier stages of learning, where learners are still perfecting their mental representation and motor program of the skill (e.g., Schmidt & Wrisberg, 2000). Moreover, those individuals who have perfected the motor program of a skill have moved beyond the cognitive stage of skill learning (Fitts & Posner, 1967) but still have yet to reach the autonomous stage. Once the motor program for a particular skill is perfected, individuals must then begin perfecting performance variations of the skill (i.e., parameterizations of the skill's GMP) before they can reach the autonomous stage of the skill learning continuum. The imagery conditions may have produced similar performance effects as the physical practice condition as a function of task difficulty and participant skill level (relative to task difficulty). It is possible that in the present study, the use of mental imagery was just as effective as the use of physical practice because the majority of the participants had yet to perfect their mental representation of the soccer dribbling skill, or lacked adequate experience in parameterization of its GMP.

Although it is *possible* that the effect of imagery intervention on soccer dribbling performance may produce a similar effect as physical practice, the large body of empirical research that has consistently concluded that physical practice alone results in a greater performance effect than mental imagery use alone (for a review, see Hall, 2001) does question the reliability, or at the very least, generalizability of the finding of the present study. Sample size must be considered when interpreting the results of the present study, as each group employed consisted only of approximately 20 participants. With respect to generalizability, participant skill level (in relation to task difficulty) must be taken into consideration. Assuming that the participants were in the earlier stages of learning the soccer dribbling task the results of the present study could not be generalized to other sport or motor tasks, or to samples of different relative skill level, regardless of reliability.

Imagery-Self-Efficacy Relationship

With respect to the measure of self-efficacy, it was predicted that self-efficacy scores would show the greatest improvement from pre- to post-intervention in the physical practice group followed by the three imagery groups and the control group.

The results of the present study indicated that neither imagery use nor physical practice had any effect on participants' self-efficacy perceptions. A significant trial effect was found in the present study, however, this finding was trivial given the structure of the self-efficacy measure. The three-item measure consisted of a progression of task difficulty, and thus, it was not surprising that participants' responses on the self-efficacy measure declined (in percentage confidence ratings) from questions one to three, respectively. There was no effect on self-efficacy found for group, or for the trial-by-group interaction.

Sport imagery research has been equivocal when comparing the effects of CS imagery intervention on participants' self-efficacy beliefs. Some studies have found that employment of CS imagery resulted in positive effects on self-efficacy (e.g., Garza & Feltz, 1998; Short, et al., 2002), while others have failed to find any effect at all (e.g., Martin & Hall, 1995; Woolfolk, Murphy, Gottesfeld, & Aitken, 1985). Martin et al. (1999) suggest that a possible explanation for these inconsistent findings may be due to employment of the incorrect imagery function (i.e., CS imagery). Imagery application literature has stressed the importance of selecting the imagery function that best reflects the intended outcome of the imagery practice/intervention (e.g., Denis, 1985; Martin et al.; Moritz et al., 1996). This argument would contend that the present study failed to find any effect on self-efficacy because CS imagery concerns images of skill development and execution, and not images of being self-confident when performing a task (which instead, is achieved through the MG-M function of imagery).

Other sport imagery research, however, *has* found a positive effect (e.g., Feltz, 1998; Short et al., 2002) thus effectively weakening the feasibility of a 'what you see is what you get' packaging of the imagery functions. Recently, Short and colleagues (2004) have stressed the importance of recognizing the individual perception of athletes' images as they relate to the function that athletes' images serve. Short et al. suggest that images that are identical in content may serve different functions for different individuals. Explanation of the differences in image function can be theoretically tied to Ahsen's (1984) Triple Code Theory of imagery. Ahsen posited that each individual imparts personal meaning to an image, and it is this *personal interpretation* of the image that Short and colleagues suggest determines the function of the image. It is possible that participants in the various studies examining the CS imagery-self-efficacy relationship imparted different meanings to the imagery they employed, which would account for the differences seen between studies with respect to CS imagery's effect on self-efficacy.

Another possible explanation for the trivial effect on self-efficacy relates to the amount of time that elapsed between intervention and the collection of self-efficacy data. Bandura (1986) notes that increases in self-efficacy might follow a temporal lag; materialization of self-efficacy effects may take time following physical or mental practice. The post-intervention self-efficacy data in the present study was collected immediately following the last intervention trial, and perhaps, not enough time was given for any self-efficacy changes in perception to have developed in the participants.

A final suggestion as to why CS imagery effects on self-efficacy were not evident addresses the setting in which the data for the present study was collected. Bandura (1996) has noted that, "[D]iversity in competitive conditions prompts reappraisals of personal efficacy" (p. 395). This statement would suggest that a lab setting such as the one employed in the present study is not the ideal setting to examine self-efficacy. Often, conditions in a lab setting remain completely invariant; a participant is asked to perform the exact same task, with the exact same outcome goal, repeatedly. It is possible that participants' self-efficacy in the present study showed no change because the 'competitive conditions' remained constant from trial to trial, thus eliminating the need for efficacy reappraisals.

Limitations

Tabachnick and Fidell (2001) note that, in general, the larger the sample size, the greater the power of the experiment. These researchers also suggest having at least 20 subjects per group in multivariate analysis to ensure multivariate normality. Although sample size for each group in the present study was approximately 20, this represented only meeting the minimum cell size requirement for multivariate analysis. A larger sample would have undoubtedly increased the power of the study, and perhaps, may have made results more conclusive (i.e., via stronger multivariate and univariate significance values).

