ATHLETE IMAGERY ABILITY AND EFFECTIVE IMAGERY USE

By

SARAH E. WILLIAMS

A thesis submitted to University of Birmingham

for the degree of

DOCTOR OF PHILOSOPHY

School of Sport & Exercise Sciences

University of Birmingham

April 2011

Abstract

The aim of this thesis was to extend existing imagery ability literature. After reviewing the literature in Chapter 1, Chapter 2 validated and modified the Movement Imagery Questionnaire-Revised to provide a more comprehensive assessment of movement imagery ability. Known as the Movement Imagery Questionnaire-3, it was employed in Chapter 3 to examine the influence of prior movement and prior observation on an individual's external visual imagery, internal visual imagery, and kinaesthetic imagery ability. The Sport Imagery Ability Questionnaire (SIAQ) was developed and extensively validated in Chapter 4 to provide a more comprehensive measure of athlete imagery ability. Chapter 5 demonstrated the SIAQ's predictive validity by investigating the interplay between imagery ability, trait confidence, and challenge and threat appraisal tendencies. Finally Chapter 6 used the SIAQ as a screening tool when investigating whether imagery could be used to alter the appraisal of a stress-evoking scenario. Overall, the thesis has resulted in two new valid and reliable assessments of imagery ability. Additionally, this research extends imagery ability literature by establishing how imagery ability can be improved, demonstrating imagery ability's association with various outcomes, and highlighting the importance of assessing different imagery content.

Dedication

This thesis is dedicated to my Grandfather who taught me the importance of a good education.

Acknowledgements

First I would like to thank my family, and extended family for always supporting me even though you have had no real idea of what I have been doing with my life the last few years. Mum you have never pressured me into anything, allowing me to make my own decisions and then supporting me 100% in each of my endeavors. For this I am incredibly grateful. Thanks must also go to my friends, in particular Laura and Lucy for persuading me to pursue a PhD when I had doubts I would be capable of doing it.

During my PhD I have been incredibly fortunate to collaborate with a number of academics and for this I am very thankful. Thanks to my second supervisor Martin for his help when I was trying to tie the neuroscience with the sport psychology. I particularly enjoyed our pizza lunches! Thanks must also go to Nikos for his insightful guidance with the multitrait multimethod analysis and George for allowing me to use such sophisticated methods to assess physiological responses to imagery.

To my 3rd year undergraduate project students, Charlene, Darren, Emma, Helen, Ian, Jo, Jules, Luke, Mark, Neil, Nick, Rosie, Sarah, and Selina, thank you for all your hard with participant recruitment and data collection. I hope you enjoyed working on the various projects as much as I did. Thanks must also go to Harry and Christos for their help with ultrasound scanning.

Since beginning my PhD I have loved being part of the “Team Jenn” experience which is thanks to the other members who have made it so much fun. In particular thanks to Rich for showing me what life was like as a PhD student and Damian for showing me the ropes once I arrived.

Thanks to the Sportex post grads who over the years have helped me out in one way or another and made completing my PhD so much fun. Special thanks must go to Kim for helping me when SEM just wouldn’t stick. I hope the sofa partially made up for that. Thank you also to Annie for making me get this thesis finished and then proofreading the entire thing – a punishment I would not put on anyone!

I must also acknowledge Barbara Byrne and her AMOS book for the guidance in SEM and my iTunes library for keeping me sane while I immersed myself in all my data analysis and thesis writing!!!

Finally and most importantly I must thank my supervisor Jenn. Thank you so much for the opportunity you provided me, and the help and guidance I have received over the last few years. I have thoroughly enjoyed my PhD experience and am proud to hand this thesis in without ever experiencing a day when I have regretted doing a PhD. I believe this is a testament to you and your approach to supervising students. The support and friendship you have given me is something I will be forever grateful for. I will never be able to thank you enough for everything you have done.

Publications and conference presentations produced during the PhD

Publications which are part of this PhD thesis

1. Williams, S. E., Cumming, J., Ntoumanis, N., Nordin, S. M., Ramsey, R., & Hall, C. R. (under review). Further validation and development of the Movement Imagery Questionnaire. *Journal of Sports Sciences*.

2. Williams, S. E., Cumming, J., & Edwards, M. G. (in press). The functional equivalence between movement imagery, observation, and execution influences imagery ability. *Research Quarterly for Exercise and Sport*.

3. Williams, S. E., & Cumming, J. (in press). Measuring athlete imagery ability: The Sport Imagery Ability Questionnaire. *Journal of Sport & Exercise Psychology*.

4. Williams, S. E., & Cumming, J. (under review). Sport imagery ability predicts challenge and threat appraisal tendencies. *European Journal of Sport Science*.

5. Williams, S. E., Cumming, J., & Balanos, G. M. (2010). The use of imagery to manipulate challenge and threat appraisal states in athletes. *Journal of Sport & Exercise Psychology*, *32*, 339-358.

Publications contributing towards parts of the thesis

1. Cumming, J., & Williams, S. E. (in press). *The role of imagery in performance*. In S. Murphy (Ed), Handbook of Sport and Performance Psychology. New York, NY: Oxford University Press.

Publications which are not part of this thesis

Journal Articles

1. Williams, S. E. & Cumming, J. (under review). Challenge vs. threat: Investigating the effect of using imagery to manipulate stress appraisal of a dart throwing task. *Anxiety, Stress, and Coping*.

2. Williams, S. E. & Cumming, J. (in preparation). *Characteristics of athlete imagery ability: further validation of the Sport Imagery Ability Questionnaire*.

3. Williams, S. E. & Cumming, J. (in preparation). *Ease of imaging predicts imagery and observational learning use.*

4. Ramsey, R., Cumming, J., Edwards, M.G., Williams, S., & Brunning, C. (2010). Examining the emotion aspect of PETTLEP based imagery and penalty taking performance in football. *Journal of Sport Behavior*, *33*, 295-315.

Published Abstracts

1. Williams, S. E., & Cumming, J. (2010). An investigation of imaged meaning propositions to manipulate athletes' challenge-threat states. *Journal of Sport and Exercise Psychology, 32,* S229-230.

2. Williams, S. E., & Cumming, J. (2010). Assessing athletes' imagery ability: The development of the Sport Imagery Ability Questionnaire. *Journal of Sport and Exercise Psychology*, 32, 230.

3. Williams, S. E., Cumming, J., & Balanos, G. M., (2010). Psychological and physiological responses to differently appraised imagery scenarios. *Journal of Sports Sciences, 27,* S47-48.

4. Ramsey, R., Cumming, J., Brunning, C., & Williams, S. (2007). A PETTLEP based imagery intervention with university soccer players. *Journal of Sport and Exercise Psychology, 27,* S196-197.

5. Stanley, D. M., Williams, S. E., & Cumming, J. (2009). Preliminary validation of a single-item measure of exercise enjoyment: The Exercise Enjoyment Scale. *Journal of Sport and Exercise Psychology, 31,* S138-139.

Conference Proceedings

1. Williams, S. E., & Cumming, J. (2008). Imagery Ability Matters: Ease of Imaging Moderates the Relationship between Imagery Frequency and Trait Sport Confidence. *In conference proceedings of the Association for Applied Sport Psychology* (p. 41). St. Louis, USA: AASP.

2. Williams, S. E., & Cumming, J. (2009). To what Extent Does the Functional Equivalence between Imagery, Observation and Action Influence Imagery Ability? Investigating Different Modes of MIQ-R Delivery. In *Proceedings of the 12th World Congress of Sport Psychology* (p. 56-57), Marrakesh, Morocco.

3. Williams, S. E., & Cumming, J. (2010). Further validation of the Sport Imagery Ability Questionnaire. In *Proceedings of the British Psychological Society's Division of Sport and Exercise Psychology 2010 Conference* (p. 39-40). Camden Lock, UK.

4. Williams, S. E., Cumming, J., & Balanos, G. M. (2010). Using imagery to manipulate a challenge-threat state and investigating the subsequent physiological, psychological, and performance outcomes. In *Proceedings of the British Psychological Society 2010 Conference* (p. 81). Stratford-upon-Avon, UK.

Conference presentations

1. Williams, S. E., & Cumming, J. (2008). *Imagery Ability Matters: Ease of Imaging Moderates the Relationship between Imagery Frequency and Trait Sport Confidence*. Presented at the 23rd Annual Meeting of the Association for Applied Sport Psychology (AASP), St. Louis, USA.

2. Williams, S. E., & Cumming, J. (2009). *To what Extent Does the Functional Equivalence between Imagery, Observation and Action Influence Imagery Ability? Investigating Different Modes of MIQ-R Delivery*. Presented at the 12th World Congress of Sport Psychology, Marrakesh, Morocco.

3. Williams, S. E., Cumming, J., & Balanos, G. M., (2009). *Psychological and physiological responses to differently appraised imagery scenarios.* Presented at the Annual British Association for Sport and Exercise Sciences (BASES) Conference, Leeds, UK.

4. Williams, S. E., Cumming, J., & Balanos, G. M. (2010). *Using imagery to manipulate a challenge-threat state and investigating the subsequent physiological, psychological, and performance outcomes.* Presented at the Annual British Psychological Society (BSP) Conference, Stratford-upon-Avon, UK.

5. Williams, S. E., & Cumming, J. (2010). *An investigation of imaged meaning propositions to manipulate athletes' challenge-threat states*. Presented at the Annual Meeting of the North American Society for the Psychology of Sport and Physical Activity (NASPSPA), Tucson, USA.

6. Williams, S. E., & Cumming, J. (2010). *Assessing athletes' imagery ability: the development of the Sport Imagery Ability Questionnaire*. Presented at the Annual Meeting of the North American Society for the Psychology of Sport and Physical Activity (NASPSPA), Tucson, USA.

7. Williams, S. E., & Cumming, J. (2010). *Further validation of the Sport Imagery Ability Questionnaire.* Presented at the Annual British Psychological Society's Division of Sport and Exercise Psychology (DSEP) Conference, Camden Lock, UK.

8. Ramsey, R., Cumming, J., Brunning, C., & Williams, S. (2007). *A PETTLEP based imagery intervention with university soccer players*. Presented at the Annual Meeting of the North American Society for the Psychology of Sport and Physical Activity (NASPSPA), San Diego, USA.

9. Stanley, D. M., Williams, S. E., & Cumming, J. (2009). *Preliminary validation of a single-item measure of exercise enjoyment: The Exercise Enjoyment Scale*. Presented at the Annual Meeting of the North American Society for the Psychology of Sport and Physical Activity (NASPSPA), Austin, USA.

Additional presentations

1. Williams, S. E., & Brunning, C. (2007). *Solving England's Penalty Nightmares: Investigating the use of Imagery for Penalty Taking.* Presented at the Annual Meeting of Research in Imagery and Observation UK (RIO-UK), Birmingham, UK.

2. Williams, S. E., & Cumming, J. (2008). *Imagery Ability Matters: Ease of Imaging Moderates the Relationship between Imagery Frequency and Trait Sport Confidence.* Presented at the Annual Meeting of Research in Imagery and Observation UK (RIO-UK), Bangor, UK.

3. Williams, S. E., Cumming, J., & Edwards, M. G. (2009). *To what Extent Does the Functional Equivalence between Imagery, Observation and Action Influence Imagery Ability? Investigating Different Modes of MIQ-R Delivery.* Presented at the Annual Meeting of Research in Imagery and Observation UK (RIO-UK), Lincoln, UK.

4. Williams, S. E., Cumming, J., & Balanos, G. M., (2009). *Psychological and physiological responses to differently appraised imagery scenarios.* Presented at the Annual Meeting of Research in Imagery and Observation UK (RIO-UK), Birmingham, UK.

Table of Contents

Appendices Page

List of Figures

List of Tables

List of Abbreviations

Frequently Used Imagery Terms

CG	Cognitive general
CS	Cognitive specific
EVI	External visual imagery
IVI	Internal visual imagery
KI	Kinaesthetic imagery
MG-A	Motivational general-arousal
MG-M	Motivational general-mastery
MS	Motivational specific
VI	Visual imagery

Questionnaires and Theories

CAS	Cognitive Appraisal Scale
CTAI	Competitive Trait Anxiety Inventory
FOLQ	Functions of Observational Learning Questionnaire
IAMS	Immediate Anxiety Measurement Scale
MIAMS	Motivational Imagery Ability Measure for Sport
MIQ	Movement Imagery Questionnaire
MIQ-3	Movement Imagery Questionnaire-3
MIQ-R	Movement Imagery Questionnaire-Revised
SIAQ	Sport Imagery Ability Questionnaire
SIQ	Sport Imagery Questionnaire
TCTSA	Theory of Challenge and Threat States in Athletes
VMIQ-2	Vividness of Movement Imagery Quesitonnaire-2

Analysis Terms

AVE	Average Variance Extracted
CFA	Confirmatory Factor Analysis
CFI	Comparative Fit Index
CR	Composite Reliability
CT	Correlated Trait
CTCM	Correlated Trait-Correlated Method
CTCM-1	Correlated Trait-Correlated Method minus one
CTCU	Correlated Trait Correlated Uniqueness
CTUM	Correlated Trait-Uncorrelated Method
CVI	Content Validity Index
ICC	Intraclass Correlation Coefficient
MTMM	Multitrait Multimethod
RMSEA	Root Mean Square Error of Approximation
SEM	Structural Equation Modelling
SRMR	Standardized Root Mean Square Residual
TLI	Tucker Lewis Index

Physiological Measures

A	Aortic Valve Area
CO	Cardiac Output
EEG	Electroencephalography
EMG	Electromyogram
fMRI	Functional Magnetic Resonance Imaging
HR	Heart Rate
PAC	Pituitary-Adreno-Cortial
SAM	Sympathetic-Adreno-Medullary
SV	Stroke Volume
TMS	Transcranial Magnetic Stimulation
TPR	Total Peripheral Resistance
VTI	Velocity Time Integral

Chapter 1

General Introduction

Elements of this manuscript have been accepted for publication under the following reference:

Cumming, J. & Williams, S. E. (in press). The role of imagery in performance. In S. Murphy (Ed), *Handbook of Sport and Performance Psychology*. New York, NY: Oxford University Press.

Athlete Imagery Ability and Effective Imagery Use

Imagery is one of the most popular mental training techniques used by athletes to improve sport performance and enhance success (for reviews see Cumming & Ramsey, 2009; Martin, Moritz, & Hall, 1999; Murphy, Nordin, & Cumming, 2008) and is therefore one of the most widely studied (Morris, Spittle, & Watt, 2005). This chapter will first provide an overview of imagery and then discuss ways athletes use it to improve performance. Based on neuroscientific literature, it will then explain why imagery is thought to improve sporting performance. The influence of imagery ability and importance of its assessment will then be discussed, and the limitations of various existing assessment methods highlighted. Finally, the need for a more comprehensive questionnaire to assess sport imaging is provided before the purpose of the thesis and each chapter are explained.

Imagery and its Use

Imagery is a cognitive process involving the internal representation of movements and actions. It shares neural and behavioural similarities to an actual experience due to activation of similar brain areas involved in the unconscious planning and execution of movements (Lotze & Halsband, 2006; Munzert, Lorey, & Zentgraf, 2009). Defining imagery has proved difficult with a variety of definitions and descriptions evident in the literature. Morris et al. (2005) explained that “the focus of each definition varies depending on the purpose for which the imagery description is used” (p. 14). Therefore selecting one specific conceptualization is difficult. However, a more generic definition offered by White and Hardy (1998) describes imagery as:

> “an experience that mimics real experience. We can be aware of ‘seeing’ an image, feeling movements as an image, or experiencing an image of smell, 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)

The suggestion that imagery "mimics" real experience encompasses the notion that it stimulates brain areas that are also active during movement execution. This point is discussed later in this chapter. Also highlighted in White and Hardy's definition is that imagery can be experienced in various senses. Of these, in sport imagery the most common aspects experienced are visual imagery (VI) and kinaesthetic imagery (KI). VI has been described by Kosslyn, Thompson, and Ganis (2006) as seeing with the "mind's eye", for example seeing movements performed by oneself or others (Holmes & Calmels, 2008; Ruby & Decety, 2001). KI refers to imaging how it "feels" to perform a movement or action. It includes the awareness of motion and positioning of body parts during the movement, as well as the force and effort experienced (Callow & Waters, 2005). While individuals often experience both VI and KI simultaneously (e.g., Cumming & Ste-Marie, 2001), brain imaging has shown these two types of imagery activate distinctive parts of the brain (Guillot et al., 2009) and individuals can shift attention between the two when instructed (Munzert et al., 2009). Finally, imagery is a conscious process that is deliberately employed. For athletes, this can be undertaken for a number of reasons which are discussed in the next section.

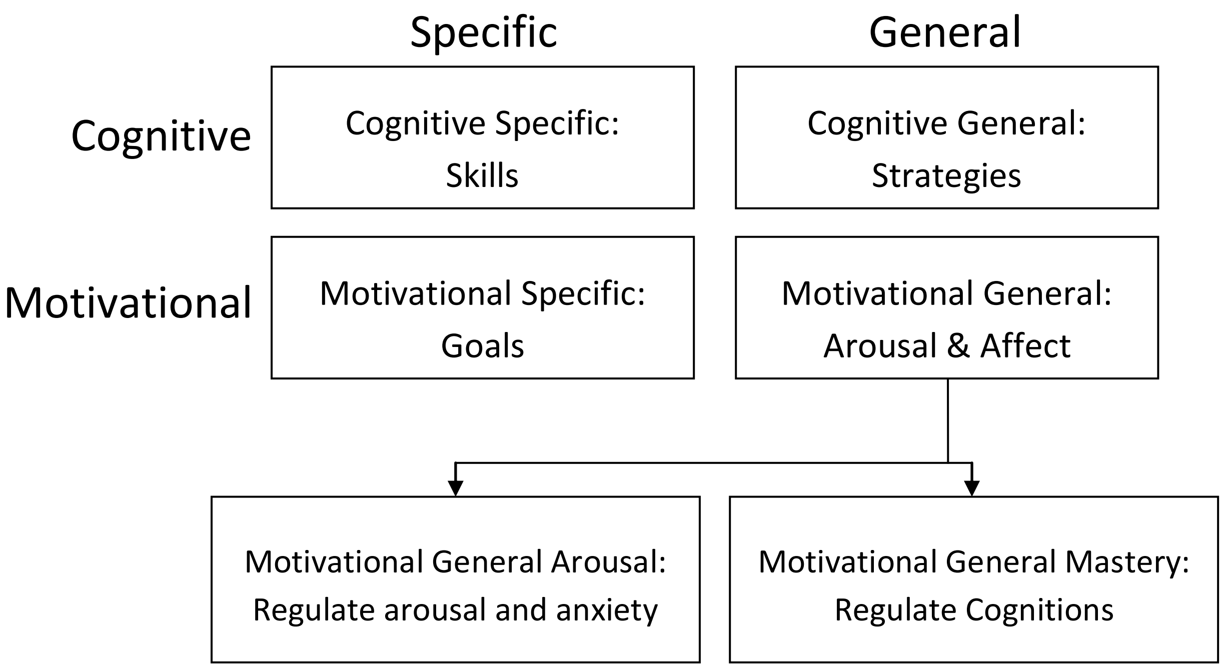
The 2 x 2 Framework

The extant literature demonstrates that imagery can directly enhance performance by improving movement execution (e.g., Li-Wei, Qi-Wei, Orlick, & Zitzelsberger, 1992; Nordin & Cumming, 2005a; Robin et al., 2007; Short et al., 2002). Imagery can also indirectly affect performance by enhancing motivation, confidence/self-efficacy, concentration, arousal and anxiety regulation, as well as augmenting emotional control, planning, creative thought processes, and reviewing and evaluating tasks and activities (e.g., Bernier & Fournier, 2010; Callow, Hardy, & Hall, 2001; Calmels, Berthoumiex, & d'Arripe-Longueville, 2004; Hale & Whitehouse, 1998; Hanton & Jones, 1999a; Munroe, Giacobbi, Hall, & Weinberg, 2000;

Murphy et al., 2008; Nordin & Cumming, 2005b, 2008; Vadocz, Hall, & Moritz, 1997). To explain how these benefits occur, Paivio (1985) developed a 2 x 2 framework identifying cognitive and motivational functions of imagery that operate for a specific action or at a more general level. According to Paivio, imagery has four main functions. They include: cognitive specific (CS), which involves imaging to improve various sport skills; cognitive general (CG), which aids game plans, strategies, and routines; motivational specific (MS), which helps to achieve various specific process, performance, and outcome goals; and motivational general (MG). The MG function was elaborated on by Hall, Mack, Paivio, and Hausenblas (1998) subdividing it into motivational general arousal (MG-A), employed to regulate feelings, mood, and emotion, and motivational general mastery (MG-M), which enhances mastery cognitions such as confidence (see Figure 1). All five of these functions are positively linked with athletic performance and success (Hall et al., 1998), with higher level athletes using the functions more than lower level athletes (Cumming & Hall, 2002b; Hall et al., 1998).

Figure 1

Paivio’s (1985) 2 x 2 framework elaborated by Hall et al. (1998)



Historically researchers have focussed on the cognitive aspects of this framework; however recent studies have shown that athletes use imagery more frequently for motivational purposes (e.g., Cumming & Hall 2002a; Hall et al. 1998). Specifically, they use imagery to enhance self-confidence/self-efficacy and protect against negative interpretations of stress and anxiety symptoms (for reviews, see Martin et al., 1999; Murphy et al., 2008). Bandura (1997) proposed that by visualising successful performance, individuals can experience an increase in their perceived ability and be more convinced they are able to execute the task (also see Feltz, 1984; Martin & Hall, 1995). Through increasing self-confidence, imagery has been shown to allow athletes to perceive stress and anxiety symptoms as being facilitative and under control (e.g., Cumming, Olphin, & Law, 2007; Hale & Whitehouse, 1998; Jones et al., 2002). For example, Hale and Whitehouse demonstrated facilitative interpretations of anxiety and heart rate (HR) during a challenge state[1] and debilitative interpretations of similar responses during a threat/pressure state. Their results suggest imagery can therefore also influence responses reflective of a challenge and threat/pressured appraisal situation. Self-confidence, perceived control, and anxiety interpretation can all be indicative of how an individual appraises a stress-evoking situation such as a championship game (see Jones, Meijen, McCarthy, & Sheffield, 2009; Blascovich & Mendes, 2000; Skinner & Brewer, 2004). Through altering these cognitions, imagery may be able to predict or even alter an athlete's appraisal tendencies.

The Applied Model of Imagery Use

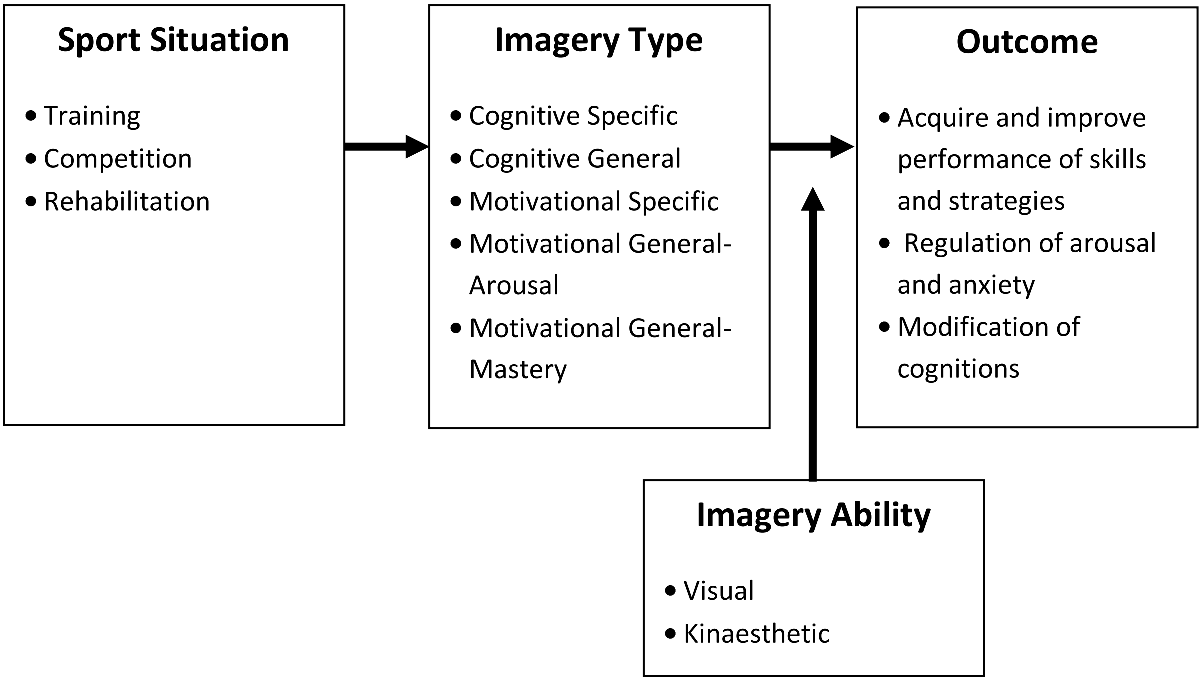
The five functions of imagery form the centre of the *applied model of imagery use* (Martin et al., 1999). As Figure 2 outlines, this model emphasises that the type/function of

[1] A challenge state is experienced when athletes perceive themselves to have the resources to meet the demands of the stressful situation, whereas a threat appraisal is experienced if they perceive insufficient resources (Jones et al., 2009).

imagery, the situation, and the individual's imagery ability influences the outcomes that result from imaging.