Due to the limited knowledge regarding athletes' use of slow motion imagery, it would be extremely difficult to generalize the results of this study to other samples and/or sports. As in most imagery studies, it is impossible to have complete control over exactly what and how the participants are imaging. For example, a participant may image at an inappropriate speed, image a task that is not relevant to performance of the goal task, or not image at all. Furthermore, although attempts were made to control for soccer task-related imagery use in the control condition, control group participants may still have spontaneously imaged on one's own while in the control condition. The inclusion of a post experimental manipulation check in this study attempted to at least recognize that these various limitations may have occurred.

Although participants were asked to image themselves performing the soccer task, an imagery script was not employed. With the exception of image speed, the participants were not told exactly how or what to image (e.g., imaging using an internal or external perspective). Given the fact that individual differences exist in imagery use between individuals (Hall, 1985), it was thought that employment of a rigid imagery script or set of guidelines, though beneficial to some participants, might restrict others. Thus, in order to study the effects of the different imagery conditions in their most 'natural' form, very little guidance regarding how and what to image was provided to the participants. With this being said, the lack of an imagery script does represent a limitation in the present study in that complete control over the different imagery conditions was not achieved.

During recorded trial performance, the participants in the present study were able to obtain knowledge of performance (i.e., visually seeing how successfully they could move around the pylons) as well receiving knowledge of results (i.e., knowing exactly how many errors were committed with each trial). This ability of the participants to receive knowledge of performance and knowledge of results may have influenced the self-efficacy scores more so than the imagery interventions employed in the present study. Anecdotally, almost all participants in the present study commented on how surprisingly difficult the soccer dribbling task was to perform. This would imply that participants' original perception of the dribbling task was that it would be relatively simple to execute successfully. Participants' perceptions of the task changed, however, as they obtained knowledge of their performance and results. Perhaps, this change in participants' perception of task difficulty influenced their self-efficacy scores more so than the imagery interventions.

Implications

It is important that sport performance researchers make every attempt to provide athletes with the most complete and comprehensive information possible regarding the use of mental training tools, such as imagery. In order to most effectively produce imagery training and intervention programs, it is crucial that researchers and practitioners understand the theoretical aspects of the construct, as well as *how* the construct is most effectively implemented.

Despite the limitations of the present study, there are several important implications of determining whether image speed is a useful imagery parameter. Although not found in the present study, it is possible that the use of slow motion images may enhance the efficacy of CS imagery use, particularly for novices who are in the initial stages of skill learning. Slow motion images may also prove useful for elite level athletes, who may employ slow motion images to enhance efficacy of the MG-M and MG-A functions of imagery.

In addition, the inclusion of a self-efficacy measure in the present study contributed to the need for further investigation into the impact of CS imagery use on self-efficacy. Results of this study will assist in the development of more effective imagery intervention programs for athletes at all competitive levels, and will also aid in directing future research in the area. Furthermore, because the relative obscurity of the study of slow motion imagery extends beyond the sport psychology community and into many other areas of the research community, results of this study may create impetus for the study of slow motion imagery in other contexts (e.g., school, work, rehabilitation, etc.).

Future Directions

Future research is needed that directly examines the effect of gender on imagery ability. Research has shown that differences in imagery ability do exisits between individuals. Paivio (1986) suggests that everyone posseses the ability to form mental images, but, the quality and, therefore, the effectiveness of the images differ from individual to individual. The ability to more effectively employ visual and kinesthetic imagery, as measured by imagery ability assessment tools such as the MIQ-R (Hall & Martin, 1997), has generally resulted in better sport skill learning and performance (e.g., Goss, Hall, Buckolz, & Fishburne, 1986; Vadocz et al., 1997). Furthermore, Martin and her colleagues (1999), in their Applied Model of Imagery Use, have identified imagery ability as serving a moderating role on the effect of imagery on performance outcomes. This understanding, that differences in imagery ability affect learning and performance, helps to substantiate the need for further investigation into the possible role gender may (or may not) hold with respect to imagery ability.

Research of any form that examines athletes' use of image speed as a type of imagery is virtually non-existent. Thus, future research examining athletes' possible employment of various image speeds is warranted. Focii may address whether manipulation of image speed is beneficial to athletes, when athletes are employing different image speeds, what it is they are imaging, what function manipulation of image speed serves, who may benefit from image speed manipulation, and how, exactly, athletes are manipulating the speed at which they image. Also of interest would be to examine how task differences may influence athletes' use, and effectiveness of image speed manipulation. Due to the limited knowledge of the exact role and even *existence* of image speed manipulation in sport, the undertaking of both quantitative and qualitative study on this topic will provide rich and valuable information regarding this potentially unaddressed imagery type.

A further avenue for image speed research that was not touched upon in the present study is the use of fast motion images by athletes. It seems only logical that if athletes are capable of imaging at a speed that is slower than actual execution speed, that they may most certainly be employing images that unfold in fast motion as well. Research addressing fast motion images, following the same research focii as that outlined for slow motion imagery study, is also warranted.

Establishing if, and when athletes are employing slow motion, real time, and fast motion imagery will increase not only our understanding of athletes' images as sport psychology researchers, but will also allow us to improve the quality and effectiveness with which we create imagery programs and interventions as sport psychology practitioners.

References

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

Ahsen, A. (1984). The triple code model for imagery and psychophysiology. *Journal of Mental Imagery, 8,* 15-42.

Andre, J.C., & Means, J.R. (1986). Rate of imagery in mental practice: An experimental investigation. *Journal of Sport Psychology, 8*, 124-128.

Bandura, Albert. (1986). *Social foundations of thought and action: A social cognitive theory.* Englewood Cliffs, NJ: Prentice Hall.

Bandura, A. (1997). *Self-efficacy: The exercise of control.* New York: W.H. Freeman.

Barr, K., & Hall, C. (1992). The use of imagery by rowers. *The Sport Psychologist, 23,* 243-261.

Beauchamp, M.R., Bray, S.R., & Albinson, J.G. (2002). Pre-competition imagery, self-efficacy and performance in collegiate golfers. *Journal of Sport Sciences, 20,* 697-705.

Biddle, S. (1993). Attribution research and sport psychology. In R.N. Singer, M. Murphey, & L.K. Tennant (Eds.), *Handbook of research on sport psychology* (pp. 437-464). New York: Macmillan.

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

Bohan, M., Pharmer, J.A., & Stokes, A.F. (1999). When does imagery practice enhance performance on a motor task? *Perceptual and Motor Skills, 88*, 651-658.

Callow, N., Hardy, L., & Hall, C. (2001). The effects of a motivational general-mastery imagery intervention on the sport confidence of high-level badminton players. *Research Quarterly for Exercise and Sport, 72*, 389-400.

Calmels, C., & Fournier, J.F. (2001). Duration of physical and mental execution of gymnastic routines. *The Sport Psychologist, 15,* 142-150.

Chartoff, R., Polaire, H.W., Savage, P., Winkler, I. (Producers), & Scorsese, M. (Director). (1980). *Raging Bull* [Motion picture]. USA: United Artists.

Cox, R.H. (2002). *Sport psychology: Concepts and applications*. New York: McGraw-Hill.

Creelman, J. (2003). Influence of mental practice on development of voluntary control of a novel motor acquisition task. *Perceptual and Motor Skills, 97,* 319-337.

Cumming, J.L., & Ste-Marie, D.M. (2001). The cognitive and motivational effects of imagery training: A matter of perspective. *The Sport Psychologist, 15,* 276-288.

de Almeida, A. I. (1999). What does the use of imagery reveal about athletes and dancers? *Avante, 5,* 52-62.

Decety, J. (1996). Do imagined and executed actions share the same neural substrate? *Cognitive Brain Research, 3*, 87-93.

DeHaven, C., Pizzo, A., (Producers), & Anspaugh, D. (Director). (1986). *Hoosiers* [Motion picture]. USA: Orion Pictures.

Denis, M. (1985). Imagery and the use of mental practice in the development of motor skills. *Canadian Journal of Applied Sport Sciences, 10,* 4S-16S.

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

Duda, J.L., Chi, L., Newton, M.L., Walling, M.D., & Catley, D. (1995). Task and ego orientation and intrinsic motivation in sport. *International Journal of Sport Psychology, 26,* 40-63.

Ericsson, K.A., Krampe, R.T., & Tesch-Römer, C. (1993). The role of deliberate practice in the acquisition of expert performance. *Psychological Review, 100,* 363-406.

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

Fitts, P.M., & Posner, M.I. (1967). *Human performance.* Belmont, CA: Brooks/Cole.

Garza, D.L., & Feltz, D.L. (1998). Effects of selected mental practice on performance, self-efficacy, and competition confidence of figure skaters. *The Sport Psychologist, 12,* 1-15.

Goss, S., Hall, C., Buckloz, E., & Fishburne, G. (1986). Imagery ability and the acquisition and retention of movements. *Memory and Cognition, 14,* 469-477.

Hall, C.R. (2001). Imagery in sport and exercise. In R.N. Singer, H.A. Hausenblas, & C.M. Janelle (Eds.), *Handbook of sport psychology* (pp. 529-549). New York: Wiley.

Hall, C.R. (1985). Individual differences in the mental practice and imagery of motor skill performance. *Canadian Journal of Sport Science, 10*, 17S-21S.

Hall, C.R., Mack, D., Paivio, A., & Hausenblas, H.A. (1998). Imagery use by athletes: Development of the Sport Imagery Questionnaire. *International Journal of Sport Psychology, 29,* 73-89.

Hall, C.R., & Martin, K.A. (1997). Measuring movement imagery abilities: A revision of the Movement Imagery Questionnaire. *Journal of Mental Imagery, 21,* 143-154.

Hall, C.R., Rodgers, W.M., & Barr, K.A. (1990). The use of imagery by athletes in selected sports. *The Sport Psychologist, 4*, 1-10.

Hall, C.R., & Pongrac, J. (1983). *Movement Imagery Questionnaire*. London, Canada: University of Western Ontario.

Hand, D.J., & Taylor, C.C. (1991). *Multivariate analysis of variance and repeated measures: A practical approach for behavioral scientists.* New York, NY: Chapman & Hall.

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

Harris, D.V., & Robinson, W.J. (1986). The effects of skill level on EMG activity during internal and external imagery. *Journal of Sport Psychology, 8,* 105-111.

Holmes, P. S. (2001). The PETTLEP approach to motor imagery: A functional equivalence model for sport psychologists. *Journal of Applied Sport Psychology, 13,* 60-83.

Horak, F.B., & Nashner, L.M. (1983). Two distinct strategies for stance posture control: Adaptation to altered support surface cognitions. *Society for Neuroscience Abstract, 9,* 65.

Jacobson, E. (1930). Electrical measurement of neuromuscular states during mental activities. *American Journal of Physiology, 96,* 115-121.