Figure 2

The applied model of imagery use in sport.



The model suggests that "what you see, really is what you get" (Martin et al., 1999, p. 260). That is, to be effective, imagery type should match the desired outcome. For example, to correctly execute a basketball free throw, the athlete should image correctly executing this skill. Although results support this prediction (for a review, see Cumming & Ramsey, 2009), research also indicates that the same image can be employed for different reasons (e.g., Nordin & Cumming, 2008; Short, Monsma, & Short, 2004). For example, imaging the correct execution of a basketball free throw may not only improve performance of the skill (CS function), but also serve as a vicarious experience to increase confidence in the ability to perform the shot (MG-M function). As a result, a delineation of imagery function (i.e., why an athlete is imaging) from imagery content (i.e., what an athlete is imaging) has been suggested (e.g., Bernier & Fournier, 2010; Callow & Hardy, 2001; Cumming & Ramsey, 2009; MacIntyre & Moran, 2010; Murphy et al., 2008; Nordin & Cumming, 2005b, 2008).

Functional Equivalence

Until recently, few theories have satisfactorily accounted for how imagery operates (Murphy et al., 2008). Neuroimaging has revealed a degree of neural overlap between imagery and the preparation and production of actual movements, suggesting imagery is in some ways functionally equivalent to motor behaviour (Johnson, 1982). Such co-activation has been observed during movement imagery, observation and execution and occurs in motor-related areas of the cerebral cortex (e.g., Decety, 1996; Ehrsson, Geyer, & Naito, 2003; Fadiga et al., 1999; Grèzes & Decety, 2001; Lotze et al., 1999). The brain areas activated during imagery, observation, and execution are specific to the nature of the movement being imaged, observed or executed such as hand or foot flexion and extension (Buccino et al., 2001; Ehrsson et al., 2003), suggesting a level of neural mirroring. These findings have found support from a plethora of behavioural techniques, such as electroencephalography (EEG), functional magnetic resonance imaging (fMRI), electromyogram (EMG), HR, skin conductance and mental chronometry (e.g., Amedi, Malach, & Pascual-Leone, 2005; Cremades & Pease, 2007; Cui, Jeter, Yang, Montague & Eagleman, 2007; Decety, 1996; Guillot et al., 2007; Guillot & Collet, 2005; Guillet, Collet, & Dittmar, 2004; Lutz, 2003; Marks & Isaac, 1995; Roure, Collet, Deschaumes-Molinaro, Delhomme, Dittmar, & Vernet-Maury, 1999).

Co-activation of brain areas is thought to prime movement execution and improve performance by strengthening the neurons responsible for actual performance, causing them to correctly activate during movement execution. Kosslyn, Ganis, and Thompson (2001), explain that "imaging, making movements might exercise the relevant brain areas…which in turn facilitate performance" (p. 639). Furthermore there is strong behavioural evidence of imagery's benefits when used immediately prior to executing a movement such as when serving at table tennis, dart throwing, returning a tennis serve, and golf putting (e.g., Li-Wei et al., 1992; Nordin & Cumming, 2005a ; Robin et al., 2007; Short et al., 2002). As well as improving performance, imagery can also hinder performance (Nordin & Cumming, 2005a; Ramsey, Cumming, Eastough, & Edwards, 2010; Ramsey, Cumming & Edwards, 2008). For example, Nordin and Cumming found that incorrectly imaging a dart throwing task, led to a poorer performance. The above studies offer compelling evidence of the benefits of imaging a task immediately prior to performing it, with the mechanism of these benefits operating via the activation of similar neural areas.

Imagery Ability and its Assessment

As highlighted in the applied model earlier, the impact of imagery on performance is influenced by an individual's imagery ability (Martin et al., 1999). Although the proficiency to generate and control images is present in all individuals, this is to varying degrees. For example, more successful athletes report more vivid imagery (e.g., Gregg & Hall, 2006; Issac & Marks, 1994; Mumford & Hall, 1985; Roberts, Callow, Hardy, Markland, & Bringer, 2008). It is important to note, however, that imagery ability is not a fixed characteristic. It can be modified with training and experience (Hall, 2001; Kosslyn, Brunn, Cave, & Wallach, 1984) and, while the capacity to image varies between individuals, there are characteristics that can be improved.

How well someone can image is represented by an amalgamation of components and characteristics (Morris et al., 2005). Because imagery involves being able to generate/form, maintain, and transform an image (Kosslyn, 1994), imagery ability should reflect the capacity to perform all or each of these processes. One measure that reflects someone's ability to generate an image is vividness. Roberts, Callow, Hardy, Markland, and Bringer (2008) describe image formation as occurring through the activation of working memory, and images displayed from working memory are represented by its vividness (see Baddeley & Andrade, 2000). The proficiency to generate an image, is also reflected by the ease with which an individual is able to do this (e.g., Hall & Martin, 1997; Gregg & Hall, 2006). This characteristic, known as ease of imaging, also encompasses the ability to maintain and transform images which are essential processes for effective imagery use.

When using imagery to improve motor performance (Goss, Hall, Buckolz & Fishburn, 1986) and motivational outcomes including self-efficacy (McKenzie & Howe, 1997), research demonstrates imagery is more effective for individual's displaying higher imagery ability. In a study to improve service return accuracy in tennis, for example, Robin et al. (2007) found greater improvements to performance for the better imagers compared to their lower level counterparts. It has therefore become common practice to screen people's imagery ability prior to interventions (Cumming & Ramsey, 2009). Athletes displaying poor imagery ability are usually either excluded (e.g., Callow et al., 2001) or provided with training exercises to facilitate imagery generation (e.g., Cumming et al., 2007). Due to imagery ability's modifiable nature, researchers typically monitor imagery ability by obtaining a measure prior to and following an intervention (e.g., Calmels, Holmes, Berthoumieux, & Singer 2004; Cumming & Ste-Marie, 2001; Rodgers, Hall & Buckolz, 1991). Therefore, researchers must have access to valid and reliable means to assess imagery ability. But because imagery can only be observed by the person performing it, measuring an individual's imagery ability is not a simple process (Lang, 1977). A number of methods have emerged over the years; the most frequent types of assessment can be classified as objective or subjective self report (Hall 1998).

Based on the notion of functional equivalence, objective measures that can reflect imagery ability and imagery quality have included those physiological and behavioural responses previously mentioned, including EEG, fMRI, EMG, HR, skin conductance, and chronometry (e.g., Amedi et al., 2005; Cremades & Pease, 2007; Decety, 1996; Marks & Isaac, 1995; Cui et al., 2007; Guillot & Collet, 2005; Guillot et al., 2007; Guillet, et al., 2004; Lutz, 2003; Roure et al., 1999). However these methods are often expensive, time consuming and not usually feasible in the applied setting. Therefore, the most common method is to use self-report questionnaires, with the most popular and well established being the Movement Imagery Questionnaire-Revised (MIQ-R; Hall & Martin, 1997).

Movement Imagery Questionnaire-Revised

Based on its predecessor the Movement Imagery Questionnaire (MIQ; Hall & Pongrac, 1983), the MIQ-R assesses ease of imaging visual and kinaesthetic movement imagery ability. Four different movements (i.e., knee lift, jump, arm movement, and waist bend) are physically performed once before visually imaging the movement and once before kinaesthetically imaging the movement. How easy individuals found being able to see and feel the movements imaged are then rated on a 7-point Likert type scale ranging from 1 (*very hard to see/feel*), to 7 (*very easy to see/feel*). Subscale (i.e., VI and KI) scores are totalled or averaged with a higher score representing greater imagery ability. The MIQ-R has a unique completion method whereby participants first physically perform each movement immediately before imaging it. This eliminates any recency effects which may occur as Lequerica, Rapport, Axelrod, Telmet, and Whitman (2002) have suggested imagery ability can be influenced by how frequently or recently a movement to be imaged was physically performed. A second benefit to physically performing each movement prior to imaging is that participants are provided with a mental representation of the movement to be imaged. Without clear instructions, a mental representation produced is thought to extremely vary (Caliari, 2008). Prior physical performance informs the administrator whether participants understand the movement they are required to image and allows the participant to experience what they are asked to image. This reduces the content discrepancy between the required and actual image. The MIQ-R's good internal reliability (for review see Hall, 1998), speed and ease of administration, and likely elimination of recency effects influencing reported imagery ability, make it a frequently employed assessment of athlete imagery ability. However, the questionnaire has two major limitations: lack of validation and failure to distinguish between VI perspectives. Both of these limitations will now be discussed in turn.

Lack of validation. Although some studies demonstrate the MIQ-R's predictive nature (e.g., Monsuma & Overby, 2004), most validation work is on its predecessor the MIQ (e.g., Goss et al., 1986; Rodgers et al., 1991; Moritz, Hall, Martin, & Vadocz, 1996). The removal of numerous items when adapting the MIQ-R means the validity of the MIQ may not generalise to the MIQ-R. There is also scant research validating the MIQ-R's factor structure. While Lorant and Nicholas (2004) concluded VI and KI ability measured by the French version of the MIQ-R are separate constructs, only recently did Monsma, Short, Hall, Gregg, and Sullivan (2009) examine the psychometric properties of the English MIQ-R, its internal and temporal reliability and gender invariance (Monsma et al., 2009). Cronbach alpha coefficients of .80, and test-retest reliability were consistent with previous MIQ studies, demonstrating good internal and temporal reliability respectively. Confirmatory factor analysis (CFA) revealed a good fit to the data, but unlike the French version, identified VI and KI to be related constructs. Although Monsma et al.'s study supports other research suggesting VI and KI to be separate but related (e.g., Abma, Fry, Li, & Relyea, 2002; Goss et al., 1986; Vadocz et al., 1997), findings concerning the MIQ-R factor structure remain inconclusive. Moreover, the measurement model tested by Monsma et al. displayed gender variance, suggesting gender differences in MIQ-R scores could result from gender variance of the factor structure rather than gender differences in imagery ability. The MIQ-R's factor structure must therefore be more closely examined to establish its validity as an assessment of movement imagery ability.

Inconclusive factor structure results may also be due to the type of CFA method previously employed. Because VI and KI are assessed using the same 4 methods (i.e., knee lift, jump, arm movement, and waist bend), a shared variance exists for each method across both subscales. A multitrait multimethod (MTMM) approach to CFA may be a better approach for MIQ-R validation as it accounts for this shared variance (Roberts et al., 2008), and may also help establish the true relationship between VI and KI.

Visual Imagery Perspective. A second MIQ-R limitation is its failure to capture a full representation of VI ability. Movement imagery can be viewed from different perspectives (Cumming & Ste-Marie, 2001; Hardy & Callow, 1999). Mahoney and Avener (1977) describe an external perspective as "a person [viewing himself or herself] from the perspective of an external observer (much like in home movies)" (p. 137). An internal perspective was described as "an approximation of the real life phenomenology such that a person actually imagines being inside his/her body and experiencing those sensations that might be expected in the actual situation" (Mahoney & Avener, 1997; p. 137) and is what the individual would see if they were actually performing the movement. Although internal imagery was thought to incorporate KI and be the superior perspective to employ (Decety, 1996; Mahoney & Avener, 1977), research has since identified kinaesthetic sensations associated with both an external and internal visual perspective (e.g., Cumming & Ste-Marie, 2001; Hardy & Callow, 1999). To avoid confusion as to whether researchers are including KI when referring to internal imagery, a distinction has been made between external visual imagery (EVI), internal visual imagery (IVI), and KI. "Perspective" is now the common term used when referring to the view point adopted by an individual (i.e. EVI vs. IVI perspective) and "modality" used when referring to senses incorporated into the imagery (i.e. VI or KI) (Hardy, 1997).

While some athletes prefer imaging from one visual perspective more than another, others switch between the two (e.g., Cumming & Ste-Marie, 2001; Ungerleider & Golding, 1991). Furthermore, each perspective can serve unique benefits. It is proposed EVI is beneficial when learning movements or when form and body coordination is important, whereas IVI is better for open skills, when timing and perception is important (Hardy & Callow, 1999; White & Hardy, 1995). Holmes and Collins, (2001) suggest the athlete's perspective employed should be appropriate for both the task and the individual. When assessing imagery ability, it is therefore important to obtain information about the ability to image EVI and IVI. If an intervention specifies imaging from a specific perspective, researchers should be informed as to whether the athlete is able to adopt this perspective. Secondly, due to better imagery ability producing greater intervention benefits (e.g., Goss et al., 1986; McKenzie & Howe, 1997; Robin et al., 2007), assessing both visual perspectives can inform the researcher which perspective the athlete should adopt. It therefore appears fundamental the MIQ-R be extended to distinguish between EVI and IVI ability and then validated.

The MIQ-R and Functional Equivalence

As explained, the co-activation between movement imagery and execution allows imagery to prime movement execution through preparing the neurons to fire more accurately (Murphy et al., 2008). When completing the MIQ-R this co-activation occurs in reverse; that is cerebral activation during execution of the MIQ-R movement is experienced before similar areas of activation occur during movement imagery. It can be suggested that movement execution of each MIQ-R item may strengthen the mental representations of movement imagery resulting in greater ease of imaging. The potential for co-activation to improve imagery ability could have a number of implications for in both research and applied settings.

In addition to enhancing performance, imagery is used to help rehabilitate injured athletes (e.g., Driediger, Hall, & Callow, 2006) and aid recovery from loss of function following stroke or spinal cord injury (e.g., Cramer, Orr, Cohen, & Lacourse, 2007; Malouin & Richards, 2010). If screened using the MIQ-R, these populations are unlikely to complete the measure with prior movement. If movement execution does prime imagery ability, scores may be lower for these individuals than if they had first physically performed the movements. Consequently, some participants may not achieve the specified cut off value and thus be excluded from the intervention when in reality the inclusion criteria would have been met had the individual been capable of performing the movement. Research is warranted to investigate whether completion of the MIQ-R with or without movement can produce a discrepancy in results.

Although movement execution is not frequently employed prior to imagery, a more common technique used before imaging is observation (e.g., Smith & Holmes, 2004; White & Hardy, 1995). For example, video modelling is employed to aid image generation in applied settings. But, research investigating the interaction between these two processes is less frequent (Morris et al., 2005). By observing a model, an individual receives a clear and vivid instruction of what they are required to image (Lang, 1979) and videos include information to incorporate into an image to improve its quality (Gould & Damarjian, 1996). Consequently using video clips is thought to enhance similarities between the imagined and actual situation, and enhance the functional equivalence between the two. Observation similarly activates the neural areas engaged during movement imagery and execution (e.g., Buccino et al., 2001; Ehrsson et al., 2003), and studies have shown observation can prime movement execution (e.g., Brass, Bekkering, Prinz, 2001; Edwards, Humphreys, & Castiello, 2003). It also follows that observation may serve as a prime to ease of imaging. Although studies demonstrate imagery to produce greater results when used in conjunction with observation (e.g. Smith & Holmes, 2004), research has not yet investigated whether this is due to observation improving an individual's imagery ability. However, qualitative reports support this may be the case. Nordin and Cumming (2005b) interviewed dancers who described observation as a method to obtain images used to subsequently facilitate performance. Similarly, Hars and Calmels (2007) found gymnasts observed others to enhance their imagery ability. Consequently, observation is a potential replacement to movement when physically impaired individuals complete the MIQ-R as well as provide a method to improve imagery ability in both healthy and clinical populations.

Comprehensive Imagery Ability Assessment

Paivio's conceptual framework (Hall et al., 1998; Paivio, 1985) and the applied model of imagery use (Martin et al., 1999) suggest athletes employ imagery varying in cognitive and motivational content to achieve numerous outcomes. However, a gap exists between the imagery content used by athletes and the assessment in their ability to generate this (Hall, 1998). Hall suggests the need for creating an instrument to comprehensively measure athletes' ability to generate images of their sport experiences by saying, "Just because athletes might be able to easily and vividly imagine themselves performing a skill (e.g., "throwing a ball"), does not mean they can just as easily and vividly imagine receiving a medal or being in control of difficult situations" (p. 171).

It would be naïve to assume MIQ-R scores of basic movements provides an accurate assessment of the ability to image complex and sport-specific cognitive and motivational images. In support, Cumming and Ste-Marie (2001) demonstrated an improvement in skate-specific imagery ability following a figure skating intervention, but this improvement was not evident when assessing imagery ability using the MIQ-R. This finding suggests imagery ability of a specific content (i.e., cognitive and motivational synchronised skating content) may not generalise to other types of content. Paivio (1985) suggests, "the trick is to find [a method of imagery ability] that is most directly related to the specific task under consideration" (p. 27S). Therefore, although the MIQ-R appropriately assesses movement imagery ability, it may not represent sport specific imagery content athletes' use. A valid and reliable questionnaire is needed to measure the ability to image content athletes experience in relation to their sport reflective of the five functions of imagery.

Summary and Rationale for Research Programme

Despite the effectiveness of imagery being strongly influenced by imagery ability, very little attention has been on its accurate assessment and how it can be improved. Most researchers will assess imagery ability through completion of the MIQ-R (Hall & Martin, 1997), which has yet to undergo an extensive validation process and does not separately assess the ability to image from an EVI and IVI perspective. Although the questionnaire eliminates recency effects, it is unknown whether prior physical performance influences ease of imaging by priming image generation through the co-activation of common neurons. Although athletes use various cognitive and motivational images, imagery ability is often assessed by the MIQ-R which is limited to the ability to image simple movements. Because it is likely this questionnaire will not provide an accurate measure of imagery ability for sport imagery intervention content, a questionnaire should be created and extensively validated to assess these cognitive and motivational images used. Comparisons between the questionnaire and objective physiological responses also reflective of the imagery scenario can be investigated to further validate the questionnaire as a measure of imagery ability.

Outline of Research Programme

In five empirical chapters, the aim of this thesis was to extend existing imagery ability literature by establishing a more comprehensive assessment of movement imagery ability and sport imagery ability, investigate how imagery ability can be improved, and examine the influence of imagery ability on various psychological and physiological responses. The aim of Chapter 2 was to comprehensively validate the MIQ-R using MTMM CFA. Four models were tested and compared to determine the model of best fit including the correlated trait (CT) model, correlated trait-correlated method (CTCM) model, correlated trait-uncorrelated method (CTUM) model, and correlated trait-correlated uniqueness model (CTCU; Marsh, 1987). An additional correlated trait-correlated methods minus one model (CTCM-1; Eid, 2000) was also tested and compared. The most parsimonious model displaying the best fit to the data was then tested for gender invariance and whether latent mean scores differed between males and females. The second study in Chapter 2 aimed to revise the MIQ-R to more comprehensively assess VI by separately assessing EVI and IVI. Thus, the resulting Movement Imagery Questionnaire-3 (MIQ-3) provided a more comprehensive assessment of movement imagery ability by assessing EVI, IVI, and KI. The factor structure of this revised questionnaire was validated using the same techniques as Study 1, and convergent validity established through comparing MIQ-3 scores with Vividness of Movement Imagery Questionnaire-2 (VMIQ-2; Roberts et al., 2008) scores - another measure of movement imagery ability.

Following validation of the MIQ-3, Chapter 3 investigated whether the functional equivalence between movement imagery and execution caused prior physical performance of MIQ-3 movements to prime the neurons involved in imagery and improve imagery ability. Completion of the MIQ-3 with and without a movement prime (i.e., physical performance of the movement before imaging it and imaging the movement without any prior physical performance) were also compared to two observation prime conditions. The first involved external observation whereby participants observed a video clip of a model performing the MIQ-3 movement from a 3rd person perspective. The second condition was internal observation, viewing the movement from a 1st person perspective.

Because athletes use imagery of varying content, the collection of studies in Chapter 4 aimed to develop and validate a comprehensive assessment of athlete imagery ability known as the Sport Imagery Ability Questionnaire (SIAQ). Based on existing literature, the premise was to establish a measure that assessed the ability to image content reflective of the five main functions of athlete imagery use (Hall et al., 1998). The final factor solution was compared with alternative models and gender variance investigated to see whether the solution was sustained for males and females. The temporal reliability of the SIAQ was investigated and content validity examined to investigate whether the questionnaire could distinguish between athletes that varied in gender and competitive level. Finally, concurrent validity was examined by comparing imagery ability scores of the SIAQ and MIQ-3.

Due to the SIAQ assessing imagery ability of cognitive and motivational imagery content, Chapter 5 examined the SIAQ's predictive validity and extended research on imagery, trait confidence, and appraisal tendencies. Although athletes high in state sport confidence tend to be better imagers than low sport confident athletes (Barr & Hall, 1992; Moritz et al., 1996), specific to trait confidence, Abma et al. (2002) found imagery ability of simple movements did not distinguish between high and low level trait confidence athletes. Whilst this finding suggests imagery ability does not predict trait sport confidence, results may be due to assessing movement imagery ability and not motivational imagery content which is thought to have the strongest link to confidence (e.g., Callow, Hardy & Hall, 1998; White & Hardy, 1998). Confidence and its more specific form of self-efficacy are in turn predictive of challenge and threat states. Specifically, the Theory of Challenge and Threat states in Athletes (TCTSA; Jones et al., 2009) proposes individuals with high levels of efficacy, confidence, and perceived control are likely to experience a challenge state. Through being able to clearly image mastery images assessed by the SIAQ such as "giving 100% effort even when things are not going well" an individual may be more likely to feel confident about their ability and perceive that they have the resources to meet the demands of a difficult situation – a characteristic indicative of a challenge state. Therefore this chapter investigated whether cognitive and motivational SIAQ imagery ability could predict trait confidence, and challenge and threat appraisal tendency, and whether these predictions varied depending on the imagery content (i.e., cognitive vs. motivational).

Finally, Chapter 6 investigated using the SIAQ as a screening tool for athletes partaking in a study examining sport specific motivational imagery. Based on findings from Chapter 5, Chapter 6 aimed to investigate whether imagery could manipulate the stress appraisal of an imaged scenario through altering cognitions such as feelings of self-efficacy and perceived control that are proposed by the TCTSA to influence whether a stress-evoking situation is appraised as a challenge or a threat (Jones et al., 2009). A second aim was to examine if the stress appraisal (i.e., challenge or threat) elicited physiological and psychological responses reflective of what would be expected in an actual situation.

The thesis chapters are presented in the same format they were submitted for publication with 4 exceptions. Firstly, for the sake of clarity, tables and figures have been inserted into the text of each chapter. Secondly, in Chapter 3, a paragraph was added to the thesis to demonstrate the premise behind how Chapter 4 was developed. Thirdly, in Chapter 6, information concerning the use of the SIAQ as a screening tool was not included in the published version for the sake of brevity. Finally, the references for every chapter have been presented in one list following Chapter 7.