Jeannerod, M. (1994). The representing brain: Neural correlates of motor intention and imagery. *Behavioral and Brain Sciences, 17,* 187-245.

Kelso, J.A.S., Holt, K.G., Rubin, P., & Kugler, P. (1981). Patterns of human interlimb coordination emerge from the properties of non-linear, limit cycle oscillatory processes: Theory and data. *Journal of Motor Behaviour, 13,* 226-261.

Lang, P.J. (1979). A Bio-informational Theory of emotional imagery. *Psychophysiology, 16,* 495-512.

Lavallee, D., Kremer, J., Moran, A. P. & Williams, M. (2004). Imagery. *Sport psychology: Contemporary themes* (pp. 32-52). New York : Palgrave Macmillan.

Lee, W.A. (1984). Neuromotor synergies as a basis for coordinated intentional action. *Journal of Motor Behavior, 16,* 135-170.

Mahoney, M.J., & Avener, M. (1977). Psychology of the elite athlete: An exploratory study. *Cognitive Therapy and Research, 1,* 135-141.

Martin, K.A., & Hall, C.R. (1995). Using mental imagery to enhance intrinsic motivation. *Journal of Sport & Exercise Psychology, 17,* 54-69.

Martin, K.A., Moritz, S.E., & Hall, C.R. (1999). Imagery use in sport: A literature review and applied model. *The Sport Psychologist, 13*, 245-268.

McKenzie, A.D., & Howe, B.L. (1997). The effect of imagery on self-efficacy for a motor skill. *International Journal of Sport Psychology, 28,* 196-210.

Millard, M., Mahoney, C., & Wardop, J. (2001). A preliminary study of mental and physical practice on the kayak wet exit skill. *Perceptual and Motor Skills,* 92, 977-984.

Milliere, M. (Producer). (2004). SportsCentre [Television broadcast]. Toronto: Bell Globemedia.

Moritz, S.E., Hall, C.R., Martin, K.A., & Vadocz, E. (1996). What are confident athletes imaging?: An examination of image content. *The Sport Psychologist, 10,* 171-179.

Munroe, K.J., Giacobbi, P.R., Hall, C., & Weinberg, R. (2000). The four Ws of imagery use: Where, when, why, and what. *The Sport Psychologist, 14*, 119-137.

Munroe, K., Hall, C., Simms, S., & Weinberg, R. (1998). The influence of type of sport and time of season on athletes' use of imagery. *The Sport Psychologist, 12,* 440-449.

Nashner, L.M. (1976). Adapting reflexes controlling the human posture. *Experimental Brain Research, 26,* 13-24.

Nideffer, R.M. (1985). *Athlete's guide to mental training.* Champaign, IL: Human Kinetics Publishers.

Orliaguet, J.P., & Coello, Y. (1998). Differences between actual and imagined putting movements in golf: A chronometric analysis. *International Journal of Sport Psychology, 29,* 157-169.

Paivio, A. (1985). Cognitive and motivational functions of imagery in human performance. *Canadian Journal of Applied Sport Science, 10,* 22s-28s.

Reed, C.L. (2002). Chronometric comparisons of imagery to action: Visualizing versus physically performing springboard dives. *Memory & Cognition, 30,* 1169-1178.

Rogers Sportsnet Inc. (2003). Sportsnetnews [Television broadcast]. Toronto: Rogers Media Inc.

Sackett, R.S. (1934). The influences of symbolic rehearsal upon the retention of a maze habit. *Journal of General Psychology, 10,* 376-395.

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

Schmidt, R.A. (1975). A schema theory of discrete motor skill learning. *Psychological Review, 82,* 225-260.

Schmidt, R.A. (1985). The search for invariance in skilled movement behavior. *Research Quarterly for Exercise and Sport, 56,* 188-200.

Schmidt, R.A. (1988). Motor and action perspective on motor behaviour. In O.G. Meijer & K. Roth (Eds.), *Complex movement behavior: "The" motor-action controversy* (pp. 3-44). Amsterdam: North-Holland.

Schmidt, R.A., Heuer, H., Ghodsian, D., & Young, D.E. (1998). Generalized motor programs and units of action in bimanual coordination. In M. Latash (Ed.), *Bernstein's traditions in motor control* (pp. 329-360). Champaign, IL: Human Kinetics Publishers.

Schmidt, R.A., & Wrisberg, C.A. (2000). *Motor learning and performance: A problem-based learning approach.* Champaign, IL: Human Kinetics Publishers.

Short, S.E., Bruggemen, J.M., Engel, S.G., Marback, T.L., Wang, L.J., Willadsen, A, & Short, M.W. (2002). The effect of imagery function and direction on self-efficacy and performance on a golf-putting task. *The Sport Psychologist, 16,* 48-67.

Short, S.E., Monsma, E.V., & Short, M.W. (2004). Is what you see really what you get? Athletes' perceptions of imagery's functions. *The Sport Psychologist, 18,* 341-349.

Shumway-Cook, A., & Woollacott, M.H. (2000). *Motor control: Theory and practical applications.* Philadelphia: Lippincott Williams & Wilkins.

Silva, J.M., & Stevens, D.E. (2002). *Psychological foundations of sport.* Boston, MA: Allyn and Bacon.

Singer, R. N. (1982). *The learning of motor skills.* New York, NY: Macmillan Publishing Co., Inc.

Slade, J.M., Landers, D.M., & Martin, P.E. (2002). Muscular activity during real and imagined movements: A test of inflow explanations. *Journal of Sport & Exercise Psychology, 24,* 151-167.