Chapter 2

Further Validation and Development of the Movement Imagery Questionnaire

This manuscript has been submitted for publication to the *Journal of Sport Sciences.*

Abstract

The purpose of this research was to more comprehensively validate and extend the Movement Imagery Questionnaire-Revised (MIQ-R; Hall & Martin, 1997). Study 1 (*N* = 400) extensively examined the MIQ-R's factor structure via a multitrait multimethod approach to confirmatory factor analyses. A correlated-traits correlated-uniqueness model provided the best fit to the data, while displaying gender invariance and no significant differences in latent mean scores across gender. Study 2 (*N* = 370) extended the MIQ-R (termed the Movement Imagery Questionnaire-3 or MIQ-3) to separately assess ease of imaging external visual imagery and internal visual imagery, as well as kinaesthetic imagery. Consistent with Study 1, a correlated-traits correlated-uniqueness model providing the best fit to the data was also invariant across gender and revealed no significant differences in gender latent mean scores. Findings highlight the method effects that occur by assessing each type of imagery ability using the same four movements, and support the 3-factor structure of the MIQ-3 as an assessment of external visual imagery, internal visual imagery, and kinaesthetic imagery ability. Researchers now have access to a valid and more comprehensive measure of movement imagery ability that eliminates the potential influence of recency effects on imagery ability.

Further validation and development of the Movement Imagery Questionnaire

Imagery is a cognitive process that can play an important role in the planning and execution of movements or actions (e.g., Nordin & Cumming, 2005a; Robin et al., 2007; Short et al., 2002). It is frequently employed to aid motor skill learning, or relearning, as well as improve motor performance in clinical, dance, and sport settings (for reviews see Cumming & Williams, in press; Malouin, Richards, Jackson, & Doyon, 2010; Murphy, Nordin, & Cumming, 2008; Page, 2010).

Although imagery occurs in a number of sensory modalities (e.g., visual, auditory, olfactory), the focus is usually on visual and kinaesthetic imagery when referring to movement imagery. Visual imagery (VI) is described as seeing with the "mind's eye" (Kosslyn, Thompson, & Ganis, 2006). Simply put, it is what the individual views in the image, including seeing movements performed by oneself or others (Holmes & Calmels, 2008; Ruby & Decety, 2001). By comparison, kinaesthetic imagery (KI) involves how it "feels" to perform a movement or action. This includes having an awareness of the movement and positioning of body parts involved as well as the force and effort experienced during the movement (Callow & Waters, 2005). It is common for individuals to simultaneously experience visual and kinaesthetic modalities during movement imagery (e.g., Cumming & Ste-Marie, 2001). Importantly, however, Munzert, Lorey, and Zentgraf (2009) demonstrated it is possible to shift attention between these modalities when instructed to do so. Further, brain imaging studies provide evidence that even though VI and KI share common areas of activation, these modalities are neurally discernable (Guillot et al., 2009). Guillot et al. (2009) demonstrated that although both VI and KI caused activation in the lateral premotor cortex, VI caused activation in occipital regions and in the superior parietal lobule, whereas activation during kinaesthetic imagery was greater in motor associated areas along with the inferior parietal lobule.

The effectiveness of VI and KI as an intervention strategy to enhance movement performance is dependent on the individual's ability to generate and control vivid images (Martin, Moritz, & Hall, 1999). Individuals with higher imagery ability have been shown to outperform their lower level counterparts (e.g., Goss, Hall, Buckolz, & Fishburne, 1986). Because of this moderation effect, researchers will screen potential participants for their imagery ability prior to experiments and interventions (Cumming & Ramsey, 2009). Those less able to image are typically either excluded from the study or provided with specific training exercises designed to facilitate and improve their imagery ability (e.g., Cumming, Olphin, & Law, 2007; Hardy & Callow 1999).

A comprehensive, yet inexpensive method of screening participants' VI and KI ability is the use of self-report questionnaires. One of the most popular and commonly used questionnaires is the revised version of the Movement Imagery Questionnaire (MIQ-R; Hall & Martin, 1997). A briefer version of its predecessor, the Movement Imagery Questionnaire (MIQ; Hall & Pongrac, 1983), the MIQ-R assesses how proficiently an individual is able to mentally see and feel four simple movements; a knee lift, jump, arm movement, and waist bend. Participants image each movement twice, once before rating how easy it is to see the movement just imaged, and once before rating how easy it is to feel the movement just imaged. Ratings range from "very hard to see/feel" to "very easy to see/feel".

The MIQ-R (and MIQ) takes the unique approach of also instructing individuals to physically perform each movement prior to generating an image of this movement. Without clear instructions, Caliari (2008) warns of considerable variability between individuals in what mental representation is produced. If a group of individuals were told to simply image themselves kicking a ball, different interpretations of these instructions might occur depending on personal experience. For example, one person might image kicking a rugby ball up in the air, while another might image a soccer ball kicked along the ground. Further, the actual kicking action might vary from person to person, with some electing to image kicking the ball out of their hands, while others might image the initiation of the kick when the ball is positioned on the floor. Instructing participants to first perform the movement will help to reduce such discrepancies in content. This procedure also provides the questionnaire administrator with an opportunity to visually confirm whether participants correctly understand the desired movement before it is imaged. Due to its elusive nature, only the imager is able to experience and evaluate the image.

Another reason to ask participants to physically perform the movement first is to account for recency effects that might influence their imagery ability. How vividly a movement is imaged might be affected by whether this movement was performed recently or frequently by the participant (Lequerica, Rapport, Axelrod, Telmet, & Whitman, 2002). Returning to the ball kicking example, someone who is currently playing football will likely recall this experience more readily from memory than an individual who has not performed this action for themselves in a long time. Differences in how easily these two participants are able to image ball kicking might therefore be influenced with their experience with the task. Physical performance prior to imaging eliminates this problem by ensuring each participant is able to readily recall the MIQ-R movements. Consequently, the MIQ-R is often preferred to other movement imagery ability questionnaires, such as the Vividness of Movement Imagery Questionaire-2 (VMIQ-2; Roberts, Callow, Hardy, Markland & Bringer, 2008), as the resulting visual and kinaesthetic scores are more likely to be an accurate reflection of the participants' actual ability to image rather than how recently the movement was physically performed.

Further to these considerations, good internal reliability has consistently been reported for the MIQ-R subscales across various populations (e.g., Abma, Fry, Li, & Relyea, 2002; Vadocz, Hall, & Moritz, 1997; for review see Hall, 1998), and a handful of studies have demonstrated its predictive validity (e.g., Monsuma & Overby, 2004; Vadocz, et al., 1997). However, evidence of the MIQ-R's validity is currently lacking, with the majority of existing studies having been conducted on the original MIQ (e.g., Atienza, Balaguer, & Garcia-Merita, 1994). Compared to the MIQ, the MIQ-R has fewer items and the rating scale is reversed. Therefore, it cannot be assumed that the MIQ-R displays a similar factor structure and model fit. For example, when examining the factor structure of the French version of the MIQ-R, Lorant and Nicholas (2004) identified VI and KI to be separate constructs despite most research finding a moderate correlation between the MIQ's visual and kinaesthetic subscales (e.g., Abma et al., 2002; Goss et al., 1986; Vadocz et al., 1997).

Until very recently, research had not investigated the psychometric properties of the more commonly used English version of the MIQ-R. To address this gap, Monsma, Short, Hall, Gregg, and Sullivan (2009) confirmed its factor structure with structural equation modelling (SEM), tested for gender invariance (i.e., tested whether the model fit varied between males and females), and examined internal and temporal reliability. Similarly to the MIQ, the MIQ-R was found to have good internal and temporal reliability, with Cronbach alpha coefficients of .84 and .88 for the VI and KI subscales respectively, and test-retest reliability coefficient of .80 for VI and .81 for KI. The confirmatory factor analysis (CFA) showed a poor fit to the data for the hypothesized factor structure of the MIQ-R (CFI = .90, NNFI = .91, SRMR = .28, RMSEA = .15). However, once a path was inserted between the visual and kinaesthetic subscales, the model fit significantly improved (CFI = .99, NNFI = .98, SRMR = .03, RMSEA = .06). This finding was contrary to the earlier validation of the French version of the MIQ-R, in which VI and KI were found to be separate, unrelated constructs, but is keeping with the more typical relationship found. Because studies usually reveal no gender differences in movement imagery ability (e.g., Lorant & Nicholas, 2004; Monsma et al., 2009) it is perhaps surprising that the MIQ-R factor structure varied between males and females. That is, the model displayed a good fit to the female sample, but data on the male sample failed to converge to the model (Monsma et al., 2009). Although two independent t-tests revealed that males and females did not significantly differ from one another in their VI and KI ability scores, due to the gender variance in model fit, this finding may be influenced by the questionnaire's varying factor structure.

Although a promising step in providing evidence in favour of the MIQ-R's psychometric properties, Monsma et al. (2009) used a traditional CFA that did not allow them to consider the common variance that might exist because the same four movements (knee lift, jump, arm movement, and waist bend) are used to assess both VI and KI. These four methods used to assess visual and kinaesthetic movement imagery ability may produce method effects. For example, an individual's VI ability of a waist bend is likely to be associated with his/her kinaesthetic imagery ability of this movement. Multitrait multimethod (MTMM) might be a more appropriate statistical approach as this type of analysis will establish the relationship among the traits (i.e., VI and KI ability), when the effects of method variance and random error are present (Schmitt & Stults, 1986; see also Marsh, 1996; Marsh & Grayson, 1995). The absence of a MTMM approach in the previous CFAs of the MIQ-R might explain why inconsistent models have been produced (i.e., a 2-factor correlated traits English version, and a 2-factor uncorrelated traits French version). It might also be the reason why the previously established factor structure of the English version of the MIQ-R was not invariant between males and females as expected. Clarity of these issues is likely to be achieved through a more extensive CFA investigation using a MTMM approach. Testing and comparing a number of models will identify the most appropriate model fit for MIQ-R data (Marsh, 1989), and provide further support for its use as a measure of movement imagery ability.

Study 1

The purpose of the first study was threefold. The first aim was to investigate whether a model using a MTMM approach to CFA provided a better fit to the data than a first order CFA, which does not account for potential method effects caused by assessing visual and kinaesthetic movement imagery ability using a knee lift, jump, arm movement, and waist bend. The second aim was to determine whether a correlated or uncorrelated traits model provided the best fit to the data, attempting to resolve the ambiguity of previous MIQ-R validation (Lorant & Nicholas, 2004; Monsma et al., 2009). Once the best fitting model was established, the third aim was to re-examine the MIQ-R's suitability of assessing male and female movement imagery ability by using two separate approaches. The first was to test for gender invariance, and the second was to investigate whether significant differences existed in the latent mean structures between males and females, which is an analysis that has yet to be done in the process of validating the MIQ or MIQ-R.

It was hypothesised that due to the same movements being used to assess both traits (i.e., VI and KI), a MTMM CFA model would display a better fit to the data than a CFA not accounting for method effects. Based on the validation of the VMIQ-2 (Roberts et al., 2008), which also assesses multiple dimensions of imagery ability using the same items, and previous research that demonstrates significant correlations between the VI and KI (e.g., Abma et al., 2002; Goss et al., 1986; Vadocz et al., 1997), we hypothesised that a correlated trait-correlated uniqueness (CTCU) model would provide the best fit to the data. Additionally, it was hypothesised that our final model would display gender invariance, and based on studies demonstrating no gender differences in imagery ability (e.g., Lorant & Nicholas, 2004; Monsma et al., 2009), that there would be no significant gender differences in latent means.

Method

Participants

Four hundred males (*n* = 181) and females (*n* = 219) participated in the study. Participants had a mean age of 20.83 years (*SD* = 2.14) and were all healthy individuals physically capable of performing the 4 MIQ-R movements.

Measures

Demographic Information. Participants provided information regarding their age and gender.

Movement Imagery Questionnaire-Revised (MIQ-R). The MIQ-R (Hall & Martin, 1997) is an 8-item questionnaire assessing movement imagery ability of four basic movements; a knee lift, jump, arm movement, and waist bend. Ease of imaging is measured in both visual and kinaesthetic modalities. For each item, participants read a description of the movement. They then physically perform the movement before assuming the same starting position to either visually or kinaesthetically image the movement. Following this step, participants rate their ease of imaging on a 7-point Likert-type scale ranging from 1 *(very hard to see/feel)* to 7 *(very easy to see/feel)*. After the items for each subscale are averaged, a higher score represents a greater ease of imaging. Due to the limitations associated with Cronbach's alpha (see Bentler, 2009; Sijtsma, 2009), internal reliability was assessed using Composite Reliability (CR) and Average Variance Extracted (AVE). The criterion level was set at the values of .70 and .50 respectively (Hair, Anderson, Tatham, & Black, 1998). Both subscales demonstrated adequate CR: VI = .88, and KI = .82, and AVE: VI = .65, and KI = .53.

Procedures

Following ethical approval, participants were recruited from the university where the lead author is based, with some participants receiving partial fulfilment of a course credit. Those interested in participating were provided with an information sheet and the nature of the study was explained in more detail by an investigator. Participants who fit the inclusion criteria (i.e., they were physically able to perform the four MIQ-R movements) and were willing to participate were informed that their participation was voluntary and signed a consent form. They were then asked to complete the MIQ-R, which was done either in small groups or individually, and took no more than 10 minutes. Once the questionnaire was completed, all forms were returned to the investigator and participants were thanked for their participation.

Data Analysis

All data were screened for univariate outliers through the examination of item skewness and kurtosis values. Multivariate outliers were detected through the calculation of Mahalanobis distance values. Multivariate normality was examined using Mardia's coefficient (Mardia, 1970). When data were identified as non normal the bootstrapping technique was employed in all further analyses. Bootstrapping enables the creation of multiple subsamples from the original data with parameter distributions being subsequently examined in each of these samples (Byrne, 2010).

A MTMM approach to CFA was used to establish the relationship among the traits (i.e., VI and KI ability) when method variance effects and random error are present (Schmitt & Stults, 1986). Convergent and discriminant validity were also assessed, with large factor loadings on trait factors supporting convergent validity, and large correlations between trait factors suggesting lack of discriminant validity among traits (Byrne, 2010). Selection of the most appropriate model depended on which displayed the best fit indices and whether the model converged to a proper solution (Marsh & Grayson, 1995). Failure to converge or convergence to an improper solution was not considered creditable. Once the model with the best fit was selected, multi-sample analysis was conducted to examine whether the factor structure was sustained for both males and females. Finally we investigated whether there were gender differences in the latent means of the factors (i.e., VI and KI).

MTMM analysis, gender invariance, and latent mean structure testing were conducted via SEM with maximum likelihood estimations using AMOS 16.0 (Arbuckle, 1999). Each model's overall goodness of fit to the data was examined and determined using the chi-squared likelihood ratio statistic ratio (χ^2). Because a non-significant χ^2 value, representative of good model fit, is rarely obtained (MacCallum, 2003), the Tucker Lewis Index (TLI), Comparative Fit Index (CFI), Standardized Root Mean Square Residual (SRMR), and Root Mean Square Error of Approximation (RMSEA) were also used. Hu and Bentler (1999) suggest values of close to.95 or above indicate a relatively good fit for the TLI and CFI, and values close to .08 or lower and .06 or lower indicate relatively good fit for the SRMR and RMSEA respectively.

For MTMM, Marsh (1989) suggests that four models should be tested and compared to determine the best model fit. These are the correlated trait (CT) model, the correlated trait-correlated method (CTCM) model, the correlated trait-uncorrelated method (CTUM) model, and the correlated trait-correlated uniqueness (CTCU) model. The CT model allows the two trait factors (i.e., VI and KI) to be correlated (2CT). This model hypothesises trait but no method effects and is equivalent to the model tested by Monsma et al (2009) during their previous MIQ-R validation. The CTCM model also involves both traits being correlated, however the 4 methods (i.e., knee lift, jump, arm movement, and waist bend) are also correlated (2CT4CM). The CTUM model allows both traits to be correlated but the four methods are not (2CT4UM). By comparing the CTUM model with the CTCM model one evaluates the extent to which the method factors are correlated (Marsh, 1989). The CTCU model postulates that both imagery types are correlated but the method effects are obtained from correlated uniqueness among the responses that share the same method (2CTCU). Marsh (1989) explains that the size of correlations between the uniqueness terms, and the model fit of this model compared to the CT model determines the extent of method effects.

Further, comparing the 2CTCU model with the 2CT4CM and 2CT4UM models tests whether any method effects are multidimensional or unidimensional. While the 2CT4CM and 2CT4UM models both assume method effects are unidimensional (i.e., they are explained by one latent method factor), the 2CTCU model does not have this assumption, instead assuming they are multidimensional.

In addition to the four models proposed by Marsh (1989), a fifth more recent model, known as the correlated trait-correlated methods minus one model (CTCM-1; Eid, 2000), was tested. This model is a variation of the CTCM model in that it contains one less method factor. Consequently we tested a model with two correlated trait and three correlated method factors (2CT3CM). It has been proposed that similarly to the CTCM model, this model determines the variance components due to trait and method effects, but without the identification problems often experienced by the CTCM model (Eid, 2000).

Results

Data Screening and Normality

Five cases were detected as multivariate outliers and were removed, resulting in a final sample size of 395 (females = 218, males = 177). Mardia's coefficient (Mardia, 1970) revealed that data did not display multivariate normality (normalized estimate = 6.98), therefore bootstrapping was employed in all further analysis.

Table 1.

MIQ-R and MIQ-3 MTMM CFA Goodness of Fit Indices for the Models with a Proper Solution.

Model	χ^2	*df*	TLI	CFI	SRMR	RMSEA (90% CI)	$\Delta\chi^2$	Δdf
Study 1								
1) 2CT	37.35**	19	.98	.98	.03	.05 (.025 - .073)		
4) 2CTCU	25.99*	15	.99	.99	.03	.04 (.010 - .070)	11.36*	4
Study 2								
1) 3CT	117.60**	51	.95	.96	.04	.06 (.045 - .074)		
4) 3CTCU	75.12**	39	.97	.98	.04	.05 (.033 - .067)	42.48**	12
3CTCUb	75.69**	42	.97	.98	.04	.05 (.029 - .063)	41.91**	9

Note: 2CT and 3CT are correlated-trait models from Study 1 and 2 respectively, 2CTCU and 3CTCU are correlated trait-correlated uniqueness models from Study 1 and 2 respectively, $\Delta\chi^2$ = chi-square difference from CT model, Δdf = difference in degrees of freedom from CT model. * $p < .05$, ** $p < .01$

MTMM CFA

The 2CT4CM, 2CT4UM, and 2CT3CM models all yielded an improper solution. All displayed negative variances and were therefore disregarded. The other two models (2CT and 2CTCU) resulted in proper solutions and consequently their fit indices were examined (see Table 1). Although the 2CT model also displayed a good fit to the data, inspection of the correlated error variances revealed all significantly correlated with one another ($p < .05$). The Satorra- Bentler χ^2 difference test (2001) was used to investigate the relative goodness of fit between the 2 models. Results revealed a significantly smaller χ^2 value for the 2CTCU model demonstrating it to provide the best fit to the data.

Alternative Model

Although results support the 2CTCU model, previous validation of the French version of the MIQ-R suggested that VI and KI are separate constructs (Lorant & Nicholas, 2004). As such, the data were reanalyzed to verify that VI and KI should be considered as related constructs. A similar model to the 2CTCU model was tested but the correlation between the traits (i.e., VI and KI) was removed (2UTCU model). Results revealed a good model fit to the data, χ^2 (16) = 40.80, $p = .001$, CFI = .97, TLI = .96, SRMR = .09, RMSEA = .06 (90% CI = .04 - .09). Although both models revealed a good fit to the data, the χ^2 difference test (Satorra & Bentler, 2001) demonstrated the 2CTCU model displayed a significantly better fit to the data than the 2UCTCU model ($\Delta\chi^2 = 14.81$, $p < .001$).

Gender Invariance

Gender invariance of the 2CTCU model was conducted using a sequential testing approach via multisample CFA. A baseline model was established, before four increasingly constrained models were tested. The first constrained model constrained the factor loadings to be equal across the two gender groups, the second also constrained the factor variances, the third also constrained the factor covariances, and the fourth also constrained the error covariances (Byrne, 2010). The χ^2 difference test (Satorra & Bentler, 2001) was used to investigate the relative goodness of fit between increasingly constrained models. Based on the recommendations of Cheung and Rensvold (2002), we also considered a change in CFI of $\leq .01$ to be reflective of model invariance. Goodness of fit results for the five models of the gender invariance analysis displayed good model fit and are reported in Table 2. In accordance with our hypothesis, the Satorra-Bentler χ^2 difference test (2001) was nonsignificant when comparing, in turn, all five increasingly constrained models, thus supporting the MIQ-R's factorial invariance across males and females. This invariance was also supported by the change in CFI being less than .01 between each increasingly constrained model.

Latent Means

Latent means analysis was also conducted on the 2CTCU model. Similarly to the analysis of gender invariance, a baseline model was first established. Factor loadings and observed item means were then constrained equal across groups and error term means were constrained to 0. Finally the factor means (unobserved means derived from the observed item means loading on the factor) of the female group were constrained to 0 to serve as the reference categories, whereas the male group factor means were freely estimated (Bentler, 1995). Thus, the results indicate whether the male latent mean scores significantly differ from female latent mean scores but do not report the actual latent male and female mean scores (Byrne, 2010). Inspection of the latent mean estimates for male participants revealed no significant differences in VI (-.033, $p = .762$) or KI (-.051, $p = .618$) compared to females. Goodness of fit results demonstrated that the model with constrained loadings and item intercepts displayed a good fit to the data, χ^2 (42) = 5.37, $p = .086$, CFI = .99, TLI = .99, SRMR = .04, RMSEA = .03 (90% CI = 0.01 - 0.05).

Table 2.

MIQ-R and MIQ-3 CTCU Fit Indices for Gender Invariance Analysis.

Model	χ^2	*df*	CFI	TLI	SRMR	RMSEA (90% CI)	$\Delta\chi^2$	Δdf	ΔCFI
Study 1									
1) Unconstrained	43.25	30	.990	.982	.035	.034 (.000 - .054)			
2) Constrained factor loadings	51.26*	36	.989	.982	.036	.033 (.004 - .052)	8.01	6	.001
3) Constrained factor variances	56.04*	38	.986	.980	.042	.035 (.011 - .053)	4.78	2	.003
4) Constrained factor covariances	57.67*	39	.987	.980	.046	.035 (.012 - .053)	1.63	1	.001
5) Constrained error covariances	60.02*	43	.987	.984	.046	.032 (.006 - .050)	2.35	4	<.001
Study 2									
1) Unconstrained	118.46*	84	.981	.970	.049	.033 (.018 - .047)			
2) Constrained factor loadings	133.79*	93	.978	.968	.054	.035 (.020 - .047)	15.33	9	.003
3) Constrained factor variances	136.68*	96	.978	.969	.054	.034 (.020 - .046)	2.89	3	<.001
4) Constrained factor covariances	148.95**	99	.973	.964	.067	.037 (.024 - .049)	12.27**	3	.005
5) Constrained error covariances	162.11**	105	.969	.961	.065	.038 (.026 - .050)	13.16	6	.004

Note: $\Delta\chi^2$ = chi-square difference, Δdf = difference in degrees of freedom, ΔCFI = change in CFI, when the fit of the more constrained model is compared with that of the previous less constrained model (Cheung & Rensvold, 2002). * $p < .05$, ** $p < .01$

Discussion

Results of the MTMM CFA revealed that the 2CTCU model provided a significantly better model fit to the data compared to the 2CT model. This was further supported by the significant correlated error variances between the same methods (e.g., between both knee lift items). This finding was in accordance with our hypothesis highlighting the influence that assessing both types of imagery ability using the same items can have on MIQ-R results – a consideration which has been previously overlooked in MIQ-R validation studies. Validation of the VMIQ-2 also found a CTCU model to be a good fit to the data (Roberts et al., 2008). Through comparing a correlated traits version of the model to an uncorrelated version, support was found for treating VI and KI as separate but related constructs. This finding is also consistent with previous studies (Abma et al., 2002; Goss et al., 1986; Vadocz et al., 1997).

Unlike earlier attempts to validate the MIQ-R, our findings support the MIQ-R as a measure of movement imagery ability for both males and females as the factor structure was invariant across males and females. This contradicts previous gender invariance testing on a similar population in which the proposed model displayed a better fit for females compared to males (Monsma et al., 2009). This discrepancy may be because method effects were not considered in previous validation of the MIQ-R. There were also no significant differences in male and female latent mean scores. Although some studies have detected gender differences in imagery ability, this is usually regarding spatio-visual imagery ability (e.g., Campos, Pérez-Fabello, & Gómez-Juncal, 2004). Our finding is in accordance with studies demonstrating no significant differences between males and females in ease of imaging movement imagery (Lorant & Nicholas, 2004; Monsma et al, 2009).

Despite the MIQ-R being more extensively validated in Study 1, the questionnaire is limited to the assessment of VI and KI ability. Researchers have argued a limitation of the

MIQ-R is its inability to distinguish between visual perspectives (e.g., Roberts et al., 2008); that is, whether the image is seen from an internal visual imagery (IVI) perspective or an external visual imagery (EVI) perspective.

An EVI perspective, also known as a third person perspective, has been described as when "a person views [himself or herself] from the perspective of an external observer (much like in home movies)" (Mahoney & Avener, 1977, p. 137). By comparison, an IVI perspective, also known as a first person perspective is described as "an approximation of the real life phenomenology such that a person actually imagines being inside his/her body" (Mahoney & Avener, 1977, p. 137), and is what the individual would see if they were actually performing the movement.

It is thought that both VI perspectives serve unique benefits. For example, EVI is valuable when performing tasks such as the learning of movements, and when form or body coordination is important as the imager is presented with a view of how the movement or action should be performed such as limb positions (Hardy & Callow, 1999; White & Hardy, 1995). Alternatively IVI is thought to be beneficial for open skills when perception and timing is important. From this internal position the individual is able to rehearse spatial locations and at what time a movement should be initiated (Hardy & Callow, 1999; White & Hardy, 1995). Therefore, depending on the type of image being performed and the intended outcome, research suggests adopting a particular perspective over another may be more beneficial (Hardy, 1997). Some athletes prefer to image from one perspective more than another, while others prefer switching between the two (e.g., Cumming & Ste-Marie, 2001; Ungerleider & Golding, 1991) and altering their images to take advantage of different viewing angles (e.g., Callow & Roberts, 2010; Nordin & Cumming, 2005b). When completing the MIQ-R it is likely that individuals will image each visual item from their preferred visual perspective. However it has been suggested that preferred VI perspective and imagery perspective ability, although related, are separate constructs (Callow & Roberts, 2010). Therefore preferred visual perspective may not reflect the perspective demonstrating the highest level of imagery ability. This has important applied implications as greater imagery ability can lead to more effective imagery interventions (e.g., Robin et al., 2007).

It appears logical that the MIQ-R be extended to more fully capture an individual's VI ability. Recently the Vividness of Movement Imagery Questionnaire (VMIQ; Issac, Marks, & Russell, 1986) was also modified to separately assess EVI, IVI, and KI with the authors arguing that the separate assessment of each type of imagery provides a more comprehensive assessment of movement imagery ability (Roberts et al., 2008). Therefore a second study was conducted with the aim to create and validate a modified version of the MIQ-R, called the Movement Imagery Questionnaire-3 (MIQ-3) to separately assess EVI, IVI, and KI.

Study 2

The primary aim of Study 2 was to validate the modified version of the MIQ-R, which is referred to hereafter as the MIQ-3, using the same MTMM CFA approach as Study 1. A second aim was to compare the final 3-factor model against alternate 2-factor models to ensure separately assessing EVI, IVI, and KI provided the best model fit. Similarly to Study 1, we also tested the best fitting model for gender invariance and compared latent mean structures of males and females to investigate any significant differences in EVI, IVI, and KI. Finally concurrent validity of the MIQ-3 was investigated by examining whether its subscales correlated with the subscales of the VMIQ-2. Although the VMIQ-2 assesses vividness and the MIQ-3 ease of imaging, it has been suggested that both are likely to reflect the processes of image formation, transformation, and maintenance (Roberts et al., 2008).

It was hypothesised that, similarly to Study 1, assessing each type of imagery using the same four movements would ensure the model displaying the best fit to the data would be one which takes into account method effects. Based on the findings of Study 1 and the previously validated VMIQ-2, it was predicated that this would be a CTCU model. Due to research suggesting EVI, IVI, and KI are separate but related constructs (e.g., Roberts et al., 2008), a second hypothesis was that the final model composed of three traits (i.e., EVI, IVI, and KI) would provide a better fit to the data than if items reflective of different types of imagery ability were forced onto the same factor (e.g., EVI and IVI loaded onto the same factor). Based on Study 1's findings, and previous research demonstrating no gender differences in imagery ability (e.g., Lorant & Nicholas, 2004; Monsma et al., 2009), we hypothesised that our final model would be gender invariant and there would be no significant differences in the latent mean structure scores between males and females. Finally it was hypothesised that the MIQ-3 would separately assess the ability to image EVI, IVI, and KI and subsequently each subscale would significantly correlate with its respected subscale on the VMIQ-2. This hypothesis was also based on significant correlations that have previously been identified between the VMIQ-2 and the MIQ-R (Roberts et al., 2008).

Method

Participants

Three hundred and seventy participants (male = 185; female = 185) with a mean age of 20.29 years (*SD* = 2.25) and took part in Study 2. Participants were all healthy individuals capable of physically performing the four MIQ-3 movements.

Measures

Demographic Information. The measures were identical to Study 1.

Movement Imagery Questionnaire-3 (MIQ-3). The MIQ-3 is an adaption of the MIQ-R (Hall & Martin, 1997), composed of 3 subscales assessing EVI and IVI, as well as KI. Consequently the same 4 movements are physically performed and imaged three times creating a 12-item questionnaire. The rating scales from the MIQ-R were retained meaning participants responses varied from 1 *(very hard to see/feel)* to 7 *(very easy to see/feel)*, with a higher averaged score on a subscale representing a greater ease of imaging. Participants were provided with a definition of EVI, IVI, and KI before they completed the questionnaire based on Mahoney and Avener (1977) and Hall's (2001) definitions of EVI and IVI, and Callow and Waters's (2005) definition of KI. External visual imagery was defined as "when you watch yourself performing the movement from an outside point of view or third person perspective. It can be likened to watching yourself on television or from another person's perspective". Internal visual imagery defined as "when you watch yourself performing the movement from an inside point of view or first person perspective. It as if you were looking out through your own eyes whilst performing the movement and is therefore what you would see while actually doing the movement". Kinaesthetic imagery was defined as "the feelings experienced if you were actually producing the movement. It includes things such as feeling your muscles contract or feeling an object your body makes contact with". The MIQ-3 demonstrated good internal reliability for each subscale with CR values of .83 (EVI), .79 (IVI), and .85 (KI), and AVE values of .55 (EVI), .52 (IVI), and .59 (KI).

Vividness of Movement Imagery Questionnaire-2 (VMIQ-2). The VMIQ-2 is a 36 item questionnaire in which participants rate the vividness of 12 movements for each of the three subscales, EVI, IVI, and KI. Participants were instructed to first image all items using EVI, followed by IVI, and KI. Movements include specific actions such as "throwing a stone into water" and whole body movements such as "running up stairs". Each image was rated on a 5-point Likert-type scale, ranging from 1 (*Perfectly clear and as vivid as normal vision or feel of movement*) to 5 (*No image at all, you only "know" that you are thinking of the skill*). For easier comparison with the MIQ-3, the ratings were reverse scored such that a higher score represented a more vivid image. The VMIQ-2 has been shown to be a valid and reliable questionnaire (Roberts et al., 2008). In the present study the VMIQ-2 demonstrated good internal reliability for each subscale with CR values of .94 (EVI), .93 (IVI), and .93 (KI), and AVE values of .56 (EVI), .52 (IVI), and .53 (KI).

Procedures

The procedures were identical to Study 1 with the exception that a subsample of participants (*n* = 168) also completed the VMIQ-2.

Data Analysis

Data were screened for univariate and multivariate outliers using the same procedures as in Study 1. Separate CFAs were first conducted on each potential MIQ-3 factor (i.e., EVI, IVI, and KI) before proceeding with a MTMM CFA of the entire model. This method is recommended to identify any potential items for removal (e.g., Biddle, Markland, Gilbourne, Chatzisarantis, & Sparkes, 2001; Jöreskog, 1993) and has been employed when adapting other questionnaires such as the VMIQ-2 (Roberts et al., 2008). Once the best three-factor model was selected using MTMM CFA, this was compared to two alternative two-factor models to examine whether a three factor model provided the best fit to the data. Gender invariance and latent means structures analysis were then conducted as in Study 1. The same computer package, bootstrapping technique, multivariate normality test, and goodness of fit criteria used in Study 1 were employed. Finally concurrent validity was established by examining the covariances between the MIQ-3 and VMIQ-2's EVI, IVI, and KI subscales in a measurement model. The factor structure of each questionnaire was first examined (Kline, 2005) before the model as a whole tested and covariances between each subscale investigated.

Results

Data Screening and Normality

No outliers were detected; hence all data were retained for the analyses. Mardia's coefficient (Mardia, 1970) revealed data did not display multivariate normality (normalized estimate = 11.64) and bootstrapping was subsequently employed in all further analyses.

MIQ-3 Single Factor Models

Results of the CFA for each potential MIQ-3 subscale revealed a good fit to the data for EVI, χ^2 (2) = 6.14, p = .046, CFI = .99, TLI = .98, SRMR = .02, RMSEA = .08 (90% CI = 0.008 - 0.146), IVI, χ^2 (2) = 7.30, p = .026, CFI = .99, TLI = .96, SRMR = .02, RMSEA = .09 (90% CI = 0.025 - 0.154), and KI, χ^2 (2) = 5.07, p = .079, CFI = .99, TLI = .99, SRMR = .02, RMSEA = .06 (90% CI = 0.001 - 0.137). Factor loadings for each subscale ranged from .70-.80 for EVI, .65-.79 for IVI, and .74-.83 for KI, demonstrating each item contributed meaningfully to its factor. Modification indices and standardized residuals revealed all values were within acceptable limits (Hair, Anderson, Tatham, & Black, 1998).

MTMM CFA

The same MTMM approach to CFA employed in Study 1was used, again involving the testing of 5 models: (1) correlated trait (3CT), (2) correlated trait-correlated method (3CT4CM), (3) correlated trait-uncorrelated method (3CT4UM), (4) correlated trait-correlated uniqueness (3CTCU), (5) correlated trait-correlated method minus 1 method model (3CT3CM). Similarly to Study 1, improper solutions occurred for the 3CT4CM, 3CT4UM, and 3CT3CM. All displayed negative variances and were consequently disregarded. The 3CT and 3CTCU models both yielded proper solutions and their fit indices were subsequently examined. In a similar fashion to Study 1, both displayed a good fit to the data (see Table 1) and all factor loadings, modification indices, and standardized residuals were within acceptable limits (Hair et al., 1998). Inspection of the correlated error variances revealed all significantly correlated with one another (p < .05) with the exception of three correlations. A second 3CTCU model was tested (3CTCUb) in which these nonsignificnat error terms were fixed to zero. Results revealed a good fit to the data (see Table 1) similar to the 3CTCU model but with significant correlations between all error variances. The Satorra-Bentler

χ^2 difference test revealed the 3CTCUb model to display a significantly lower χ^2 value compared to the 3CT model and as such display the best fit to the data.

Alternative Models

Although results support the 3CTCU model and the interfactor correlation between EVI and IVI was only .38, the data were reanalyzed to verify that EVI and IVI should be separately assessed. A two trait factor model (VI + KI) was specified in which the four items assessing EVI and four items assessing IVI were all forced onto the same factor to assess VI. The four kinaesthetic items remained together on the second trait factor to separately assess KI. As can be seen in Table 3, results revealed a poor fit to the data when EVI and IVI were forced onto the same factor.

The correlation between KI and IVI was moderate in size (r = .60). When describing the process of imaging from an internal perspective some researchers have included characteristics of KI in their definition such as "experiencing [the] sensations that might be expected in the actual situation" (e.g., Mahoney and Avener, 1977, p.137). Although since then there has been a call to distinguish between the two processes, we wanted to ensure each factor was assessing a different type of imagery ability. Consequently, a second alternate model (IVI, KI + EVI) was devised in which IVI and KI items were forced onto one factor, and EVI remained on the second factor to separately assess EVI. As can be seen in Table 3, the second 2-factor alternative model also revealed a poor fit to the data, demonstrating the 3 factor model to be the most appropriate.

Table 3.

MIQ-3 Goodness of Fit Indices for 3CTCU Model and Alternate Models using CTCU CFA (Study 2).

Model	χ^2	*df*	TLI	CFI	SRMR	RMSEA (90% CI)
3CTCU	75.12*	39	.97	.98	.04	.05 (.03 - .07)
2CTCU VI + KI	369.13*	41	.71	.82	.11	.15 (.13 - .16)
2CTCU IVI,KI + EVI	243.66*	41	.82	.88	.07	.12 (.10 - .13)

Note: 3CTCU is the correlated trait-correlated uniqueness model with external visual imagery, internal visual imagery, and kinaesthetic imagery all as separate factors, 2CTCU VI + KI is correlated trait-correlated uniqueness model with external and internal visual imagery perspectives on one factor and kinaesthetic imagery on the other, 2CTCU IVI, KI + EVI is correlated trait-correlated uniqueness model with internal visual and kinaesthetic imagery on one factor and external visual imagery on the other, * $p < .001$.

Gender Invariance

Goodness of fit results for the five models of the gender invariance analysis are reported in Table 2. Although the change in χ^2 was significant when the factor covariances were constrained to be equal across males and females, the change in CFI was smaller than .01. This finding, along with the non significant change in χ^2 between the other increasingly constrained models, supports the gender invariance of the final MIQ-3 model.

Latent Means

Results revealed that latent mean estimates reported by male participants did not significantly differ compared to those for females for EVI (-.195, p = .126), IVI (-.136, p = .232), and KI (.018, p = .885). Similarly to Study 1, even when the factor loadings and observed means were constrained to be equal across males and females, the model still displayed a good fit to the data, χ^2 (102) = 142.17, p = .005, CFI = .98, TLI = .97, SRMR = .05, RMSEA = .03 (90% CI = .018 - .045).

Concurrent Validity

The CFA model fit for the VMIQ-2 revealed an adequate fit to the data, χ^2 (555) = 22.63, p < .001, CFI = .93, TLI = .92, SRMR = .06, RMSEA = .06 (90% CI = 0.06 - 0.07) and all factor loadings, modification indices, and standardized residuals were within acceptable limits (Hair et al., 1998). The measurement model was then tested as a whole. Results revealed an adequate fit to the data, χ^2 (1020) = 1641.60, p < .001, CFI = .92, TLI = .90, SRMR = .06, RMSEA = .06 (90% CI = 0.06 - 0.07) and all factor loadings, modification indices, and standardized residuals within acceptable limits (Hair et al., 1998). Examination of the covariances between MIQ-3 and VMIQ-2 subscales revealed significant correlations between all MIQ-3 and VMIQ-2 subscales (see Table 4). Moreover, the imagery subscale measured by the MIQ-3 (i.e., EVI, IVI, and KI) correlated most highly with its reflective subscale on the VMIQ-2.

Table 4.

Correlations between the MIQ-3 and VMIQ-2 subscales.

VMIQ-2	MIQ3 EVI	MIQ3 IVI	MIQ3 KI
EVI	0.679**	0.554**	0.259*
IVI	0.239*	0.628**	0.351**
KI	0.246*	0.533**	0.706**

Note: * = $p < .05$, ** = $p < .001$.

Discussion

As with Study 1, results supported a CTCU model. This is due to the significant correlated error variances between the same methods. Although 3 of these correlations were nonsignificant, once these were not allowed to correlate, the model fit was still significantly better than the 3CT model. Consequently, similarly to Study 1, a method effect exists when assessing each type of imagery ability using the same four movements.

The fact that the 3-factor CTCU model provided the best fit to the data, along with the correlations between each subscale, demonstrates EVI, IVI, and KI ability to be separate but related constructs – a finding similar to previous research (e.g., Roberts et al., 2008). This supports the advantage of employing the MIQ-3 so that a more comprehensive assessment of movement imagery ability is obtained.

This 3-factor CTCU model also displayed gender invariance, demonstrating it to be a suitable measure for assessing external visual, internal visual, and kinaesthetic movement imagery ability for both males and females. There were also no significant differences in latent mean scores due to gender. Similar to Study 1, this is in accordance with previous studies that have failed to detect a difference in movement imagery ability between males and females and provides further evidence for the MIQ-3 as a valid measure of EVI, IVI, and KI ability for both genders. Finally significant correlations between the MIQ-3 and the VMIQ-2 demonstrate the MIQ-3's concurrent validity. The significant correlations between the same subscales on both questionnaires demonstrate that the MIQ-3, similarly to the VMIQ-2, is assessing EVI, IVI, and KI ability. However the fact that these correlations are only moderate in size demonstrates that each questionnaire is not assessing the exact same thing. This can be partly explained due to the MIQ-3 assessing ease of imaging and the VMIQ-2 assessing vividness of the image. Nonetheless, these findings support the MIQ-3's capacity to assess ease of imaging EVI, IVI, and KI.

General Discussion

Overall the results from both studies identified the MIQ-R and MIQ-3 to be valid and reliable measures of visual and kinaesthetic movement imagery ability. The CTCU model displayed the best fit for both MIQ-R and MIQ-3 data highlighting the method effects that occur by assessing each imagery ability trait using the same four movements – something that has been overlooked in previous MIQ-R validation. Consequently, an individual's ability to image a knee lift from an EVI perspective for example, is likely to be associated with his/her ability to image a knee lift from an IVI perspective and from a kinaesthetic modality as all three include imaging the same movement (i.e., use the same method). However the CTCU model suggests that although these method effects exist, each measure has its own method effect and the common method factor is reflected in the covariances between the measures using the same method (Kenny & Kashy, 1992). The model fit of both questionnaires was also invariant across gender, and imagery ability between males and females did not significantly differ according the latent means. Finally comparison of the final MIQ-3 3-factor CTCU model with alternate 2-factor models revealed EVI, IVI, and KI are separately assessed by the MIQ-3. Concurrent validity of the MIQ-3 was also supported through the significant correlations of EVI, IVI, and KI ability measured by the MIQ-3 with EVI, IVI, and KI ability measured by the VMIQ-2.

Along with the VMIQ-2, validation of the MIQ-3 as an assessment of EVI, IVI, and KI means that researchers now have access to two valid and reliable measures that assess movement imagery ability. The MIQ-3 may be preferred over the VMIQ-2 when there is space to allow participants to physically perform the movements to be imaged as this approach can account for receny effects and provide greater control over how a movement is imaged. By comparison, the VMIQ-2 may be more appropriate when space is limited or participants are unable to physically perform the movements (Hall, 1998). Depending on the situation and the population to be screened, the most appropriate measure can be selected suggesting the MIQ-3 and VMIQ-2 are complimentary assessments of movement imagery ability.

Separately assessing each VI perspective provides a more comprehensive understanding of an individual's imagery ability and his/her capabilities of taking part in an upcoming intervention. For example, if the MIQ-R is used to screen for an IVI intervention, a researcher will not know how well the individual is specifically able to image from an IVI perspective. A visual MIQ-R score that exceeds the cut-off value may be a result of good EVI and may be misleading in how effective the intervention is likely to be. By separately assessing each VI perspective, the researcher will be more informed of whether individuals are able to sufficiently meet the criteria of the intervention, and take the more appropriate action. The MIQ-3 is also very beneficial in applied settings due to its separate assessment of VI perspectives. Research has demonstrated that imagery perspective ability and preferred imagery perspective, although related, are separate constructs (Callow & Roberts, 2010). Consequently it would appear logical for researchers, when designing an imagery intervention, to separately assess EVI and IVI and take these results into consideration in order to maximise the benefits of the intervention for the athlete. If a particular perspective is necessarily employed in an intervention, the MIQ-3 can also inform the practitioner whether they need to work with the athlete to improve their imagery ability to ensure they are able to experience the appropriate images required.

Due to its infancy, there are various other validation methods that future research should expose the MIQ-3 to. Although Study 2 directly compared the MIQ-3 subscales with those on the VMIQ-2 to establish its convergent validity, future research should investigate its predictive validity to ensure that similarly to the MIQ-R, it is able to predict things such as performance and psychological characteristics influential of performance such as anxiety and confidence (e.g., Monsuma & Overby, 2004; Vadocz, et al., 1997). Test-retest reliability of the questionnaire would also be a worthy investigation to ensure it is a reliable measure over time. Supportive findings would mean the MIQ-3 could be used to monitor any changes in imagery ability as a result of an imagery intervention or imagery training.

In conclusion, the present two studies more thoroughly validated the MIQ-R, and then modified it to provide a more comprehensive assessment of VI ability by separately assessing EVI and IVI, in addition to KI. Using MTMM CFA, support of a method effect existed for both the MIQ-R, and the modified MIQ-3. This was due to assessing each imagery trait with the same four movements. Results in Study 2 confirmed a 3-factor model in which EVI, IVI, and KI ability were all separate but related constructs. Future research should establish the MIQ-3's predictive validity to further validate the questionnaire as a comprehensive assessment of movement imagery ability.

Chapter 3

The Functional Equivalence Between Movement Imagery, Observation, and Execution Influences Imagery Ability

An edited version of this manuscript has been accepted for publication under the following reference:

Williams, S.E., Cumming, J. & Edwards, M.G. (in press). The functional equivalence between movement imagery, observation, and execution influences imagery ability. *Research Quarterly in Exercise and Sport.*

Abstract

Based on literature identifying movement imagery, observation, and execution to elicit similar areas of neural activity, research has demonstrated movement imagery and observation to successfully prime movement execution. To investigate whether movement and observation could prime ease of imaging from an external visual imagery perspective, an internal visual imagery perspective, and kinaesthetic modality, 36 participants (M_{age} = 20.58; *SD* = 3.11; 18 female, 18 male) completed the Movement Imagery Questionnaire-3 under four modes of delivery (movement prime, external observation prime, internal observation prime, and image-only). Results revealed ease of imaging was significantly greater during the movement and observation prime conditions compared to the image-only condition ($p < .05$). Specifically when priming external visual imagery and internal visual imagery, observation only facilitated ease of imaging when the perspective was congruent with the imagery perspective. Results support the utilization of movement and observation to facilitate ease of imaging, but highlight the importance of considering visual perspective when using observation.

The Functional Equivalence between Movement Imagery, Observation, and Execution Influences Imagery Ability

The effectiveness of imagery has led to its popular utilization in sport as a means to enhancing the execution of physical skills and consequently sporting success (for review see Cumming & Ramsey, 2009; Martin, Moritz, & Hall, 1999; Murphy, Nordin, & Cumming, 2008). Research suggests its impact can be influenced by an individual's capacity to create and control vivid images, with a number of studies demonstrating imagery to be more effective for individuals who display higher levels of imagery ability compared to their lower level counterparts (e.g., Hall, Buckolz, & Fishburne, 1992). Consequently, screening individuals for their ability to visually and kinaesthetically image has become a standard procedure in imagery intervention research, most commonly by using validated questionnaires (Cumming & Ramsey, 2009).

One of the most popular and well established questionnaires to assess imagery ability is the Movement Imagery Questionnaire-Revised (MIQ-R; Hall & Martin, 1997). It is considered a valid measure demonstrating good reliability when used in numerous settings (for review see Hall, 1998). Based on its predecessor, the Movement Imagery Questionnaire (MIQ; Hall & Pongrac, 1983), the MIQ-R is comprised of four movements (knee lift, jump, arm movement, and waist bend). Unlike other imagery ability questionnaires, the MIQ-R takes the unique approach of instructing participants to physically perform each movement before subsequently imaging the movement in either the visual or kinaesthetic modality. Prior physical performance of each movement eliminates any potential recency effects which may influence reported imagery ability (Lequerica, Rapport, Axelrod, Telmet, & Whitman, 2002). Prior movement also provides participants with a clear mental representation of the movement to be imaged, and reduces discrepancies in image content between the required and actual image. Participants performing the movement overtly thereby enables the researcher to verify, through observation, whether the participant understood the movement to be imaged. Therefore, resulting discrepancies in MIQ-R scores between individuals are more likely due to the ease with which the individuals are able to generate the images rather than being more/less familiar with performing the physical movement, or due to discrepancies in imagery content. However, research has yet to investigate the extent to which physical performance prior to imaging influences reported MIQ-R scores.