Tabachnick, B.G., & Fidell, L.S. (2001). *Using Multivariate Statistics* (4th ed.). Boston: Allyn and Bacon.

Taylor, J.A., & Shaw, D.F. (2002). The effects of outcome imagery on golf-putting performance. *Journal of Sport Sciences, 20,* 607-613.

Vadocz, E.A., Hall, C.R., & Moritz, S.E. (1997). The relationship between competitive anxiety and imagery use. *Journal of Applied Sport Psychology, 9,* 241-253.

Vealey, R.S., & Walter, S.M. (1993). Imagery training for performance enhancement and personal growth. In J.M. Williams (Ed.), *Applied sport psychology: Personal growth to peak performance* (2nd ed., pp. 200-224). Mountain View, CA: Mayfield.

Weinberg, R.S. (1981). Relationship between mental preparation strategies and motor performance: A review and critique. *Quest, 33*, 195-213.

Weinberg, R.S., & Gould, D. (2003). *Foundations of sport and exercise psychology* (3rd ed.). Champaign, IL: Human Kinetics Publishers.

White, A., & Hardy, L. (1998). An in-depth analysis of the uses of imagery by high level slalom canoeists and artistic gymnasts. *The Sport Psychologist, 12*, 387-403.

Williams, A.M., Davids, K., & Williams, J.G. (1999). *Visual action and perception in sport.* New York, NY: E & FN Spon, Routledge.

Woolfolk, R.L., Murphy, S.M., Gottesfeld, D. & Aitken, D. (1985). Effects of mental rehearsal of task motor activity and mental depiction of task outcome on motor skill performance. *Journal of Sport Psychology, 7,* 191-197.

Appendix A

Letter of Information

UNIVERSITY OF
WINDSOR

Letter of Information

Effects of Image Speed on the Acquisition and Performance of a Soccer Skill

You are being asked to participate in a research study conducted by Jenny O, under the supervision of Dr. Krista Chandler, from the Faculty of Human Kinetics at the University of Windsor. The results of this study will fulfil the research component required for the completion of a Masters Thesis in Human Kinetics.

If you have any questions or concerns about the research, please feel to contact Dr. Krista Chandler at (519) 253-3000, ext. 2446, or through e-mail at: chandler@uwindsor.ca.

Purpose of the Study

The purpose of this study is to examine the effects of different imagery speeds on the acquisition and performance of a serial motor skill. Imagery can be defined as mentally creating or recreating experiences in one's mind, and can be used to rehearse skills and strategies, increase confidence, and control emotions and feelings of anxiety. The structure of athletes' images can differ from athlete to athlete. These differences may include differences in image perspective, vividness, feeling, audition, olfaction, and/or speed.

Procedures

If you volunteer to participate in this study, we would ask you to do the following things:

The following procedures will take place in the Education Building Gymnasium at the University of Windsor.

Session 1

You will be asked to come in for an initial session at which point in time you will be administered a brief questionnaire that assesses your imagery use with respect to different types of imagery. This questionnaire will take approximately 20 minutes to complete.

The total length of time that you can expect to spend participating in session 1 of this study will be approximately 20 minutes.

Session 2

You will twice be asked to fill out a brief self-efficacy questionnaire designed specifically for this study. The questionnaire will ask you about your confidence in your ability to successfully perform the task being asked of you. This questionnaire will take approximately two minutes to complete.

You will also be asked to physically perform a soccer task, dribbling a soccer ball. You will be asked to perform two sets of three trials of this task, and will be given rest time in between trial attempts as well as in between sets. In between sets, you may also be asked to image yourself performing the soccer task, under specific imaging guidelines. The soccer task trials and imagery practice will take approximately 20-25 minutes to complete.

Upon completion of the soccer task trials and the imagery practice, you will be asked to fill out a short, four-question survey which asks about your use of imagery and/or other mental skills during your soccer trial attempts. This survey will take approximately five minutes to complete.

The total length of time that you can expect to spend participating in session 2 of this study will be approximately 35 minutes.

Potential Risks and Discomforts

There are no anticipated risks associated with participating in this study that extend beyond the normal physical risks associated with performing the various soccer skills involved in the soccer task. The researcher has ensured that the area in which the soccer task will be performed is large enough to allow for free and unrestricted movement, and the soccer task will be clearly outlined and explained to you before you are asked to attempt it.

Potential Benefits to Subjects and/or to Society

By participating in this study, you may reap direct benefits from the imagery training. You will have been taught effective imaging methods that you will be able to use in other sporting contexts as well as in other aspects of life (e.g., when studying for a test or exam). You will be informed during the debriefing session of currently accepted imaging methods that have been empirically shown to produce positive effects.
Determining whether it is possible that the employment of slow motion imagery further enhances the positive benefits of imagery would represent an important contribution to the athletic community in that more effective imagery intervention and training programs would be made possible. The results of this study will also be a unique contribution to the growing body of knowledge regarding athletes' imagery use.

Payment for Participation

As compensation for participating in this study, you will be awarded a 2% bonus mark to be applied towards your final 95-211 – Principles of Mental Skills Training course grade. This bonus mark has been approved by your course professor. In order to obtain this 2% bonus mark, however, you must remain a participant in this study for the duration of the data collection phase (i.e., through all trials, imagery practice, and questionnaire administration).