Findings from neurophysiological and behavioural brain imaging studies indicate that movement execution has the potential to influence imagery ability. Originating from research in monkeys, co-activation of neurons (termed “mirror neurons”) has been measured in the region of F5 pre-motor cortex and posterior parietal area PF during movement execution and observation (for review see Rizzolatti & Craighero, 2004). Using a variety of techniques including Functional Magnetic Resonance Imaging (fMRI), Transcranial Magnetic Stimulation (TMS) and Positron Emission Tomography, studies support the existence of a shared neuron system in humans for movement execution, observation and motor imagery (e.g., Buccino et al., 2001; Clark, Tremblay, & Ste-Marie, 2003; Decety, 1996; Ehrsson, Geyer, & Naito, 2003; Fadiga et al., 1999; Lotze et al., 1999). More importantly, the areas of co-activation during movement imagery and observation corresponded with specific areas of neuronal activity elicited during movement execution of the same tasks (Buccino et al., 2001; Ehrsson et al., 2003). That is, brain activity that is related to the imagery and observation of movement appears to be organized in a similar fashion to brain activity related to movement execution.

Within the sport psychology literature, the notion that motor imagery activates the same neural areas as those that become active during the planning and execution of actual movements has been more commonly referred to as *functional equivalence* (Decety, 1996). It is thought that this neuronal co-activation serves to facilitate the learning of skills through imitation (Jeannerod, 2001). Consequently, incorporating imagery prior to action execution enables an individual to prepare and plan for a movement by accessing and strengthening its mental representations (Murphy et al., 2008). Numerous studies have consistently demonstrated imagery's effectiveness as a prime to enhance the execution, and consequently outcome success, for a variety of different sport skills including golf putting (Short et al., 2002) and dart throwing (Nordin & Cumming, 2005a). If imagery primes movement execution due to the shared neuron system, this priming effect may also work in reverse (Holmes, Cumming, & Edwards, 2010). That is, prior movement execution might strengthen the mental representation and subsequently enhance an individual's ability to image that movement. When completing the MIQ-R, physical performance before imaging each movement might therefore serve to enhance ease of imaging the movement, reflected in higher imagery ability scores.

Using a similar argument, prior observation may also prime subsequent imagery due to shared cognitive-neural processes between movement imagery and observation (e.g., Clark et al., 2003). When an individual observes or images an action, the same regions of the brain are activated as when they physically perform the same task (Gallese & Goldman, 1998). Studies have shown that observation can facilitate subsequent movement, serving as a "prime" to action execution (e.g., Brass, Bekkering, & Prinz, 2001; Castiello, Lusher, Mari, Edwards, & Humphreys, 2002; Edwards, Humphreys, & Castiello, 2003). However, to our knowledge, research has not yet investigated whether observation can produce a similar priming effect to enhance ease of imaging as reflected in an assessment of imagery ability, or compared ease of imagery primed with observation to ease of imaging in the absence of observation. Lang (1979) has proposed that observation may facilitate the imagery process by providing the individual with a clear and vivid instruction of what they are required to image. Qualitative research by Nordin and Cumming (2005b) supports this claim with interviewed dancers describing observation as a method to obtain images used to subsequently facilitate performance. Similarly, Hars and Calmels (2007) revealed that gymnasts report observing others to enhance their imagery ability.

In addition to investigating the effects of prior observation on ease of imaging, another issue to examine is the congruency of observation and imagery perspectives. During visual imagery (VI), the movement can be viewed from different perspectives (Cumming & Ste-Marie, 2001; Hardy & Callow, 1999). An external imagery perspective is when, “a person views [himself or herself] from the perspective of an external observer (much like in home movies)” (Mahoney & Avener, 1977, p. 137), and is also referred to as a third person perspective. An internal imagery perspective is described as “an approximation of the real life phenomenology such that a person actually imagines being inside his/her body” (Mahoney & Avener, 1977, p. 137). From this first person perspective, individuals see the movements through their own eyes as if they were actually performing them. Individuals may prefer to image from one perspective more than another while others prefer switching between the two perspectives (Cumming & Ste-Marie, 2001; Ungerleider & Golding, 1991). Although it was originally believed that kinaesthetic imagery (KI) could only be experienced during internal imagery (Decety, 1996; Mahoney & Avener, 1977), leading to definitions confounding the two concepts, KI has also been associated with external imagery (Cumming & Ste-Marie, 2001; Hardy & Callow, 1999). To avoid confusion with whether researchers are including KI when discussing internal imagery, there has been a separation of external visual imagery (EVI), internal visual imagery (IVI), and KI, with “perspective” being the common term used when referring to the visual perspective adopted by an individual (i.e. first vs. third person perspective) rather than modality (i.e., visual or kinaesthetic; Hardy, 1997). Holmes and Collins (2001) suggest that both EVI and IVI potentially activate motor representations and strengthen the neural network responsible for movement execution.

Similarly to imagery, observation can be experienced from internal (first person) and external (third person) perspectives (e.g., Jackson, Meltzoff, & Decety, 2006). Although observation from an internal and external perspective both elicit similar patterns of neuronal activity to that of movement execution, this activation is greater in the contralateral hemisphere (i.e., opposite side of the body to the active limb) during internal observation and greater in the ipsilateral hemisphere (i.e., same side of the body as the active limb) during external observation (for a more detailed discussion, see Shmuelof & Zohary, 2008). Likewise, Ruby and Decety (2001) identified differences in neuron activation when imaging from a first person perspective compared to a third person perspective. More recently using TMS, differences in motor evoked potentials were found when performing motor imagery from an internal perspective compared to that from an external perspective (Fourkas, Avenanti, Urgesi, & Aglioti, 2006). These differences in brain activation between an internal and external perspective could influence the effectiveness of observation priming VI. Research has identified that a greater congruency between the observed action and the executed action can produce a stronger prime (e.g., Brass et al., 2001; Heyes, Bird, Johnson, & Haggard, 2005) suggesting a similar principle might apply when using observation to prime movement imagery. That is, observation will prime the subsequent image to a greater extent when the neuronal activation of the two processes is more closely matched (i.e., observed and imaged in the same perspective).

The aim of the present study was to investigate the effect of movement execution and observation primes on individuals' reported imagery ability, measured as ease of imaging using the MIQ-3 and compare this to imaging with no prime. A second aim was to investigate whether any effects on ease of VI, as a result of an observation prime, were more pronounced when the imagery and observation perspectives were congruent (i.e., matched). It was hypothesised that the movement execution and observation primes would lead to greater ease of imaging scores compared to imaging the movements with no prior movement or prior observation. For visual movement imagery, it was further hypothesised that observation in the perspective congruent to that used during the imagery would produce higher ease of imaging scores than observing from the incongruent perspective.

Method

Participants

Thirty six participants (18 females, 18 males) with a mean age of 20.58 years (*SD* = 3.11) representing a total of 11 different sports participated in the study. Participants had been involved in their chosen sport for between 1 and 16 years (*M* = 9.06; *SD* = 3.52), and competed at either a recreational (*n* = 8) or competitive club (*n* = 28) level. All individuals were classified as right hand dominant according to the Edinburgh Handedness Inventory (Oldfield, 1971).

Measures

Demographic information. Participants were asked to provide information about their age, gender, sport played, competitive level, and years of playing experience.

Visual imagery perspective assessment. Preferred imagery perspective was assessed with a single item asking participants to consider whether they generally view imaged movements through EVI or IVI. Responses were rated on a 7-point Likert-type scale, ranging from 1 (*completely internal*) to 7 (*completely external*).

Movement Imagery Questionnaire-3 (MIQ-3). The MIQ-R (Hall & Martin, 1997) is an 8-item questionnaire measuring individuals' ability to image four movements (knee lift, jump, arm movement, and waist bend) in visual and kinaesthetic modalities. For each item, participants read a description of the movement, physically perform the movement, and then image the movement using either VI or KI. Participants rate their ease of imaging on a 7-point Likert-type scale ranging from 1 *(very hard to see/feel)* to 7 *(very easy to see/feel)*, with a higher averaged score on a subscale representing a greater ease of imaging. Both subscales correlate highly ($r = .77$, $p < .001$) with its predecessor the MIQ (Hall & Pongrac, 1983), which is a reliable measure of assessing an individual's VI and KI ability (Hall, 1998).

Because the MIQ-R does not distinguish between EVI and IVI when assessing VI ability, the modified MIQ-3 was used as it assesses EVI, IVI, and KI ability. Each of the 4 movements were imaged three times resulting in a total of 12 items. The rating scale from the original MIQ-R was retained for the MIQ-3. Cronbach alpha coefficients, reflecting the internal reliability of all three subscales, are reported in Table 1. Throughout the delivery methods (movement prime, external observation prime, internal observation prime, and image-only), all three subscales displayed good internal reliability with alpha coefficients of .70 or above except for EVI during the movement prime delivery condition ($\alpha = .69$).

Post MIQ-3 evaluation. Following the external observation or internal observation prime conditions, participants completed a Post MIQ-3 Evaluation form to assess how similar to the model performing the movements in the video clips they perceived themselves to be. Ratings were made on a 7-point Likert-type scale ranging from 1 *(not at all similar)* to 7 *(very similar)*.

Observation Video Clips

All video clips for the internal observation and external observation prime conditions were digitally recorded using a Canon IXUS 50 camera. The four movements (knee lift, jump, arm movement, and waist bend) were performed by the model following the MIQ-3 instructions. The model was a 23 year old female who wore the same clothing for all video clips. Each movement was filmed from both perspectives and each clip was matched in terms of the visual and temporal characteristics to maximize the similarity between the two observation conditions. All MIQ-3 movements were performed in the same location ranging in duration from 3.11s for the jump to 10.22s for the waist bend.

When filming internal observation clips, the camera was securely fastened to the model's head at eye level so all internal video clips were recorded as if viewing the movement through the eyes of the model. All clips began from the viewpoint of the participant model looking straight ahead. The camera moved to fixate gaze on the knee and arm during the knee lift and arm movement respectively before returning to look straight ahead once each movement had finished. For the jump, the camera faced straight ahead and as a result, during the upward phase of the jump, the arms of the model came into view as they were extended and moved back down out of the shot during the landing phase of the movement. Finally, the waist bend again began looking straight ahead but with the model's arms raised and consequently at each side of the shot. During the waist bend, the camera view moved downwards and viewed the model's feet and then hands which came into view and touched the feet before rising back up again to the starting position of looking straight ahead.

All external observation video clips were recorded from an angle of 140 degrees at a distance of 3.90m from the model. The camera was placed on a tripod 96cm above the ground, the height of the model's navel. A 140 degree angle was used because action recognition research has shown viewing a movement from 180 degrees can produce greater ipsilateral hemisphere activation compared to when executing the movement (Shmuelof & Zohary, 2008). However, it has been suggested that the switch of viewing perspective occurs at 135 degrees (Waller & Hodgson, 2006; see also Burgess, 2006). Consequently, a 140 degree video clip maintained an external perspective viewpoint while reducing ipsilateral hemisphere activation.

Procedures

The study was first approved by the ethical committee at the university where the authors are based. Right handed participants were recruited from different sport clubs based at the university and the surrounding area of the UK.

At the beginning of the study, individuals were given an information letter and the nature of the study was explained by an investigator. Those who agreed to participate understood it was voluntary and signed a consent form. Next, participants were provided with White and Hardy's (1998) definition of mental imagery, along with Mahoney and Avener's (1977) and Hall's (2001) descriptions of internal and external imagery perspectives before completing the Visual Imagery Perspective Assessment.

To reduce order effects, participants were then randomly assigned to a counterbalanced order in which they completed the MIQ-3 under the different methods of delivery 5-10 days apart. The methods of delivery were: (1) movement prime (i.e., completing the adapted MIQ-3 in its original movement format physically performing each movement prior to imaging); (2) external observation prime (i.e., completing the adapted MIQ-3 observing a video of a model perform the movement from an external perspective prior to imaging); (3) internal observation prime (i.e., completing the adapted MIQ-3 observing a video of a model perform the movement from an internal perspective prior to imaging); and (4) image-only (i.e., completing the adapted MIQ-3 in the absence of a movement or observation prime with only the verbal description preceding the image).

Instructions for how to complete each item were delivered over four Microsoft Office PowerPoint slides shown to the participants on a Toshiba Tecra A2 laptop computer with a 12 inch screen. The first slide contained the written description of the movement, which participants were asked to read. The second slide instructed participants to either physically perform the movement (movement prime) or observe a video clip of the movement (observation primes). The second slide was not necessary for the image-only condition and was therefore not included. Instead, the presentation proceeded to the third slide. The third slide instructed participants to image the movement using EVI, IVI, or KI. Finally, the fourth slide instructed participants to rate ease of imaging the movement. Following either of the observation prime conditions, participants filled out a Post-MIQ-3 Evaluation Form once all 12 items were completed to rate their perceived similarity to the model. The same procedure was repeated for all four visits. At the end of the fourth visit, participants were debriefed on the nature of the experiment and thanked for their participation.

Results

Preliminary Analyses

Data screening and statistical analyses. All data were inspected for missing values and outliers based on the recommendations of Tabachnick and Fidell (2007). No mistakes, missing data or multivariate outliers were present. Repeated measures ANOVAs and repeated measures MANOVAs were used to analyze data for both the preliminary and main analyses. Pillai's Trace criterion was always reported as this is considered the most robust of significance tests (Olson, 1976). Equal variance of the between-subject factor variables were examined using Levene's test of Equality of Error Variances. All data complied with assumptions so no further action was taken. The equality of the within-subject factor variable was examined using Mauchly's test of Sphericity. In some instances the data violated this assumption of homogeneity of the variance-covariance matrices ($p < .05$). In these cases, the Greenhouse-Geisser correction was reported to reduce the degrees of freedom (Greenhouse & Geisser, 1959).

Preferred perspective. Previous research has demonstrated the clarity of an image to vary as a result of preferred VI perspective (Glisky, Williams, & Kihlstrom, 1996). Consequently preliminary analysis was performed to examine whether preferred perspective influenced reported MIQ-3 scores. A repeated measures MANOVA with preferred perspective as the between-subject factor revealed no significant differences in imagery ability (EVI, IVI, and KI) across the delivery methods.

Perceived model similarity. Studies have demonstrated the effect of observation to be to a greater extent when the model is more similarly matched to the observer (e.g., Gould & Weiss, 1981). Perceived model similarity was reasonably high across all individuals for both external (M = 5.42, SD = .84) and internal (M = 5.14, SD = 1.22) observation perspectives. A repeated measures ANOVA was carried out with gender as the between-subject factor to investigate whether the observation perspectives differed in how similar the model was perceived to be and whether these differences were due to the participant's gender. Results revealed no significant differences. The similarity of the model to males and females was confirmed by a repeated measures MANOVA on MIQ-3 scores with gender as the between-subject factor. Results also revealed no significant differences due to gender.

Main Analyses

The main analysis investigated whether MIQ-3 prime condition (i.e., mode of delivery; movement execution, external observation, internal observation and image-only) influenced imagery ability (i.e., EVI, IVI and KI MIQ-R scores). A 4 (MIQ-3 prime condition) x 3 (imagery type) MANOVA with repeated measures on the second factor was carried out. Results revealed a significant multivariate effect for condition, Pillai's trace = .53, F (9, 315) = 7.44, $p < .001$, $\eta^2 = .18$, observed power = 100%. The univariate analysis is reported for EVI, IVI and KI in the following sections.

EVI. Inspection at the univariate level revealed a significant effect for EVI, F(2.41, 84.47) = 7.77, $p < .001$, $\eta^2 = .18$. Post hoc analysis revealed that the external observation prime produced significantly higher MIQ-3 scores compared to the internal observation prime (p = .007, Cohen's d = .62) and image-only (p = .013, Cohen's d = .62) conditions. Moreover, the movement execution prime produced significantly higher MIQ-3 scores compared to the image-only condition (p = .016, Cohen's d = .47).

IVI. Inspection at the univariate level revealed a significant effect for IVI, $F(3, 105) = 10.17$, $p < .001$, $\eta^2 = .23$. Post hoc analysis revealed that the internal observation prime produced significantly higher MIQ-3 scores compared to the external observation prime ($p = .027$, Cohen's $d = .53$) and image-only conditions ($p < .001$, Cohen's $d = .82$). Additionally, the movement execution prime produced significantly higher MIQ-3 scores compared to the image-only condition ($p = .003$, Cohen's $d = .60$). If a Bonferroni adjustment is made to control for a possible type I error, the internal observation prime would no longer produce significantly greater MIQ-3 scores than the external observation prime due to the more conservative alpha level (p < .017).

KI. Inspection at the univariate level revealed a significant effect for KI, $F(3, 105) = 8.00$, $p < .001$, $\eta^2 = .19$. Post hoc analysis revealed that the movement execution ($p = .001$, Cohen's $d = .75$), external observation ($p = .019$, Cohen's $d = .48$) and internal observation ($p = .004$, Cohen's $d = .44$) prime conditions all produced significantly higher MIQ-3 scores compared to the image-only condition. A more conservative alpha level to prevent type I error results in external observation narrowly no longer produce significantly greater results than image-only. All MIQ-3 means and standard deviations for each imagery type across all delivery conditions are presented in Table 1.

Table 1.

Means, standard deviations, and internal reliabilities of MIQ-3 scores during the different methods of delivery

	MIQ-3 delivery conditions											
	Prior Movement			Prior External Observation			Prior Internal Observation			Image-Only		
	α	*M*	*SD*	α	*M*	*SD*	α	*M*	*SD*	α	*M*	*SD*
EVI	.69	5.17^{a*}	1.00	.77	$5.31^{a*\ b**}$	0.88	.89	4.65	1.22	.83	4.65	1.21
IVI	.73	5.28^{a**}	0.86	.85	5.01	0.99	.75	$5.50^{a***\ c*}$	0.86	.83	4.69	1.10
KI	.83	5.26^{a**}	1.13	.80	4.95^{a*}	1.10	.88	4.92^{a**}	1.14	.81	4.42	1.10

Note. ^{a} = significantly greater than image-only, ^{b} = significantly greater than prior internal observation, ^{c} = significantly greater than prior external observation. * = ($p < .05$), ** = ($p < .01$), *** = ($p < .001$)

Discussion

The primary aim of the study was to compare the effect of movement execution and observation primes on athletes' ease of imaging from an EVI perspective, IVI perspective, and KI modality compared to imaging with no prime. A second aim was to investigate whether any effects resulting from an observation prime on ease of VI, were greater when the imagery and observation perspectives were congruent (i.e., matched). Consequently the MIQ-R was modified from its original format to produce the MIQ-3 which assessed EVI, IVI and KI. Participants were asked to complete the MIQ-3 under a movement, external observation, and internal observation prime condition and an image-only condition. It was hypothesised that movement and observation would prime subsequent imagery and facilitate ease of imaging reflected in higher MIQ-3 scores compared to the image-only condition. With regards to the effect of observation priming EVI and IVI, it was hypothesised that this would be more effective when the perspective was congruent with that adopted during the imagery, compared to incongruent and image-only prime conditions.

Overall the findings were supportive of our hypotheses. Ease of imaging for all three types of imagery was significantly higher following prior movement execution compared to the image-only condition. This supports our prediction based on the neural co-activation found between movement execution and imagery, that movement execution can prime imagery ability/ease of imaging (Ehrsson et al., 2003; Fadiga et al., 1999; Lotze et al., 1999). Although there has been extensive research demonstrating that imagery can serve as a prime for subsequent movement (e.g., Nordin & Cumming, 2005a; Short et al., 2002), to our knowledge, the results of the present study are the first to provide evidence, reflected in MIQ-3 scores, that physically performing the movement to be imaged can be used to prime ease of imaging thereby facilitating an individual's imagery experience.

A similar result was found for observation. That is, both observation prime conditions facilitated ease of imaging producing significantly higher MIQ-3 scores compared to the image-only condition. Due to the neural co-activity during observation and movement execution (Buccino et al., 2001; Fadiga, Fogassi, Pavesi, & Rizzolatti, 1995), observation has been identified as a prime for movement thereby facilitating its execution (e.g., Brass et al., 2001; Castiello, et al., 2002; Edwards, et al., 2003). Results from this study reveal that observation can also serve as an appropriate prime to image generation by facilitating an individual's ease of imaging. More importantly however, this priming effect (represented by significantly higher MIQ-3 scores) only occurred for VI when the viewed observation clip was congruent with the VI perspective adopted by the individual (i.e., external observation primed EVI, and internal observation primed IVI). When observation and imagery perspectives were incongruent, the observation failed to prime ease of imaging with MIQ-3 scores not significantly differing from those reported during the image-only condition. Studies have previously identified that both imagery and observation from different visual perspectives can produce variations in areas of neural activation (e.g., Fourkas et al., 2006; Jackson et al., 2006; Ruby & Decety, 2001). Moreover priming effects have been identified as more pronounced when there is greater congruency between the prime and the outcome condition (e.g., Brass et al., 2001; Heyes, et al., 2005). Thus, it could be suggested that observing a movement from an incongruent perspective failed to prime ease of imaging due to less overlap in neuronal activation between the prime and the outcome. Unlike VI (i.e., EVI and IVI), observation from different perspectives appeared to have no bearing on reported kinaesthetic ease of imaging. Results did not significantly differ when comparing KI scores from the external observation and internal observation prime conditions. This supports research which postulates KI to be a separate construct from both EVI and IVI (Roberts, Callow, Hardy, Markland, & Bringer, 2008; Williams et al., 2011) as both the external observation and internal observation prime conditions produced significantly higher MIQ-3 scores compared to the image-only condition. Consequently, observation can also serve as a prime for KI. However, type 1 error may explain this finding because external observation no longer produces greater MIQ-3 scores for KI (p = .019), albeit by narrow margins, when a more conservative alpha level is used (p < .017).

When considering the MIQ-3 results of each type of imagery (i.e., EVI, IVI, and KI) within each prime condition it could be argued, based on visual inspection of the MIQ-3 scores, the congruent effect may only occur during the internal observation prime condition. That is because, within this prime condition, the MIQ-3 IVI score of 5.50 appears to be greater than MIQ-3 scores of 4.65 and 4.92 for EVI and KI respectively. In the other prime conditions, the MIQ-3 scores appear to be less discrepant. Due to VI and KI being separate but related constructs (Roberts et al., 2008; Williams et al., 2011), statistical violation prevents us from conducting an ANOVA to verify whether this difference in the internal observation prime condition is significant. We nevertheless offer this alternative explanation for interpreting the results of the study. Consequently, when the aim is to prime imagery in research, investigators may consider whether it is more beneficial to employ observation and imagery of a 1st person, or internal visual perspective. It is important to note, however, that this suggestion is merely through observing the data rather than the conclusion of statistical tests.

The study findings provide a number of implications to both the research and applied setting. With regards to imagery screening, unlike other questionnaires, the MIQ-R instructs participants to physically perform and then image each questionnaire item (movement execution prime condition). As the results demonstrate, absence of this movement execution (i.e., the image-only condition) will significantly impact upon an individual’s reported imagery ability leading to reduced MIQ-R scores. This would have implications on reported imagery ability in rehabilitative settings for individuals unable to physically perform all or some of the MIQ-R movements. For example, it might not be advisable for injured athletes with back or hamstring problems to perform the waist bend. Imagery has been suggested to be a beneficial technique for injured athletes to aid recovery (e.g., Cupal & Brewer, 2001; Ievleva & Orlick, 1991). Similarly, motor imagery has been suggested to be a cost effective method to facilitate in the recovery of movement loss following a brain lesion (e.g., Jackson, Lafleur, Malouin, Richards, & Doyon, 2001; Liu, Chan, Lee, & Hui-Chan, 2004; Malouin, Belleville, Richards, Desrosiers & Doyon, 2004). According to our findings, if individuals unable to physically perform movements were screened using the MIQ-R questionnaire, they would report significantly lower imagery ability scores compared to if they were able to physically perform each movement. The MIQ-RS (Gregg, Hall, & Butler, 2007) and Kinaesthetic and Visual Imagery Questionnaire (Malouin, et al., 2007) were developed as more suitable measures to use with individuals who have movement limitations. However, it is still likely that individuals with severe movement impairment would be incapable of physically performing the movements from these questionnaires. In these circumstances, our data point to an alternative method of MIQ-R completion without compromising ease of imaging scores. Researchers could replace the movement execution instructions with prior observation to maintain an accurate reflection of the participant's ease of imaging, which in turn, could be used to more accurately reflect the true imagery ability of the individual.