Confidentiality

Any information that is obtained in connection with this study and that can be identified with you will remain confidential and will be disclosed only with your permission. All questionnaires, surveys, and trial data will be kept in strict confidence, and will be kept in the secure office of the primary investigator. Once all questionnaire, survey, and trial data have been entered into a statistical analysis program and the final draft of the manuscript for this study completed, the questionnaires, surveys, and trial data will be destroyed.

Participation and Withdrawal

You can choose whether to be in this study or not. If you volunteer to be in this study, you may withdraw at any time without consequences of any kind. However, please keep in mind that if you choose to withdraw from the study you will no longer be eligible to receive the 2% bonus mark toward your final 95-211 – Principles of Mental Skills Training course grade. You may also refuse to answer any questions you don't want to answer and still remain in the study. The investigator may withdraw you from this research if circumstances arise which warrant doing so.

Feedback of the Results of this Study to the Subjects

You will be provided with feedback regarding the results of this study upon your request. If you would like to receive a copy of the results of this study please email the primary investigator at oo@uwindsor.ca.

Rights of Research Subjects

You may withdraw your consent at any time and discontinue participation without penalty. This study has been reviewed and received ethics clearance through the University of Windsor Research Ethics Board. If you have questions regarding your rights as a research subject, contact:

Research Ethics Coordinator
University of Windsor
Windsor, Ontario
N9B 3P4

Telephone: 519-253-3000, ext. 3916
E-mail: lbunn@uwindsor.ca

SIGNATURE OF INVESTIGATOR

These are the terms under which I will conduct research.

Signature of Investigator

Date

Appendix B

Consent Form

UNIVERSITY OF
WINDSOR

Consent to Participate in Research

Effects of Image Speed on the Acquisition and Performance of a Soccer Skill

You are being asked to participate in a research study conducted by Jenny O, under the supervision of Dr. Krista Chandler, from the Faculty of Human Kinetics at the University of Windsor. The results of this study will fulfil the research component required for the completion of a Masters Thesis in Human Kinetics.

If you have any questions or concerns about the research, please feel to contact Dr. Krista Chandler at (519) 253-3000, ext. 2446, or through e-mail at: chandler@uwindsor.ca.

Purpose of the Study

The purpose of this study is to examine the effects of different imagery speeds on the acquisition and performance of a serial motor skill. Imagery can be defined as mentally creating or recreating experiences in one's mind, and can be used to rehearse skills and strategies, increase confidence, and control emotions and feelings of anxiety. The structure of athletes' images can differ from athlete to athlete. These differences may include differences in image perspective, vividness, feeling, audition, olfaction, and/or speed.

Procedures

If you volunteer to participate in this study, we would ask you to do the following things:

The following procedures will take place in the Education Building Gymnasium at the University of Windsor.

Session 1

You will be asked to come in for an initial session at which point in time you will be administered a brief questionnaire that assesses your imagery use with respect to different types of imagery. This questionnaire will take approximately 20 minutes to complete.

The total length of time that you can expect to spend participating in session 1 of this study will be approximately 20 minutes.

Session 2

You will twice be asked to fill out a brief self-efficacy questionnaire designed specifically for this study. The questionnaire will ask you about your confidence in your ability to successfully perform the task being asked of you. This questionnaire will take approximately two minutes to complete.

You will also be asked to physically perform a soccer task, dribbling a soccer ball. You will be asked to perform two sets of three trials of this task, and will be given rest time in between trial attempts as well as in between sets. In between sets, you may also be asked to image yourself performing the soccer task, under specific imaging guidelines. The soccer task trials and imagery practice will take approximately 20-25 minutes to complete.

Upon completion of the soccer task trials and the imagery practice, you will be asked to fill out a short, four-question survey which asks about your use of imagery and/or other mental skills during your soccer trial attempts. This survey will take approximately five minutes to complete.

The total length of time that you can expect to spend participating in session 2 of this study will be approximately 35 minutes.

Potential Risks and Discomforts

There are no anticipated risks associated with participating in this study that extend beyond the normal physical risks associated with performing the various soccer skills involved in the soccer task. The researcher has ensured that the area in which the soccer task will be performed is large enough to allow for free and unrestricted movement, and the soccer task will be clearly outlined and explained to you before you are asked to attempt it.

Potential Benefits to Subjects and/or to Society

By participating in this study, you may reap direct benefits from the imagery training. You will have been taught effective imaging methods that you will be able to use in other sporting contexts as well as in other aspects of life (e.g., when studying for a test or exam). You will be informed during the debriefing session of currently accepted imaging methods that have been empirically shown to produce positive effects.
Determining whether it is possible that the employment of slow motion imagery further enhances the positive benefits of imagery would represent an important contribution to the athletic community in that more effective imagery intervention and training programs would be made possible. The results of this study will also be a unique contribution to the growing body of knowledge regarding athletes' imagery use.

Payment for Participation

As compensation for participating in this study, you will be awarded a 2% bonus mark to be applied towards your final 95-211 – Principles of Mental Skills Training course grade. This bonus mark has been approved by your course professor. In order to obtain this 2% bonus mark, however, you must remain a participant in this study for the duration of the data collection phase (i.e., through all trials, imagery practice, and questionnaire administration).

Confidentiality

Any information that is obtained in connection with this study and that can be identified with you will remain confidential and will be disclosed only with your permission. All questionnaires, surveys, and trial data will be kept in strict confidence, and will be kept in the secure office of the primary investigator. Once all questionnaire, survey, and trial data have been entered into a statistical analysis program and the final draft of the manuscript for this study completed, the questionnaires, surveys, and trial data will be destroyed.