The results also have implications when working with athletes who are injury free. Mulder, Zijlstra, Zijlstra, and Hochstenbach (2004) previously demonstrated that imagery can sometimes be ineffective for improving performance of a totally novel movement. Consequently receiving a prime such as movement immediately prior to imaging is likely to improve the benefits of the imagery intervention.

The combined use of observation with imagery is an approach frequently used in applied settings, but with limited research evidence supporting potential benefits (Morris, Spittle, & Watt, 2005). Significantly higher MIQ-3 scores following prior observation compared to only imaging in the present study suggests that athletes should find imagery significantly easier following observation of the skill to be imaged. Adding observation could enhance potential effects of an imagery intervention as numerous studies have identified imagery to be more effective for individuals who display higher levels of imagery ability compared to their lower level counterparts (Goss, Hall, Buckolz, & Fishburne, 1986; Hall et al., 1992). However, the perspective of the observation clip appears very important in determining whether it will successfully prime ease of imagery. An important finding of the study is that an observation clip incongruent with the athlete's VI perspective produces similar MIQ-3 scores to those found by merely imaging the movement with no prior observation (or prior movement). If the primary reason for using video clips is to facilitate an individual's ease of imaging, the perspective of the video clip should match the perspective adopted by the athlete during the intervention.

Prime conditions movement execution and observation provide support for enhancing the functional equivalence between the image and the actual performance, and in particular, support the physical and environmental elements of the PETTLEP model (Holmes & Collins, 2001; Physical, Environment, Task, Timing, Learning, Emotion, Perspective). The physical component encourages athletes to become actively involved in the imagery process by performing movements or holding the correct equipment involved during the skill to maximize and strengthen the amount of co-activation between the image and the actual movement (Holmes & Collins, 2001). Gould and Damarjian (1996) have previously suggested that dynamic KI can help athletes more clearly recall sensations associated with performance. Our findings support this point and extend movement execution's benefits to

VI, which was also facilitated. The environment element suggests incorporating relevant characteristics from the environment by viewing video clips and photos resulting in a more effective access to the motor representation of the movement being imaged (Holmes & Collins, 2001). Evidence from the present study suggests that more functionally equivalent imagery is easier to perform.

As with all research, this study is not without its limitations. By adapting the MIQ-R for the current study to separate EVI from IVI, we address the criticism it has received from Roberts et al. (2008) for its inability to distinguish between VI perspectives. This is an important contribution to the measurement of movement imagery ability. Our results indicate good internal reliability for the three separate constructs, and we are currently undertaking further research to validate this 12-item MIQ-3 on a larger sample.

Secondly, findings are only with regards to movement imagery ability. Research has demonstrated that as well as improved skill execution, athletes use imagery to effectively achieve various cognitive and motivational specific and general outcomes such as to regulate stress and anxiety, and modify cognitions (see Hall et al., 1998; Paivio, 1985; Callow, Hardy, & Hall, 2001; Hanton and Jones, 1999a; Jones, Mace, Bray, MacRae & Stockbridge, 2002). Observational learning is also used by athletes for cognitive and motivational purposes (Cumming, Clark, Ste-Marie, McCullugh, & Hall, 2005). Therefore it would be interesting to investigate the relationship between observation and imagery ability of varying imagery content. However, as of yet there is no valid and reliable questionnaire which provides a measure of imagery ability for both cognitive and motivational imagery content. The development of such a measure is needed before any further investigation can take place.

A second consideration is that ease of imaging is reflected by self reported questionnaire scores. Although participant ratings are considered the most popular method used to assess imagery ability, response bias may occur based on criteria participants use to rate their imagery (Richardson, 1977). Despite this criticism, numerous studies have supported the use of questionnaires by correlating self-reported ratings of imagery ability to more objective measures (e.g., Cremades & Pease, 2007; Cui, Jeter, Yang, Montague, & Eagleman, 2007). Future research could be conducted to investigate the inclusion of more objective forms of imagery including chronometric assessment and neuroimaging techniques such as fMRI (e.g., Guillot et al., 2008).

The majority of participants recruited in this study demonstrated an above average VI and KI ability as reflected in their MIQ-3 scores across the delivery conditions. Future research should investigate whether different delivery methods have a similar impact on MIQ-3 scores for individuals who display more extreme imagery ability values (e.g., those who find it very hard to see/feel compared to very easy to see/feel). Although our study revealed no differences when comparing preferred imagery perspective, our participants were generally able to image from both visual perspectives demonstrating fairly good imagery ability for EVI and IVI. It would be interesting to see whether similar effects for VI are apparent for individuals who excel or are unable to image from one particular visual perspective. Additionally, it would be relevant to examine at what point, if any, maintaining the preferred perspective becomes a stronger predictor of ease of imaging than the congruency between the observation and imagery perspective.

Numerous studies have suggested that greater imagery ability will lead to more effective imagery in achieving desired outcomes (Goss et al. 1986; Hall et al., 1992). Our findings suggest that both movement execution and observation primes can be used to enhance ease of imaging. Consequently, it is essential that future research compares the effects of movement execution and observation primes on ease of imaging to determine whether these enhancements lead to greater performance outcomes. Investigation should include the congruency/incongruency of imagery and observation perspectives to see whether performance outcomes are similar to those reflected in visual ease of imaging scores. That is, performance would be more greatly enhanced if the imagery perspective adopted by the athletes is congruent with that of the video clips observed by the athlete.

In conclusion, past research suggests that imagery can produce more effective intervention results for individuals who display higher levels of imagery ability. Results of the present study reveal movement execution and observation experienced prior to imaging can facilitate an individual's ease of imaging. Movement execution primes appeared to have no additional enhancements in ease of imaging to that provided by observation. However with regards to VI, this was only the case when the observation was congruent with the VI perspective adopted by the athlete. Observation from an incongruent perspective to that of the imagery failed to facilitate ease of imaging. Findings therefore suggest that using such methods prior to imaging could enhance the effectiveness of an imagery intervention by means of enhancing an individual's imagery ability. However, with regards to observation enhancing ease of imaging VI, this may only be the case when the imagery and observation perspective are congruent.

Chapter 4

Measuring Athlete Imagery Ability: The Sport Imagery Ability Questionnaire

This chapter has been accepted for publication under the following reference:

Williams, S.E., & Cumming, J. (in press). Measuring athlete imagery ability: The Sport Imagery Ability Questionnaire. *Journal of Sport and Exercise Psychology*.

Abstract

This research aimed to develop and provide initial validation of the Sport Imagery Ability Questionnaire (SIAQ). The SIAQ assesses athletes' ease of imaging different types of imagery content. Following an extensive pilot study, 375 athletes completed a 20-item SIAQ in Study 1. Exploratory factor analysis revealed a 4-factor model assessing skill, strategy, goal, and affect imagery ability. Confirmatory factor analysis (CFA) established this 4-factor structure in Study 2 (N = 363 athletes). In Study 3 (N = 438 athletes), additional items were added to create a fifth mastery imagery subscale that was confirmed through CFA. Study 4 (N = 220 athletes) compared the SIAQ to the Movement Imagery Questionnaire-3. Significant bivariate correlations ($p < .05$) confirmed the SIAQ's concurrent validity but demonstrated differences in imagery ability of different content. Overall, the SIAQ demonstrates good factorial validity, internal and temporal reliability, invariance across gender, and an ability to distinguish between athletes of different competitive levels. Findings highlight the importance of separately assessing imagery ability of different content.

Measuring Athlete Imagery Ability: The Sport Imagery Ability Questionnaire

Imagery is a popular and well established strategy used to improve performance (for reviews see Cumming & Ramsey, 2009; Murphy, Nordin, & Cumming, 2008). Its effect however, is influenced by an individual's capacity to create and control vivid images (Martin, Moritz, & Hall, 1999). The effectiveness of an imagery intervention increases for those reporting a higher ability to image (Hall, Buckolz, & Fishburne, 1992). For example, Robin et al. (2007) demonstrated that individuals with higher imagery ability experienced greater improvement in the accuracy of their tennis serve return compared to poorer imagers. Additionally, Martin et al. (1999) hypothesized imagery ability would moderate the relationship between imagery use and its intended outcome – a proposal that has received support (Goss, Hall, Buckolz, & Fishburne, 1986; Cumming, 2008).

Kosslyn (1994) explains that imaging involves the generation/formation, maintenance, and transformation of images, with an individual's imagery ability likely capturing their proficiency in performing each of these processes. Ease of imaging is a characteristic thought to reflect these processes, and as such, is commonly referred to when discussing and wanting to assess imagery ability (e.g., Hall & Martin, 1997; Gregg & Hall, 2006). Vividness is another characteristic indicative of these processes (Kosslyn, 1994). Roberts, Callow, Hardy, Markland, and Bringer (2008) describe image formation as occurring through the activation of working memory, and images displayed from working memory are represented by its vividness (see Baddeley & Andrade, 2000). Imagery ability can be therefore reflected by any number of characteristics that represent an individual's capacity to form, maintain and transform images, including ease and/or vividness.

It has become commonplace for researchers to measure participants' imagery ability as an inclusion criteria for experiments and field-based interventions (Cumming & Ramsey, 2009). Athletes displaying poor imagery ability are excluded from studies or provided with training exercises to aid their image generation (e.g., Cumming, Olphin, & Law, 2007). Although termed “ability”, imagery can be developed through investment of time and effort (Hall, 2001). For this reason, researchers also monitor changes in athletes’ imagery ability over the course of an intervention (e.g., Cumming & Ste-Marie, 2001; Rodgers, Hall, & Buckolz, 1991).

Due to these many uses, it is necessary for researchers to have valid and reliable means to assess imagery ability. Self-report questionnaires are the most regularly used method, with the revised versions of the Movement Imagery Questionnaire (MIQ-R; Hall & Martin, 1997) and the Vividness of Movement Imagery Questionnaire (VMIQ-2; Roberts et al., 2008) being the two current popular choices. The MIQ-R and VMIQ-2 are fairly quick and easy to administer, and both instruments display good psychometric properties. They also share the similarity of assessing an individual’s ability to image specific movements (e.g., knee lift) and actions (e.g., jumping off a high wall).

The extant literature indicates that movement imagery ability questionnaires are often used beyond their intended purpose. For example, Ramsey, Cumming, Edwards, Williams, and Brunning (2010) screened participants using the MIQ-R. However, their intervention involved sport-specific images (kicking a soccer ball from the penalty spot), stimulus information about the environment (e.g., the goal keeper, the net), and physical and emotional responses to the situation (e.g., butterflies in the stomach, feeling confident). Although the MIQ-R has proven valuable for controlling individual differences in imagery interventions involving motor skill acquisition (Hall, 1998), it does not likely fully capture the imagery ability needed by participants in Ramsey et al.’s intervention as well as the many sport imagery interventions conducted in research and applied settings (e.g., Callow & Waters, 2005; Cumming & Ste-Marie, 2001). Hall (1998) explained this problem by saying, “Just because athletes might be able to easily and vividly imagine themselves performing a skill (e.g., "throwing a ball"), does not mean they can just as easily and vividly imagine receiving a medal or being in control of difficult situations" (p. 171). He suggested the need for developing a new instrument to more comprehensively measure athletes' ability to generate images of their sport experiences.

It is well documented that athletes use imagery for other purposes such as to modify cognitions and regulate arousal and anxiety (Martin et al., 1999). These reasons are classed as serving a motivational general (MG; i.e., images of arousal and cognition) function for athletes (Paivio, 1985). The learning and enhancement of movement performance, on the other hand, is categorized as a cognitive specific (CS; i.e., images of skills) function. Other functions are cognitive general (CG; i.e., images of strategies, game plans, and routines) and motivational specific (MS; i.e., images of process, performance, and outcome goals). Hall, Mack, Paivio, and Hausenblas (1998) further subdivided the MG function into motivational general-arousal imagery (MG-A; i.e., images of affect, mood, and emotions) and motivational general-mastery imagery (MG-M; i.e., images of mastery cognitions). Athletes report using imagery for all five of these functions, with motivational imagery the most frequently reported (Cumming & Hall, 2002a; Hall et al., 1998).

The imagery functions are thought to elicit different types of imagery content following the principle outlined by Martin et al. (1999) of "what you see, really is what you get" (p. 260). For example, athletes intending to improve performance of a specific skill will image themselves executing this skill. However, Murphy et al. (2008) and others (e.g., Cumming & Ramsey, 2009; Callow & Hardy, 2001) argue that these concepts are not identical and there is a need to separate function (i.e., why athletes image) from content (i.e., what athletes image). This is because research has demonstrated that images can serve multiple functions for athletes (Nordin & Cumming, 2008; Short, Monsma, & Short, 2004). For example, two hurdlers may image performing the correct hurdling technique, but one may use this image to improve their hurdling performance (CS function) while the same content may be used to improve the other's confidence at hurdling (MG-M function).

With regards to imagery ability, the focus is on measuring the individual's ability to generate imagery content, not why they are imaging this content. However, a gap currently exists between the imagery content commonly reported by athletes and how their ability to generate this content is typically assessed (Hall, 1998). As stated by Paivio (1985), "[t]here is no single best measure [when assessing imagery ability] and the trick is to find [a method] that is most directly related to the specific task under consideration" (p. 27S). For example, Cumming and Ste-Marie's (2001) five-week cognitive and motivational imagery intervention led to significant improvements in participants' ability to image skate specific images. However, these changes did not generalize to increased MIQ-R scores, which remained the same as baseline. This finding reinforces the need for an imagery ability measure of sport related content that can be used to more accurately screen participants, thus more effectively controlling for individual differences, as well as detecting improvements. To our knowledge, the literature currently lacks a valid and reliable measure to assess athletes' ability to image content reflecting the five imagery functions (i.e., CS, CG, MS, MG-A, and MG-M imagery).

In recent years, Gregg and Hall (2006) have made progress towards filling this gap by developing the Motivational Imagery Ability Measure for Sport (MIAMS). The MIAMS assesses participants' ease and level of emotion experienced following the generation of eight motivational general images (i.e., four MG-A and four MG-M images). Although the authors have provided evidence to support the validity and reliability of the questionnaire, the MIAMS is limited to the assessment of motivational general imagery only, to the exclusion of MS imagery and both forms of cognitive imagery.

To overcome these issues, the aim of the present investigation was to develop a valid, reliable, and comprehensive assessment of athletes' imagery ability called the Sport Imagery

Ability Questionnaire (SIAQ). The SIAQ was designed to differ from existing questionnaires by (1) assessing sport-specific images rather than the generic movements/actions, and (2) simultaneously measuring cognitive and motivational imagery ability to allow for direct comparisons of different imagery content.

Pilot Study

An extensive pilot study was carried out to identify a suitable pool of items and rating scale to use in the development of the SIAQ. It has been suggested that image formation, transformation, and maintenance can be assessed in terms of ease (e.g., MIQ-R) and vividness (e.g., VMIQ-2; see Roberts et al., 2008). Consequently, both ease and vividness ratings were included to determine whether these would appropriately measure sport imagery ability.

Method

Instrument development. The initial items were drawn from the Sport Imagery Questionnaire (SIQ; Hall et al., 1998), which assesses the frequency of athletes' imagery. Each of the SIQ's 30 items represents one of the five imagery functions: (1) CS (e.g., "When learning a new skill, I imagine performing it perfectly"), (2) CG (e.g., "I imagine entire plays/programs/sections just the way I want them to happen in an event/game), (3) MS (e.g., "I image others applauding my performance"), (4) MG-A (e.g., "I image the stress and anxiety associated with my sport"), and (5) MG-M (e.g., "I imagine myself appearing self-confident in front of my opponents"). Because the SIAQ is intended to assess imagery content rather than function, item wording was modified to remove reference to the reasons why athletes image. For example, the SIQ item *"I imagine myself handling the arousal and excitement associated with my sport"* was changed to *"the anticipation and excitement associated with my sport"*. All SIAQ items stemmed from *"I image…"*. In total, 35 items designed to assess five types of imagery content were distributed to participants, including items tapping imagery that was cognitive specific and general in nature (i.e., images associated with performing various skills, and performing strategies, routines, and game plans). The remaining items reflected motivational specific and general imagery, including images concerned with achieving goals and outcomes (MS imagery), experiencing the feelings and emotions associated with performance (MG-A imagery), and thoughts associated with persistence and performing well in the face of adversity (MG-M imagery). Content validity was assessed by five sport psychology research experts, who have experience designing questionnaires, and five athletes. All researchers and athletes systematically examined the wording and content of items, and rated the extent they believed each item matched its intended subscale description. Ratings were made on a 7-point Liket type scale ranging from 1 (*poor match*) to 6 (*excellent match*). From these ratings, the Content Validity Index (CVI; Lynn, 1986) was calculated for each item by dividing the number of athletes and researchers who rated the item as a good match, very good match, or excellent match to a subscale, by the total number of athletes and researchers taking part in the rating exercise (i.e., 10). Only nine items were below the .80 criteria believed to be indicative of a valid item (Lynn, 1986). These potentially problematic items were revised as per suggestions made by the raters and were included in the pilot test. All other items had a CVI ranging between .80 (8/10) and 1 (10/10), and were therefore retained. During the pilot test, athletes were asked to first image each item, then rate both the ease they could image the scenario described and its vividness. Ratings were made on a 7-point Likert type scale ranging from 1 (*ease: very hard to image, vividness: no image at all, just thinking about it*) to *7* (ease: *very easy to image, vividness: perfectly clear & vivid as normal vision or feeling*).

Demographic Information. Participants provided information regarding their age, gender, type of sport (i.e., team or individual), sport played, competitive level and years of playing experience.

Participants. For participant details see Table 1.

Table 1

Participant characteristics for Pilot study, Study 1, Study 2, Study 3, and Study 4.

		Pilot Study	Study 1	Study 2	Study 3	Study 4
N		403	375	363	438	220
Male		198	179	175	207	86
Female		205	196	188	231	134
*M*age (SD)		20.16 (3.44)	24.73 (8.84)	24.79 (9.31)	21.55 (6.91)	19.50 (0.99)
Number of sports		33	31	33	38	30
Sport type	Team	249	272	217	259	127
	Individual	154	103	146	179	93
Competitive Level	Recreational	48	54	44	66	40
	Club	246	220	236	205	130
	Regional	88	87	72	94	31
	Elite	21	14	11	73	19
Experience (SD)		8.66 (4.36)	10.96 (8.51)	10.93 (8.21)	9.06 (5.85)	8.23 (3.82)

Note: All reported values represent the number of participants with the exception of mean age and experience that are reported in years.

Procedure. Following ethical approval, a heterogeneous sample of participants was recruited from UK sports clubs. Individuals were contacted directly by an investigator who provided them with an information sheet and explained the nature of the study. Those agreeing to participate understood it was voluntary and signed a written consent form. Next, participants completed the SIAQ and provided their demographic information in a quiet environment, usually before or after a typical training session. Participants were asked to complete the questionnaire as honestly as possible and not to confer with any other athletes. Once finished, all completed materials were returned to the investigators.

Results and Discussion

Factor analysis considers an underlying structure caused by the latent variables (Costello & Osborne, 2005). Because Paivio's framework (1985; Hall et al., 1998) and the SIQ provided this structure for the SIAQ, principle axis factoring with oblimin rotation was carried out on the data to reduce the 35 SIAQ items to a number of meaningful factors (Tabachnick & Fidell, 2007). A large number of these items met the criterion level of .30 or above on a non intended subscale and were therefore considered to cross load onto other factors. The most problematic items were discarded and the 20 items appearing most likely to load on a single factor underwent wording alterations and further development for Study 1.

Very high correlations between ease of imaging and vividness for each item ranged from .74- .88 suggesting that although ease of imaging and vividness are conceptually separate constructs, participants were unable to distinguish between the two in the pilot study. This was further confirmed by the numerous questionnaires in which participants mirrored their responses for ease of imaging and vividness by simply selecting the same rating for vividness as they did for ease. We decided to remove the vividness rating and retain ease of imaging for two reasons. Firstly, this dimension has been used extensively in other questionnaires (e.g., MIQ-R, MIAMS), and has been shown to influence the effectiveness of imagery interventions (e.g., Robin et al., 2007), and moderate the relationship between imagery use and a range of outcomes (e.g., Goss et al., 1986; Cumming, 2008). Secondly, some athletes voiced difficulties in comprehending what was meant by the vividness of an image. For Study 1, the questionnaire stem was modified from *"I image…"* to *"In relation to my sport, how easy is it for me to image…"* because the stem "I image…" no longer made sense for all items. *"In relation to my sport"* was added to the beginning of the stem to reduce the length of instructions for athletes to read, and *"how easy is it for me to image"* was included to reflect the rating scale.

Study 1

The purpose of Study 1 was to examine the factor structure of the 20 item SIAQ identified in the pilot study.

Method

Participants

For participant details see Table 1.

Measures

Sport Imagery Ability Questionnaire. The 20-item SIAQ retained from the pilot study was used with the same ease of imaging scale *(1 = very hard to image, 2 = hard to image, 3 = somewhat hard to image, 4 = neutral (not easy or hard), 5 = somewhat easy to image, 6 = easy to image, 7 = very easy to image).*

Demographic Information. The measures were identical to the pilot study.

Procedures

The procedures were identical to the pilot study.

Results and Discussion

Data Screening and item characteristics

A list of all 20 items along with their means, standard deviations, skewness and kurtosis values are reported in Table 2. Means ranged from 3.93 to 5.80. Response variability was deemed satisfactory as examination of each item's standard deviation revealed values greater than 1.00, a method previously employed during the initial stages of developing other questionnaires (Cumming, Clark, Ste-Marie, McCullagh, & Hall, 2005; Hall et al., 1998). Item skewness and kurtosis values were distributed within the tolerance levels of normality assumptions.

Table 2.

SIAQ items distributed in Study 1, and mean, standard deviation, skewness and kurtosis values.

Item	Mean	SD	Skewness	Kurtosis
1. Making up plans/strategies in my head	**4.76**	**1.36**	**-0.56**	**-0.42**
2. Giving 100% effort even when things are not going well	5.24	1.36	-0.59	-0.33
3. Refining a particular skill	**4.87**	**1.27**	**-0.44**	**-0.46**
4. The positive emotions I feel while doing my sport	**5.80**	**1.16**	**-0.95**	**0.39**
5. Alternative plans/strategies	**4.50**	**1.28**	**-0.25**	**-0.34**
6. Other athletes congratulating me on a good performance	5.25	1.27	-0.55	-0.21
7. Being mentally tough	5.08	1.27	-0.48	-0.24
8. The anticipation and excitement associated with my sport	**5.69**	**1.09**	**-0.85**	**0.63**
9. Improving a particular skill	**4.94**	**1.22**	**-0.25**	**-0.50**
10. Myself winning a medal	**4.92**	**1.61**	**-0.56**	**-0.39**
11. Each section of an even/game plan (e.g., offense vs. defence, fast vs. slow)	4.83	1.35	-0.33	-0.29
12. The excitement associated with performing	**5.76**	**1.05**	**-0.91**	**0.90**
13. Remaining focussed during a challenging situation	5.20	1.16	-0.59	0.38
14. Making corrections to physical skills	**4.62**	**1.29**	**-0.18**	**-0.55**
15. Being interviewed as a champion	**3.93**	**1.82**	**0.04**	**-0.72**
16. The feelings that lead to a good performance	5.12	1.33	-0.73	0.11
17. Performing a skill well	5.44	1.12	-0.77	0.74
18. Remaining positive after a mistake	4.45	1.37	-0.15	-0.50
19. Myself winning	**5.43**	**1.29**	**-0.11**	**0.42**
20. Creating a new event/game plan	**4.53**	**1.26**	**-0.24**	**-0.46**

Note: Boldface indicates items that were retained

Table 3.

SIAQ items and factor loadings for a four-factor solution (Study 1).