Participation and Withdrawal

You can choose whether to be in this study or not. If you volunteer to be in this study, you may withdraw at any time without consequences of any kind. However, please keep in mind that if you choose to withdraw from the study you will no longer be eligible to receive the 2% bonus mark toward your final 95-211 – Principles of Mental Skills Training course grade. You may also refuse to answer any questions you don't want to answer and still remain in the study. The investigator may withdraw you from this research if circumstances arise which warrant doing so.

Feedback of the Results of this Study to the Subjects

You will be provided with feedback regarding the results of this study upon your request. If you would like to receive a copy of the results of this study please email the primary investigator at oo@uwindsor.ca.

Rights of Research Subjects

You may withdraw your consent at any time and discontinue participation without penalty. This study has been reviewed and received ethics clearance through the University of Windsor Research Ethics Board. If you have questions regarding your rights as a research subject, contact:

Research Ethics Coordinator
University of Windsor
Windsor, Ontario
N9B 3P4

Telephone: 519-253-3000, ext. 3916
E-mail: lbunn@uwindsor.ca

SIGNATURE OF RESEARCH SUBJECT/LEGAL REPRESENTATIVE

I understand the information provided for the study entitled: **Effects of Slow Motion Imagery Practice on the Acquisition and Performance of a Serial Motor Skill** as described herein. My questions have been answered to my satisfaction, and I agree to participate in this study. I have been given a copy of this form.

Name of Subject

Signature of Subject — Date

SIGNATURE OF INVESTIGATOR

These are the terms under which I will conduct research.

Signature of Investigator — Date

Appendix C

Movement Imagery Questionnaire – Revised

(MIQ-R; Martin & Hall, 1997)

Movement Imagery Questionnaire – Revised (MIQ-R; Hall & Martin, 1997)

Instructions

This questionnaire concerns two ways of mentally performing movements which are used by some people more than by others, and are more applicable to some types of movements than others. The first is attempting to form a visual image or picture of a movement in your mind. The second is attempting to feel what performing a movement is like without actually doing the movement. You are requested to do both of these mental tasks for a variety of movements in this questionnaire, and then rate how easy/difficult you found the tasks to be. The ratings that you give are not designed to assess the goodness or badness of the way you perform these mental tasks. They are attempts to discover the capacity individuals show for performing these tasks for different movements. There are no right or wrong ratings that are better than others.

Each of the following statements describes a particular action or movement. Read each statement carefully and then actually perform the movement as described. Only perform the movement a single time. Return to the starting position for the movement just as if you were going to perform the action a second time. Then depending on which of the following you are asked to do, either (1) form as clear and vivid a visual image as possible of the movement just performed, or (2) attempt to feel yourself making the movement just performed without actually doing it.

After you have completed the mental task required, rate the ease/difficulty with which you were able to do the task. Take your rating from the following scale. Be as accurate as possible and take as long as you feel necessary to arrive at the proper rating for each movement. You may choose the same rating for any number of movements "seen" or "felt" and it is not necessary to utilize the entire length of the scale.

RATING SCALES

Visual Imagery Scale

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

Kinesthetic Imagery Scale

7	6	5	4	3	2	1
Very easy to feel	Easy to feel	Somewhat easy to feel	Neutral (not easy, not hard)	Somewhat hard to feel	Hard to feel	Very hard to feel

1. ***STARTING POSITION***:	Stand with your feet and legs together and your arms at your sides.
ACTION:	Raise your knee as high as possible so that you are standing on your left leg with your right leg flexed (bent) at the knee. Now lower your right leg so that you are again standing on two feet. Perform these actions slowly.
MENTAL TASK:	Assume the starting position. Attempt to feel yourself making the movement just performed without actually doing it. Now rate the ease/difficulty with which you were able to do this mental task.
	RATING: ____________

2. ***STARTING POSITION***:	Stand with your feet slightly apart and your hands at your sides.
ACTION:	Bend down low and then jump straight up in the air as high as possible with both arms extended above your head. Land with your feet apart and lower your arms to your sides.
MENTAL TASK:	Assume the starting position. Attempt to see yourself making the movement just performed with as clear and vivid a visual image as possible. Now rate the ease/difficulty with which you were able to do this mental task.
	RATING: ____________

3. ***STARTING POSITION***:	Extend your arm of your nondominant hand straight out to your side so that it is parallel to the ground, palm down.
ACTION:	Move your arm forward until it is directly in front of your body (still parallel to the ground). Keep your arm extended during the movement and make the movement slowly.
MENTAL TASK:	Assume the starting position. Attempt to feel yourself making the movement just performed without actually doing it. Now rate the ease/difficulty with which you were able to do this mental task.
	RATING: ____________

4. ***STARTING POSITION***:	Stand with your feet slightly apart and your arms fully extended above your head.
ACTION:	Slowly bend forward at the waist and try and touch your toes with your fingertips (or if possible, touch the floor with your fingertips or hands). Now return to the starting position, standing erect with your arms extended above your head..
MENTAL TASK:	Assume the starting position. Attempt to see yourself making the movement just performed with as clear and vivid a visual image as possible. Now rate the ease/difficulty with which you were able to do this mental task.
	RATING: ____________

5. ***STARTING POSITION***:	Stand with your feet slightly apart and your hands at your sides.
ACTION:	Bend down low and then jump straight up in the air as high as possible with both arms extended above your head. Land with your feet apart and lower your arms to your sides.
MENTAL TASK:	Assume the starting position. Attempt to feel yourself making the movement just performed without actually doing it. Now rate the ease/difficulty with which you were able to do this mental task.
	RATING: ____________

6. ***STARTING POSITION***:	Stand with your feet and legs together and your arms at your sides.
ACTION:	Raise your knee as high as possible so that you are standing on your left leg with your right leg flexed (bent) at the knee. Now lower your right leg so that you are again standing on two feet. Perform these actions slowly.
MENTAL TASK:	Assume the starting position. Attempt to see yourself making the movement just performed with as clear and vivid a visual image as possible. Now rate the ease/difficulty with which you were able to do this mental task.
	RATING: ____________

7. ***STARTING POSITION***:	Stand with your feet slightly apart and your arms fully extended above your head.
ACTION:	Slowly bend forward at the waist and try and touch your toes with your fingertips (or if possible, touch the floor with your fingertips or hands). Now return to the starting position, standing erect with your arms extended above your head..
MENTAL TASK:	Assume the starting position. Attempt to feel yourself making the movement just performed without actually doing it. Now rate the ease/difficulty with which you were able to do this mental task.
	RATING: ____________

8. ***STARTING POSITION***:	Extend your arm of your nondominant hand straight out to your side so that it is parallel to the ground, palm down.
ACTION:	Move your arm forward until it is directly in front of your body (still parallel to the ground). Keep your arm extended during the movement and make the movement slowly.
MENTAL TASK:	Assume the starting position. Attempt to see yourself making the movement just performed with as clear and vivid a visual image as possible. Now rate the ease/difficulty with which you were able to do this mental task.
	RATING: ____________

Appendix D

Soccer Task Performance Self-Efficacy Measure

(Based on recommendations of Bandura, 1997)

Self-Efficacy Measure (based on recommendations made by Bandura, 1997)

Please indicate below how confident you are that you can successfully carry out each of the activities listed below using the following scale:

0%	10%	20%	30%	40%	50%	60%	70%	80%	90%	100%
I am very certain I cannot do this					I am unsure; it could go either way					I am very certain I can do this

For example, if you have *complete confidence* that you can perform the soccer task at least as fast as your average practice time, and, without making any errors in 1 out of your next 3 attempts, then you would write down 100% in the space provided beside question 1. However, if you are not very confident that you could perform the soccer task at least as fast as your average practice time and without making any errors in 3 of your next 3 attempts, you would write down a relatively low number.

% Confidence

1. I believe that I can perform this soccer task at least as fast as my average practice time, and, without making any errors in **1** of my next 3 attempts. ________
2. I believe that I can perform this soccer task at least as fast as my average practice time, and, without making any errors in **2** of my next 3 attempts. ________
3. I believe that I can perform this soccer task at least as fast as my average practice time, and, without making any errors in **3** of my next 3 attempts. ________

Appendix E

Post-Experimental Manipulation Check (2-item; physical practice and control groups)

Post-Experiment Manipulation Check

Please answer the following questions. The information collected from this questionnaire will assist the researcher in the data analysis of the study. There are no right or wrong answers.

1. What other strategies or techniques, if any, did you use to help you in your task attempts?

2. If you were not asked to use imagery, did you find that you used imagery on your own? If yes, when?

Appendix F

Post-Experimental Manipulation Check (4-item; imagery groups)

Post-Experiment Manipulation Check

Please answer the following questions. The information collected from this questionnaire will assist the researcher in the data analysis of the study. There are no right or wrong answers.

1. What other strategies or techniques, if any, did you use to help you in your task attempts?

2. If you were asked to use imagery, did you image for the entire time that was set aside for you to image? If not, approximately how much time did you spend of the designated imagery time actually imaging?

3. If you were asked to use imagery, do you feel that you imaged at the appropriate speed(s) as instructed by the researcher? If not, how was your image speed different than what was asked (i.e. faster or slower)?

4. If you were asked to use imagery, did you feel that the imagery helped your performance?

Vita Auctoris

Name: My Phung Jenny O

Place of Birth: Cherating, Malaysia

Year of Birth: 1979

Education:

Master of Human Kinetics
University of Windsor
Windsor, ON
2003-2005

Honors, Bachelor of Physical Health and Education
Laurentian University
Sudbury, ON
1998-2003

Presentations:

"Effects of image speed on the acquisition and performance of a soccer skill". To be presented at the North American Society for Psychology of Sport and Physical Activity (NASPSPA) conference, St. Pete Beach, Florida, June, 2005.

"The effects of a cognitive specific imagery and image speed intervention on self-efficacy in a soccer dribbling task". Presented at the Eastern Canada Sport and Exercise Psychology Symposium, University of Windsor, Windsor, Ontario, March, 2005.

"Consideration of cognitive general and cognitive specific imagery as deliberate practice: A proposed study". Presented at Eastern Canada Sport and Exercise Psychology Symposium, Brock University, St. Catharines, Ontario, March, 2004.

Scholarly Experiences:

Chair, Eastern Canada Sport and Exercise Psychology Symposium
Organizing Committee
Faculty of Human Kinetics
University of Windsor
Windsor, ON
March 2004 – April 2005

Attended the Canadian Society for Psychomotor Learning and Sport Psychology (SCAPPS) conference
Saskatoon, SK
October, 2004

Attended the North American Society for Psychology of Sport and Physical Activity (NASPSPA) conference
Vancouver, BC
June, 2003

Attended the Eastern Canada Sport and Exercise Psychology Symposium (ECSEPS) conference, McGill University, Montréal, Québec, March, 2003.