Item	Strategy Images	Goal Images	Affect Images	Skill Images
Alternative plans/strategies	0.752			
Making up plans/strategies in my head	0.686			
Creating a new event/game plan	0.682			
Being interviewed as a champion		0.827		
Myself winning a medal		0.800		
Myself winning		0.606		
The excitement associated with performing			0.876	
The anticipation and excitement associated with my sport			0.740	
The positive emotions I feel while doing my sport			0.556	
Refining a particular skill				0.793
Improving a particular skill				0.780
Making corrections to physical skills				0.514

Principle axis factoring

Principle axis factoring with oblimin rotation identified five factors with eigenvalues ranging from 1.15 to 6.37, together accounting for 61.09% of the variance. However 2 items failed to load onto any factor and 1 cross loaded highly on more than one factor. These were dropped in subsequent iterations of the analysis. In runs two to four, an additional five items were systematically dropped due to either loading below the criterion, failing to load on any factor, or loading on more than one factor. The remaining twelve items were entered in the fifth run. This final solution resulted in 4 factors/subscales with 3 items per factor. Eigenvalues ranged from 1.13 to 4.05, together accounting for 69.63% of the variance. These four imagery subscales were named skill imagery, strategy imagery, goal imagery, and affect imagery. The final 12 items and their factor loadings are reported in Table 3.

Internal consistency and bivariate correlations

Due to the limitations associated with Cronbach's alpha (see Bentler, 2009; Sijtsma, 2009), internal reliability was assessed using Composite Reliability (CR) and Average Variance Extracted (AVE). The criterion level was set at the values of .70 and .50 respectively (Hair, Anderson, Tatham, & Black, 1998). All subscales demonstrated adequate CR: skill imagery = .74, strategy imagery = .75, goal imagery = .79, and affect imagery = .78, and AVE: skill imagery = .50, strategy imagery = .50, goal imagery = .57, and affect imagery = .55. Bivariate correlations revealed significant small to moderate relationships between the subscales, with values ranging from 0.24 to 0.45 ($p < .001$). The size of these relationships indicates that the subscales of the SIAQ are measuring related but distinct constructs.

The results of Study 1 indicate the SIAQ measures imagery ability of four types of imagery content. These subscales map onto Paivio's (1985) framework, with two subscales reflecting cognitive imagery (skills and strategies), and two tapping motivational imagery (goals and affect). Despite the similarities between the SIQ and the SIAQ, the crucial difference is that the SIQ focuses on *how frequently* athletes image whereas the SIAQ concerns itself with how well athletes can generate images of different content. A further distinction is the lack of a mastery imagery subscale on the SIAQ to tap MG-M content. Images of being confident and in control cross loaded on different subscales, and were removed from the final solution.

Study 2

After establishing the SIAQ's four-factor structure in Study 1, the purpose of Study 2 was to use confirmatory factor analysis (CFA) to validate these findings with a new sample. Imagery modality was also considered to determine whether athletes' ratings represented their ease of seeing, ease of feeling, or a combination of the two. Athletes report experiencing kinaesthetic imagery (KI) in conjunction with visual imagery (VI; Glisky, Williams, & Kihlstrom, 1996), and research suggests imaged feelings can include physiological responses, emotions, rhythm and timing, weight, and spatial awareness (Callow & Waters, 2005; Nordin & Cumming, 2005b). Consequently we predicted, based on the content of SIAQ items, ease of imaging ratings would reflect an image generated with both VI and KI.

Method

Participants

For participant details see Table 1.

Measures

Demographic Information. The measures were identical to the pilot study and Study 1.

Sport Imagery Ability Questionnaire (SIAQ). The final 12 items from Study 1 were retained for Study 2 and rated with the same ease of imaging scale.

See-feel ratings. A subsample of 132 participants also rated the extent their generated images were composed of being able to see and feel the scenario. These ratings were made on a 7-point Likert type scale ranging from 1 *(completely see, no feel)* to 7 *(completely feel, no see)*. Mean scores were calculated by averaging the items representing each subscale to examine modality composition by imagery type.

Procedures

The procedures were identical to the pilot study and Study 1.

Results and Discussion

Data Screening and item characteristics

All item skewness and kurtosis values were distributed within the tolerance levels of normality assumptions. A total of 23 missing data cases were deleted from the data set resulting in a final sample of 340 (n = 156 males, n = 184 females).

Confirmatory Factor Analysis (CFA)

Data was analyzed via structural equation modelling (SEM) with maximum likelihood estimations using the computer package AMOS 16.0 (Arbuckle, 1999)[1]. Based on the significant correlations between subscales in Study 1, a model in which subscales were allowed to correlate (i.e., correlated trait model) was created. The model's overall goodness of fit was tested using the chi-squared likelihood ratio statistic (χ^2) with a larger value indicating a poorer fit (Jöreskog & Sörbom, 1993).

Although a non-significant χ^2 value represents a good model fit, this is very rarely obtained in practice (MacCallum, 2003). Consequently, based on Hu and Bentler's (1999) recommendations, two types of additional fit indices are reported, the standardized root mean square residual (SRMR; Bentler, 1995) and a supplementary incremental fit index (e.g., Tucker Lewis Index, Comparative Fit Index, or Root Mean Square Error of Approximation). The SRMR, used to calculate the average difference between the sample variances and

[1] A covariance matrix was factor analyzed. However the Likert-scaled items were also treated as ordinal data at the request of an anonymous reviewer and the CFA solutions in Studies 2, 3, and 4 were also analyzed using polychoric correlations. Comparison of the factor loadings for the model when the data was treated as ordinal and interval were very similar (mean difference: Study 2 = 0.007, Study 3 = 0.005, Study 4 = 0.01). As such, in line with the majority of published psychometric papers, we treated the data as interval throughout the chapter.

covariances and the estimated population variances and covariance, is a measure of absolute fit index (Tabachnick & Fidell, 2007). An adequate fit is indicated by a value close to 0.08 (Hu & Bentler, 1999). The Comparative Fit Index (CFI; Bentler, 1990) and the Tucker Lewis Index (TLI; Bollen, 1989) compare the estimated model to an independence model using different approaches (Jöreskog & Sörbom, 1993). For both fit indices, a cut-off value of close to 0.95 has been suggested to indicate an adequate fit (Hu & Bentler, 1999). Finally, an assessment of how well the model approximates the data is calculated by the Root Mean Square Error of Approximation (RMSEA; Steiger, 1990). The RMSEA determines the model's estimated lack of fit to a population covariance matrix expressed as the discrepancy per degree of freedom (Browne & Cudeck, 1993). A cut-off value close to 0.06 indicates an adequate fit (Hu & Bentler, 1999). Finally standardized factor loadings, standardized residuals, and modification indices were examined to investigate any model misspecification. It is important to note there is some debate in the literature with regards to how appropriate the values indicative of adequate model fit are (see Markland, 2007; Marsh, Hau, & Wen, 2004). For this reason, caution is advised when interpreting results. Despite this issue, these criteria are still the most commonly reported as indications of an adequate model fit.

Inspection of Mardia's coefficient (Mardia, 1970) revealed data did not display multivariate normality (Mardia's multivariate kurtosis = 19.37; normalized estimate = 9.74). Consequently the bootstrapping technique was employed. This method enables the creation of multiple subsamples from the original data and then parameter distributions examined relative to each of these samples (Byrne, 2010).

The 4-factor model identified in Study 1 demonstrated an adequate fit to the data in Study 2, χ^2 (48) = 96.19, $p < .05$, CFI = .96, TLI = .95, SRMR = .05, RMSEA = .05 (90% CI = 0.04 - 0.07). Inspection of the standardized factor loadings (ranging from 0.58 to 0.86), modification indices, and standardized residuals revealed all values were within acceptable limits and no offending estimates existed (Hair et al., 1998). Consequently each item meaningfully contributed to its intended subscale.

Internal Consistency and Interfactor Correlations

Adequate internal reliability was demonstrated for all 4 subscales with CR values ranging from .76 to .80 and AVE values ranged from .52 to .58. Interfactor correlations revealed significant correlations ranging from .12 to .45 ($p < .001$).

See and Feel

Mean scores for modality composition of ease ratings were 3.63 (*SD* = 1.08) for skill imagery, 3.48 (*SD* = 1.02) for strategy imagery, 3.59 (*SD* = 1.04) for goal imagery, and 5.15 (*SD* = 0.86) for affect imagery. Values demonstrate that when athletes image SIAQ items, these are composed of both being able to see and feel the scenario. A repeated measures ANOVA revealed that compared to the other types of imagery, affect images were composed significantly more of being able to feel the image, $F(3, 393) = 87.87$, $p < .001$, $\eta^2 = .40$, observed power = 100%. This is likely due to affect imagery items referring to feelings and emotions associated with sport. As such, it is likely that when participants image this type of content, the image is expressed to a greater extent in terms of being able to experience these feelings within the image compared to seeing it. Despite this difference, results demonstrate "ease of imaging" is reflective of an athlete's capacity to see *and* feel the image.

Results of Study 2 cross-validate the findings in Study 1 with an independent sample by demonstrating a good fit to the data for the 4-factor model. Findings suggest it would be redundant to separately assess "ease to see" and "ease to feel" each image, with the likelihood of high correlations existing between the two similar to previous studies (e.g., Cumming, 2008; Nordin & Cumming, 2008).

Study 3

To further assess the validity and reliability of the SIAQ, a third study was carried out. In the earlier stages of analyses undertaken in Study 1, and in conjunction with Paivio's (1985) revised theoretical framework (Hall et al., 1998), results suggested the possibility of a fifth factor (mastery). But due to item cross loading, further refinement to the wording of these items was necessary. The purpose of Study 3 was to revise the SIAQ to include a fifth factor by introducing 3 mastery items reworded from Study 1. A second aim was to compare the final CFA solution with alternative models and investigate gender invariance to determine whether the final factor structure was sustained for males and females. The third purpose was to examine the test-retest reliability of the SIAQ by administering the questionnaire on two separate occasions. The final purpose of Study 3 was to see if the SIAQ is able to distinguish between populations of athletes based on previous research suggesting that certain athlete characteristics such as competitive level will influence imagery ability (e.g., Roberts et al., 2008). Specifically, we examined whether the SIAQ would distinguish between males and females, and higher- and lower-level athletes based on their reported ease of imaging scores. Based on previous research, it was hypothesized that there would be no gender differences but athletes of a higher competitive level would display greater imagery ability compared to those competing at a lower-level (e.g., Gregg & Hall, 2006; Roberts et al., 2008).

Method

Participants

For participant details see Table 1.

Measures

Demographic Information. The measures were identical to the pilot study, Study 1 and Study 2.

Sport Imagery Ability Questionnaire (SIAQ). To create a fifth mastery subscale, the SIAQ for Study 3 was composed of the same items and rating scale used in Study 2, but with 3 additional items ("giving 100% effort even when things are not going well", "staying positive after a setback", "remaining confident in a difficult situation"). The wording of the new items came from a combination of existing SIQ items along with rewording of items from Study 1 that showed a potential for loading together to represent the mastery subscale.

Procedures

The procedures were identical to the pilot study, Study 1, and Study 2 with the exception that approximately 3 months after the SIAQ was completed a random sample of 26% of the athletes (n = 116) completed the SIAQ for a second time.

Results and Discussion

Data Screening and item characteristics

All item skewness and kurtosis values were distributed within the tolerance levels of normality assumptions. Twelve missing data cases were deleted resulting in a final sample of 426 (n = 199 males, n = 227 females).

Confirmatory Factor Analysis (CFA)

Similarly to Study 2, CFA was conducted using AMOS 16.0 (Arbuckle, 1999) with maximum likelihood estimation procedures. Inspection of Mardia's coefficient revealed data did not display multivariate normality. Similarly to Study 2, the bootstrapping technique was employed. The model's overall goodness of fit was tested using the χ^2, SRMR, TLI, CFI, and RMSEA. Based on the same criteria as Study 2, an adequate fit to the data was established for a final 5-factor model, χ^2 (80) = 204.53, $p < .05$, CFI = .96, TLI = .95, SRMR = .04, RMSEA = .06 (90% CI = 0.05 - 0.07). All factor loadings (0.62 to 0.88), modification indices, and standardized residuals were within acceptable limits and no offending estimates existed in the data (Hair et al., 1998).

Internal Consistency and Interfactor Correlations

The SIAQ demonstrated good internal reliability for all five subscales with CR values ranging from .76 to .86, and AVE values ranging from .51 to .68. Significant interfactor correlations between the five subscales ranged from 0.26 to 0.46 ($p < .001$).

Alternative Models

The 5-factor model with correlated traits was compared to four other models to ensure that an alternate model would not provide a better fit to the data. A one-factor model with all 15 items loading on one imagery subscale, and a 5-factor uncorrelated traits model (without correlations between the 5 latent variables) revealed a poor fit to the data using the same criteria as employed previously. These poor fitting models indicate that sport imagery ability is a multidimensional construct best represented by an individual's ability to image a number of separate, but related, types of imagery. A two-factor correlated traits model was examined in which skill and strategy items were forced onto a cognitive subscale, and goal, affect, and mastery items forced onto a motivational subscale. Similarly to the one-factor model and uncorrelated traits model, results revealed a poor fit indicating skill and strategy imagery to measure different types of content not represented by a higher order cognitive factor. Similarly, goal, affect, and mastery images are not better represented by a higher order motivational factor. Finally, a hierarchical model was tested in which the five first-order latent factors (i.e., skill, strategy, goal, affect, and mastery images) were represented by a higher order latent factor (i.e., global sport imagery ability). Results revealed an adequate model fit similar to the first-order model with correlated traits which suggests the hierarchical model should be preferred because it is considered more parsimonious (Koufteros, Babbar, & Kaighobadi, 2009). However, to separately assess an athlete's imagery ability of the five types of imagery, or investigate the effect of each on various outcomes, we suggest using the first order correlated traits model. Results for all five CFAs are presented in Table 4.

Table 4.

SIAQ CFA fit indices for alternative CFAs (Study 3).

Model	χ^2	*df*	CFI	TLI	SRMR	RMSEA
Single factor 1st order CFA	1366.00*	90	0.57	0.49	0.12	0.18
Two-factor 1st order CFA (correlated traits)	1106.41*	89	0.65	0.59	0.11	0.16
Five-factor 1st order CFA (uncorrelated traits)	651.94*	90	0.81	0.78	0.25	0.12
Five-factor 1st order CFA (correlated traits)	190.17*	80	0.96	0.95	0.04	0.06
Hierarchical model	212.25*	85	0.96	0.95	0.05	0.06

Note: * = $p < .05$

Gender Invariance

To examine whether the SIAQ factor structure was sustained for both males and females, analysis of invariance was conducted using a sequential testing approach via multisample CFA. After a baseline model was established, two additional models were devised that were increasingly constrained. The first examined the equality of the measurement through constraining the factor loadings, the second constrained the factor variances, and the third examined the equality of the structural parameters through constraining the factor covariances across the male and female samples (Byrne, 2010). The relative goodness of fit between increasingly constrained models was investigated using the χ^2 difference test (Satorra & Bentler, 2001). The stringent test of invariance resulting from the χ^2 difference test is suggested to be too excessive for SEM that can be described as approximations of reality (e.g., Cudeck & Brown, 1983). Based on the recommendations of Cheung and Rensvold (2002), we also considered a change in CFI of $\leq .01$ to be reflective of model invariance. Goodness of fit results for the four models of the invariance analysis is reported in Table 5. Although the χ^2 difference was only nonsignificant between the unconstrained model and the constrained factor loadings model, the change in CFI was $< .01$ between all 4 steps, supporting the scale's factorial invariance across gender.

Test Retest Reliability

Intraclass correlation coefficients were calculated using a two-way random effect model (Ntoumanis, 2001) to establish test-retest reliability. ICC values for skill (.83), strategy (.86), goal (.86), affect (.75), and mastery (.85) images were all above the acceptable cut off (Vincent, 1999). Consequently results demonstrate temporal reliability of the SIAQ over a three month period.

Table 5.

SIAQ fit indices for gender invariance analysis (Study 3).

Model	χ^2	*df*	CFI	TLI	SRMR	RMSEA	$\Delta\chi^2$	Δdf	ΔCFI
Unconstrained	295.38*	160	.954	.940	.059	.045			
Constrained factor loadings	307.06*	170	.954	.943	.0359	.044	11.68	10	<.001
Constrained factor variances	318.57*	175	.951	.942	.069	.044	11.51*	5	.003
Constrained factor covariances	337.81*	185	.948	.941	.073	.044	19.24*	10	.003

Note: $\Delta\chi^2$ = chi-square difference, Δdf = difference in degrees of freedom, ΔCFI = change in CFI, when the fit of the more constrained model is compared with that of the previous less constrained model (Cheung & Rensvold, 2002). * = $p < .01$.

Group Differences

Additional validity of the SIAQ was established through two multivariate analyses of variances (MANOVAs) to examine whether ease of imaging varied according to gender, competitive level (i.e., high- vs. low-level athletes). For each analysis the five SIAQ subscales served as the dependent variables, and gender or competitive level was the independent variable. Follow up analysis of significant multivariate results were investigated through discriminant function analyses to examine specifically which types of imagery (i.e., skill, strategy, goal, affect, and mastery) could predict gender and competitive level (i.e., low- vs. high level athletes). The five SIAQ subscales served as the predictor variables, and gender or competitive level was the dependent variable. For competitive level recreational and club level athletes were athlete classified as low-level athletes and regional and elite level athletes were classified as high-level athletes. Note that regional is equivalent to state level athletes in the USA or provincial level athletes in Canada.

Gender. A one-way MANOVA revealed imagery ability differed between males and females, Pillai's trace = .04, $F(5, 420) = 3.64$, $p = .003$, $\eta^2 = .04$, observed power = 93%. Results of the follow up discriminant function analysis revealed a significant mean difference in mastery images ($p < .001$) when comparing male scores ($M = 5.10$, $SD = 1.06$) with female scores ($M = 4.73$, $SD = 1.01$). A significant association was revealed between gender and all predictors that accounted for 5.7% of between group variability. Closer analysis of the structural matrix confirmed only mastery images (.74) predicted gender, with skill, strategy, goal, and affect imagery acting as poor predictors. Cross validated classification showed that overall only 62.0% were correctly classified. Although contrary to our hypothesis, this result is in accordance with some previous studies that have identified gender differences in imagery ability (e.g., Campos, Pérez-Fabello, & Gómez-Juncal, 2004). Future research is encouraged to investigate the similarities and differences between male and female athletes' skill, strategy, goal, affect, and mastery imagery ability.

Competitive Level. A one-way MANOVA revealed imagery ability differed with competitive level, Pillai's trace = .067, $F(5, 420) = 6.04$, $p < .001$, $\eta^2 = .07$, observed power = 100%. Discriminant function analysis revealed significant mean differences for skill, strategy, goal, and mastery SIAQ subscales when predicting competitive level ($p < .001$). A significant association was revealed between competitive level and all predictors that accounted for 6.7% of between group variability. Closer analysis of the structural matrix confirmed skill (.76), strategy (.67), goal (.80), and mastery images (.56) predicted competitive level. Cross validated classification showed that overall 64.3% were correctly classified. This supports the SIAQ's ability to distinguish between groups of athletes and is consistent with previous research demonstrating that athletes competing at a higher level can display greater imagery ability (e.g., Roberts et al., 2008).

SIAQ Imagery Content

A repeated measures ANOVA investigated any differences in ease of imaging across SIAQ subscales. Mauchly's test of Sphericity was examined to investigate the equality of the within-subject factor (SIAQ subscales). The data violated this assumption ($p < .05$) so the Greenhouse-Geisser correction was reported. Results revealed significant differences in ease of imaging between the imagery content measured by the SIAQ, $F(3.66, 1556.43) = 124.31$, $p < .001$, $\eta^2 = .23$, observed power = 100%. Post hoc analysis revealed that participants found it significantly easier to image affect images ($M = 5.92$, $SD = .83$) compared to skill images ($M = 5.16$, $SD = .96$) which were significantly easier to image than strategy ($M = 4.83$, $SD = 1.18$), goal ($M = 4.83$, $SD = 1.30$), and mastery ($M = 4.90$, $SD = 1.05$) images. Similarly to athletes using functions of imagery to varying extents (e.g., Cumming & Hall, 2002a; Hall et al., 1998), athletes also diverge in their ability to image different content. This finding reinforces the need to capture an athlete's range of sport imagery ability.

Study 4

Despite Studies 1, 2, and 3 validating the factor structure of the SIAQ, it is yet to be compared to other imagery ability questionnaires to establish its concurrent validity. Investigating the correlations between the SIAQ and another measure would establish how SIAQ subscales relate to imagery ability assessed by other measures. The purpose of Study 4 was to therefore examine the concurrent validity of the SIAQ by investigating relationships between the SIAQ ease of imaging sport images and ease of imaging movement images measured by the most recent version of the Movement Imagery Questionnaire, the Movement Imagery Questionnaire-3 (MIQ-3; Williams, Cumming, & Edwards, in press). A secondary purpose of Study 4 was to examine the five-factor model fit of the SIAQ on a second population of athletes. A priori hypothesized relationships were thought to exist between the SIAQ and MIQ-3 due to both questionnaires measuring ease of imaging. However, it was thought these would be moderate in size due to the SIAQ assessing imagery ability of a different content to that assessed by the MIQ-3.

Method

Participants

For participant details see Table 1.

Measures

Demographic Information. The measures were identical to the pilot study, Study 1, 2, and 3.

Sport Imagery Ability Questionnaire (SIAQ). The same 15-item SIAQ used in Study 3 was distributed in Study 4.

Movement Imagery Questionnaire-3 (MIQ-3). The MIQ-3 (Williams et al., in press) is a 12-item questionnaire designed to measure individuals' ease of imaging external visual imagery (EVI), internal visual imagery (IVI), and KI of specific movements. Developed from the MIQ-R (Hall & Martin, 1997), it requires athletes to image 4 movements; a knee lift, jump, arm movement, and waist bend. Participants are asked to physically perform, and then image, the movement. Each movement is imaged three times, once from an EVI perspective, once from an IVI perspective, and once kinaesthetically, resulting in a total of 12 movements physically performed and then imaged. Following each image, participants rate the ease they are able to produce the image on a 7-point Likert type scale ranging from 1 *(very hard to see/feel)* to 7 *(very easy to see/feel)*. A higher score therefore represents a higher ability to perform VI or KI. Williams et al. (2011) identified the MIQ-3 to be a valid and reliable questionnaire.

Procedures

The procedures were identical to Study 3 with the exception that participants also completed the MIQ-3. This questionnaire administration was done in either small groups or in isolation. Overall participation took no longer than 30 minutes.

Results and Discussion

Data Screening

All data was inspected for missing cases, skewness and kurtosis based on previous recommendations (Tabachnick & Fidell, 2007).

Confirmatory Factor Analysis (CFA)

Similarly to previous studies, CFA was conducted using AMOS 16.0 (Arbuckle, 1999) with maximum likelihood estimation procedures and the same fit criteria were used. The data did not display multivariate normality so the bootstrapping technique was employed. Similarly to Study 3, an adequate fit to the data was established for a five-factor model,

χ^2 (80) = 108.59, $p < .05$, CFI = .98, TLI = .97, SRMR = .04, RMSEA = .04 (90% CI = 0.02 - 0.06), and factor loadings (0.61 to 0.88), modification indices, and standardized residuals were within acceptable limits (Hair et al., 1998). This adequate model fit demonstrating similar results to those obtained in Study 3 support the consistency of a 5-factor model.

Internal Consistency

Both the SIAQ and MIQ-3 demonstrated good internal reliability for each subscale. The SIAQ's CR ranged between .78 and .86 and its AVE ranged between .55 and .67. CR of the MIQ-3 ranged from .80 to .87 and its AVE ranged from .51 to .62.

Correlations

For a review of all correlations between the SIAQ and MIQ-3 see Table 6. In support of our a priori hypothesis, significant bivariate correlations were evident between the SIAQ and the MIQ-3 for the majority of subscales indicating a relationship between movement imagery ability and sport imagery ability. The small to moderate in size of these correlations, ranging from .14 to .24 ($p < .05$), suggests that although there is a relationship between the questionnaires, imagery ability of movement imagery and sport imagery content are not the same trait. The SIAQ therefore taps ease of imaging a different content to the MIQ-3 questionnaire.

The relationship between the SIAQ and MIQ-3 appears to be influenced by imagery content of the SIAQ with greater correlations for affect and mastery images rather than skill and strategy. However, the difference between the largest correlation (affect imagery and IVI, $r = .24$) and the smallest correlation (strategy imagery and KI, $r = .14$) was not significant (Steiger's $Z = 1.52$, $p > 0.05$).

Table 6.

Bivariate correlations between the SIAQ subscales and the MIQ-3 subscales.

	MIQ3		
	EVI	IVI	KI
Skill	0.15*	0.24***	0.19**
Strategy	0.15*	0.20**	0.14*
Goal	0.12	0.11	0.20**
Affect	0.24***	0.24***	0.24***
Mastery	0.23**	0.17*	0.22**

Note: * = $p < .05$, ** = $p < .01$, *** = $p < .001$.

Although the majority of SIAQ subscales correlate with the MIQ-3 subscales, goal imagery failed to significantly correlate with either of the MIQ-3 VI subscales. This highlights how different the visual characteristics of goal images are compared with movement images assessed by the MIQ-3. Although not a priori hypothesized, this suggests an individual's ability to image scenarios of one content will not necessarily transfer to an ability to see images of a completely different content. Such a finding highlights the importance of Paivio's (1985) suggestion that one should find the method most directly related to the specific task when assessing an individual's imagery ability. Although an athlete may display high levels of movement imagery ability assessed by the MIQ-3, they may not necessarily have a good ability to image the content associated with achieving goals and outcomes.

General Discussion

The aim of the present research was to develop and validate the SIAQ. Based on the work of Hall et al. (1998), the SIAQ was designed to assess the ability to image sport specific, cognitive and motivational imagery content. The well-established SIQ and its underlying framework (Hall et al., 1998; Paivio, 1985) formed the basis of the initial SIAQ items. Item modifications were made to deemphasize imagery function and ensure the ability to image the scenario's content was assessed. Results from Study 1 identified four types of imagery (skill, strategy, goal, and affect), which were confirmed in Study 2 through the use of CFA. The third study provided further confirmation of the four factors already established as well as identifying, with the inclusion of additional items, a fifth factor of mastery images, that was replicated and confirmed in Study 4. Study 3 also confirmed the gender invariance of the SIAQ and its temporal reliability, and distinguished between athletes based on characteristics such as competitive level. Finally a comparison between the SIAQ and the MIQ-3 demonstrated concurrent validity of the SIAQ.

Although the SIAQ was not able to distinguish between ease of imaging and vividness, it is important to point out that while these dimensions appear to share a measured overlap in the processes they reflect (i.e., image formation, maintenance, and transformation; Roberts et al., 2008), these are conceptually different characteristics of imagery ability. Ease of imaging refers to the extent an individual is readily able to image a scenario, whereas vividness refers to the clarity and richness associated with an image. There is likely to be a positive association between the two dimensions. For example an individual who finds it easier to image a scenario is also likely to be able to image it more clearly and vividly. However, it is also possible for an individual to image a scenario easily, but with less vividness. Likewise, an individual learning to make an image more vivid may find this image more difficult to generate. Future research must attempt to tease these characteristics apart to provide a more comprehensive assessment of imagery ability.

The SIAQ provides a comprehensive assessment of athlete imagery ability by assessing five types of imagery content closely associated with the five functions of athlete imagery use. Study 4 demonstrated this content is different to movement imagery ability. CFA results and factor correlations in Studies 2, 3, and 4 identified that skill, strategy, goal, affect, and mastery imagery are all different but related types of imagery content. Study 2 demonstrated that ease of imaging was reflective of being able to see and feel the imagery scenario, which was also confirmed by the similar correlations found between SIAQ subscales and MIQ-3 EVI, IVI, and KI in Study 4. The lack of significant differences in the fit of the first-order correlated traits model and hierarchical model suggests either can be used depending on whether researchers want to separately assess each type of imagery content or not.

Results from Study 3 reveal athletes significantly differ in their imagery ability depending on the content imaged, further supporting the importance and relevance of separately assessing the various images athletes' experience, rather than assessing one type and generalizing it to other imagery scenarios. Notably skill imagery ability, which may be thought to be comprised of content most closely associated to movement imagery, was significantly easier to image compared to strategy, goal, and mastery imagery, yet it was significantly more difficult to image compared to affect imagery. If the MIQ-3 or VMIQ-2 is used to assess imagery ability prior to an intervention that incorporates imagery content more reflective of that assessed by the SIAQ, an overestimation of the ability to image strategies, goals and outcomes, and mastery type images, and an underestimation of the ability to image scenarios encompassing feelings and emotions associated with performance may occur. Consequently it is important for researchers to select the imagery ability measure that is most appropriate for the upcoming intervention. For example, the SIAQ should be used if the intervention encompasses sport related images whereas the VMIQ-2 or MIQ-3 would be preferred if separate assessment of both visual perspectives is needed or if the intervention includes imagery of movement content that is not sport related. Separately assessing different types of imagery ability at the outset enables researchers to tailor the content of an imagery intervention to be reflective of the type of imagery an athlete is most capable of performing.

Athletes of a higher competitive level found it significantly easier to generate sport images. Although various studies have established competitive level differences as a result of movement imagery ability (e.g., Gregg & Hall, 2006; Roberts et al., 2008), very few have demonstrated the influence competitive level has on imagery ability of sporting content. Research has identified athletes competing at a higher level use imagery more frequently (e.g., Hall et al., 1998), and athletes who use imagery more frequently, tend to display higher levels of imagery ability. Consequently, athletes of a higher competitive level would be expected to be able to generate images with greater ease than their lower level counterparts. Therefore, as well as extending previous research, this finding further validates the SIAQ as a measure of sport imagery ability.

The SIAQ's temporal reliability was supported by test-retest reliability over a 3 month period suggesting any increases in reported SIAQ scores following an intervention of three months or less are likely to result from improvements in imagery ability. Study 4 established the SIAQ's concurrent validity and demonstrated that imagery ability reflected by one questionnaire will not necessarily generalize to another. Both the SIAQ and the MIQ-3 assess imagery ability in terms of ease of imaging on a similar 7-point Likert type scale. This provides further support for the suggestion that discrepancies between the two questionnaires are a result of differing content rather than other factors such as the construct of imagery ability being assessed or the discrepancy in the rating scales.

Development of the SIAQ has opened various avenues of future research. As a new questionnaire, it should undergo further validation. Although the SIAQ has been compared to the MIQ-3 as a measure of imagery ability, there are other valid and reliable imagery ability questionnaires such as the VMIQ-2 that assess other characteristics of imagery ability (e.g., vividness). Because the SIAQ evolved from the five types of imagery identified by the SIQ (Hall et al., 1998), it would also be logical to examine relationships between the SIAQ and

SIQ subscales in future research. In addition, potential moderating effects of imagery ability, proposed by the applied model of imagery use (Martin et al., 1999), can be more extensively examined due to the SIAQ's capacity to assess different types of imagery outlined in the model.

Finally, as well as performance improvements, imagery has been associated with various motivational processes and outcomes (for review see Cumming & Ramsey, 2009). With the existence of a valid and reliable questionnaire providing a comprehensive assessment of the ability to image athlete imagery content, the relationship between imagery ability and psychological characteristics associated with sporting success/failure can be more extensively explored.

In conclusion, the present investigation established and validated a reliable questionnaire assessing skill, strategy, goal, affect, and mastery sport imagery ability, the content of which reflects the five functions of imagery used by athletes (Hall et al., 1998). Therefore, a much wider range of imagery content athletes experience in relation to their sport can now be assessed. Through the validation process, novel contributions were also made to imagery ability research. Results replicate and extend findings of Roberts et al. (2008) and others (e.g., Gregg & Hall, 2006), revealing a higher competitive level is associated with greater sport specific imagery ability of varying content. Secondly, this is the first study to our knowledge that has identified imagery ability to differ depending on imagery content. The SIAQ demonstrated concurrent validity through its comparison with the MIQ-3, but these findings along with those in Study 3, demonstrate an ability to generate movement imagery cannot be generalized to other imagery content such as goal images. Future research should continue to validate the SIAQ through other means such as investigating SIAQ imagery ability with other measures of imagery ability, imagery use represented by the SIQ, and other characteristics that influence sporting performance. Demonstrating the SIAQ's predictive validity of imagery use and other outcomes would further establish this questionnaire as an effective assessment of athlete imagery ability.

Chapter 5

Sport Imagery Ability Predicts Challenge and Threat Appraisal Tendencies

This manuscript has been submitted for publication to the *European Journal of Sport Science.*

Abstract

The present study investigated the interplay among athletes' sport imagery ability, trait confidence, and tendency to appraise situations as a challenge and threat. The potential mediating role of trait confidence was also tested. 207 athletes (M_{age} = 19.44; *SD* = 1.26; 90 female, 117 male) completed the Sport Imagery Ability Questionnaire (Williams & Cumming, in press) to assess skill, strategy, goal, affect, and mastery ease of imaging, the confidence subscale of the Competitive Trait Anxiety Inventory (Albrecht & Feltz, 1987) to measure trait confidence, and the Cognitive Appraisal Scale (Skinner & Brewer, 2002) to assess tendencies to appraise sport situations as a challenge and as a threat. Structural equation modelling supported a model whereby mastery and goal imagery ability both positively predicted confidence, which in sequence positively predicted challenge appraisal and negatively predicted threat appraisal tendency. Partial support was found for confidence mediating the relationship between mastery imagery ability and appraisal tendencies. In addition, mastery ease of imaging and affect ease of imaging directly predicted challenge appraisal tendency (positive direction), and mastery ease of imaging directly predicted threat appraisal tendency (negative direction). Results highlight the importance of motivational imagery ability and the need to assess athletes' ability to image different content.

Sport Imagery Ability Predicts Challenge and Threat Appraisal Tendencies

The Sport Imagery Ability Questionnaire (SIAQ; Williams & Cumming, in press) is a new measure which provides a more complete assessment of athlete imagery ability than previously available. Most imagery ability questionnaires assess how proficiently individuals generate movement images of simple actions, with the Movement Imagery Questionnaire-3 (MIQ-3; Williams, Cumming & Edwards, in press) and Vividness of Movement Imagery Questionnaire-2 (VMIQ-2; Roberts, Callow, Hardy, Markland & Bringer, 2008) as two popular examples. The SIAQ was developed to address the gap between the diverse range of sport-specific images athletes experience and existing assessments of their imagery ability (see Hall, 1998; Paivio, 1985; Williams & Cumming, in press). Derived from Hall, Mack, Paivio, and Hausenblas's (1998) extension of Paivio's (1985) original framework, the SIAQ measures the ability to generate five types of imagery content: skill, strategy, goal, affect, and mastery. Skill and strategy imagery ability represent images that are cognitive in nature, whereas goal, affect, and mastery images are motivational in content. After validating the five factor structure of the SIAQ, Williams and Cumming highlighted its potential for extending imagery ability research by simultaneously measuring cognitive and motivational imagery ability.

Athletes are known to use imagery more frequently for motivational rather than for cognitive purposes (e.g., Cumming & Hall 2002a; Hall et al. 1998). One such function is to enhance self-confidence or, its more specific form, self-efficacy (for reviews see Martin, Moritz, & Hall, 1999; Murphy, Nordin, & Cumming, 2008). Athletes who image more frequently also report higher levels of trait and state self-confidence (e.g., Abma, Fry, Li, & Relyea, 2002; Beauchamp, Bray, & Albinson, 2002; Callow & Hardy, 2001; Moritz, Hall, Martin, & Vadocz, 1996; Vadocz, Hall, & Moritz, 1997). Imagery interventions have also led to increased self-confidence and self-efficacy (e.g., Callow, Hardy & Hall, 2001; Jones, Mace, Bray, MacRae & Stockbridge, 2002; Nordin & Cumming, 2005a; Short et al., 2002). A proposed mechanism to explain these effects is that imaging successful performance of a task can convince an athlete that he or she can successfully execute the task (Feltz, 1984; Martin & Hall, 1995).

Indeed, Bandura's social cognitive theory (1977, 1997) suggests that imaginal experiences are a potential antecedent of self-efficacy. If people visualise themselves performing well in a difficult competition, their perceived efficacy to perform well in this situation is thought to simultaneously increase. Images of being successful, such as in handling difficult situations may therefore enhance self-efficacy and confidence by acting as vicarious experiences. If this mastery image has been previously experienced (i.e., drawn from a past memory of a real performance), it may also provide the athlete with a sense of performance accomplishment. Notable is that both vicarious experiences and performance accomplishments are the main sources of self-efficacy. Callow and Waters (2005) extended this suggestion to kinaesthetic imagery by suggesting that improvements in confidence resulting from their intervention were due to the performance accomplishment information provided by imaging the sensations of how it feels to successfully perform. While most studies have investigated the relationship between imagery use and confidence, less research has examined the potential influence of imagery ability on confidence.

Elite athletes who frequently use imagery possess well developed imagery ability (Barr & Hall, 1992; Orlick & Partington, 1988), and athletes high in sport confidence are known to be better imagers than low sport confident athletes (Barr & Hall, 1992; Moritz et al., 1996). For example, Moritz et al. identified that high state confident athletes displayed significantly higher visual and kinaesthetic imagery ability compared to their lower level counterparts. Callow, Roberts, and Fawkes (2006) showed participants who imaged completing a down-hill ski-slalom course while standing on the snow, wearing their equipment and adopting their race position (i.e., dynamic imagery) had more vivid images and increased confidence at performing the task than those using static imagery. They suggest vividness, a characteristic of imagery ability, may mediate imagery's influence on confidence. Regarding trait confidence, Abma et al. (2002) reported the ability to image simple movements did not distinguish between high and low level trait confidence athletes. Whilst this finding suggests imagery ability does not predict trait sport confidence, the results may be due to the method used to assess imagery ability.

Although cognitive and motivational imagery content is used to enhance confidence and efficacy (Nordin & Cumming, 2005a; Short, Monsma, & Short, 2004), use of mastery images has the strongest link to confidence (e.g., Callow, Hardy & Hall, 1998; White & Hardy, 1998). It follows that an individual's ability to image mastery content may also have the strongest link to confidence levels. If an athlete is able to clearly and vividly see themselves appearing confident, they are more likely to generally feel more confident. Abma et al. (2002) assessed athletes' ability to image simple movements using the Movement Imagery Questionnaire-Revised (Hall & Martin, 1997). Because imagery ability can significantly differ according to the content imaged (Williams & Cumming, in press), the resulting MIQ-R scores will not likely generalise to the athletes' ability to generate motivational content. With the emergence of the SIAQ, the relationship between imagery ability and trait confidence should be re-examined to clarify which types of imagery ability relate to trait confidence levels.

Higher levels of confidence are associated with other psychological characteristics that influence sporting success. These include increasing facilitative interpretations of stress and anxiety (e.g., Jones, Hanton, & Swain, 1994; Jones & Swain, 1995), which in turn can influence an athlete's motivational state. Imagery is one method that can enable athletes to perceive stress and anxiety symptoms as facilitative and under control by eliciting higher levels of self-confidence or self-efficacy (e.g., Cumming, Olphin, & Law, 2007; Jones et al., 2002). Facilitative interpretations of stress are associated with a challenge appraisal whereas debilitative interpretations relate to a threat appraisal (Jones, Meijen, McCarthy, & Sheffield, 2009). Challenge-appraised and threat-appraised motivational states are characterized by adaptive and maladaptive approaches to coping respectively (Blascovich & Mendes, 2000). When approaching a stressful situation, such as an important competition, high self-confidence is a precursor to a challenge state by helping athletes to perceive they have the resources to meet the demands (Jones et al., 2009). In contrast, a threat state is experienced when demands are perceived to outweigh the person's available resources in the situation.

Pulling these different empirical and theoretical threads together, it is therefore proposed that confidence may mediate the relationship between imagery ability and challenge and threat appraisal tendencies. In other words, imagery ability may indirectly predict challenge and threat appraisal tendencies via its relationship with self-confidence. Moreover, certain types of imagery ability measured by the SIAQ may directly relate to a challenge or threat appraisal tendency. For example, being able to more easily see mastery images such as "giving 100% effort even when things are not going well" (SIAQ item 2) will likely help an individual perceive they have the resources to meet the demands of a difficult situation – a characteristic indicative of a challenge appraisal. Similarly, greater imagery ability of "the positive emotions I feel while doing my sport" (SIAQ item 4) is likely to infer emotions associated with a challenge appraisal. Hence, greater mastery and affect imagery ability will increase the likelihood athletes appraise stress-evoking situations as a challenge and reduce the likelihood of appraising them as a threat.

Due to the SIAQ's capacity to assess sport related cognitive and motivational imagery content, the purpose of the study was to examine the interplay between sport imagery ability, trait confidence, and challenge and threat appraisal tendencies. It also provided the opportunity to further validate the SIAQ by establishing its predictive validity of trait confidence and stress appraisal tendency. The first aim was to investigate whether skill, strategy, goal, affect, and mastery ease of imaging predicts trait confidence, and if trait confidence predicts challenge and threat appraisal tendency. The second aim was to investigate whether trait confidence mediates the relationship between ease of imaging and challenge and threat appraisal tendencies. The third aim was to investigate whether affect and mastery ease of imaging directly predict challenge and threat appraisal tendencies.

It was hypothesised that by serving as a vicarious experience, greater SIAQ imagery ability, regardless of whether this is cognitive or motivational in nature, would positively predict trait confidence. However, the ability to image mastery content was expected to be the strongest predictor. It was also predicted that trait sport confidence would positively predict a challenge appraisal tendency and negatively predict a threat appraisal tendency due to participants perceiving they have the resources to meet the demands of the situation (Jones et al., 2009). Additionally, it was hypothesised that trait confidence would mediate the relationship between ease of imaging and appraisal tendencies as imagery can increase self-confidence resulting in facilitative interpretations of stress and anxiety reflective of a challenge state (Cumming et al., 2007; Jones et al., 2002). Finally, greater affect and mastery imagery ability, due to reflecting a challenge appraised state, was expected to directly predict a challenge and threat appraisal in a positive and negative direction respectively.

Method

Participants

Two hundred and seven athletes (117 males, 90 females) with a mean age of 19.44 (*SD* = 1.26) years took part in the study. Participants represented a total of 32 different team (*n* = 129) and individual (*n* = 78) sports with the majority coming from soccer (*n* = 50), rugby (*n* = 28), athletics (*n* = 12), and field hockey (*n* = 12). Participants had been participating in their chosen sport for an average of 6.32 years (*SD* = 1.97) and represented a variety of competitive levels including recreational (*n* = 27), club (*n* = 115), regional (*n* = 57), and elite (*n* = 8).

Measures

Demographic Information. Participants provided demographic information which included their gender, age, sport played, competitive level and years of playing experience in their sport.

Sport Imagery Ability Questionnaire. The SIAQ (Williams & Cumming, in press) is a 15-item questionnaire designed to measure athletes' ability to image a variety of sport-related images. Five subscales each composed of 3 items represent skill images (e.g., making corrections to physical skills), strategy images (e.g., creating a new game/event plan), goal images (e.g., myself winning a medal), affect images (e.g., the anticipation and excitement associated with my sport), and mastery images (e.g., remaining confident in a difficult situation). Participants rate the ease with which they are able to generate each image on a 7-point Likert type scale ranging from 1 *(very hard to image)* to 7 *(very easy to image)*. An average score is then calculated for each of the five types of imagery. Williams and Cumming (in press) have demonstrated the SIAQ to be a valid questionnaire with good psychometric properties. In the present study, the SIAQ demonstrated adequate internal reliability with Composite Reliability (CR) and Average Variance Extracted (AVE) values all above .70 and .50 respectively (Hair, Anderson, Tatham, & Black, 1998) for skill (CR = .82, AVE = .60), strategy (CR = .84, AVE = .63), goal (CR = .84, AVE = .63), affect (CR = .78, AVE = .54), and mastery (CR = .81, AVE = .60) images.

Competitive Trait Anxiety Inventory. The Competitive Trait Anxiety Inventory (CTAI; Albrecht & Feltz, 1987) is a 27-item questionnaire which assesses how cognitively anxious (e.g., I am concerned about performing poorly), somatically anxious (e.g., my body feels tense), and self confident (e.g., I'm confident about performing well) individuals generally feel with regards to competing in their chosen sport. For the present study only the confidence intensity subscale was used. Participants rate the intensity with which they usually experience each of the 9-items before or during competition on a 4-point Likert type scale ranging from 1 (*not at all*) to 4 (*very much so*). The CTAI confident intensity subscale demonstrated adequate internal reliability in the present study with CR being .89 and AVE being .50.

Cognitive Appraisal Scale. Participants' trait style of their cognitive appraisal tendency was assessed using the cognitive appraisal scale (CAS; Skinner & Brewer, 2002). The CAS is an 18-item self evaluative questionnaire that assesses the likelihood participants appraise situations as a challenge (e.g., I tend to focus on the positive aspects of any situation) and a threat (e.g., I feel like a failure). A variety of general thoughts and feelings are described and participants rate the extent they agree or disagree with generally experiencing each one. Ratings are made on a 6-point Likert-type scale ranging from 1 (*strongly disagree*) to 6 (*strongly agree*). For the present study, participants were asked to answer all questions specific to sport. The CAS demonstrated adequate internal reliability in the present study for both the challenge (CR = .89, AVE = .50) and threat (CR = .94, AVE = .60) subscales.

Procedures

Participants were recruited from an undergraduate class and participated for a course credit. Individuals were provided with an information sheet explaining the nature of the study and those agreeing to take part provided their consent understanding that their participation was voluntary. Participants then provided their demographic information and completed the SIAQ, CTAI confidence subscale, and CAS before being thanked for their participation. Completion of the study took no longer than 30 minutes.

Results

Data Screening

Data was screened for skewness and kurtosis with all values distributed within the tolerance levels of normality assumptions based on the recommendations of previous research (Tabachnick & Fidell, 2007).

Questionnaire Factor Structure

Data was analysed via structural equation modelling (SEM) with maximum likelihood estimations using the computer package AMOS 16.0 (Arbuckle, 1999). Following the two-step approach to SEM, the factor structure of each questionnaire was first examined (Kline, 2005). Each model's overall goodness of fit was tested using the chi-squared likelihood ratio statistic (χ^2; Jöreskog & Sörbom, 1993). Because a non-significant χ^2 value representing a good model fit is affected by sample size, two types of additional fit indices are reported (Hu and Bentler, 1999). First, the standardized root mean square residual (SRMR; Bentler, 1995) and Root Mean Square Error of Approximation (RMSEA) were selected as indicators of absolute fit. A model with good fit to the data is thought to be reflected in values of $\leq .08$ and .06 respectively (Hu & Bentler, 1999). Secondly, the Tucker Lewis Index (TLI) and Comparative Fit Index (CFI) were selected to reflect incremental fit with values $> .90$ and .95 indicating an adequate and excellent model fit respectively (Hu & Bentler, 1999). Although there is some debate in the literature with how appropriate these values are (see Markland, 2007; Marsh, Hau, & Wen, 2004), these criteria are still the most commonly reported as indications of an adequate model fit and subsequently followed here.

The CFA for the model representing the SIAQ revealed a good fit to the data, χ^2 (80) = 116.87, $p = .005$, CFI = .97, TLI = .96, SRMR = .04, RMSEA = .05 (90% CI = 0.03 - 0.07). The CFA for the model representing the CAS revealed a slightly poorer fit to the data, χ^2 (134) = 367.38, $p < .001$, CFI = .89, TLI = .88, SRMR = .08, RMSEA = .09 (90% CI = 0.08 - 0.10). Consequently problematic items were removed in a step-by-step process to improve model fit through inspection of the modification indices. Hofmann (1995) justifies this approach as resultant models derive from the best-performing indicators without sacrificing the hypothesized model structure. Following the removal of two items[1] from the threat subscale, the CFA for the model representing the CAS revealed an adequate fit to the data, χ^2 (103) = 211.30, $p < .001$, CFI = .94, TLI = .94, SRMR = .07, RMSEA = .06 (90% CI = 0.06 - 0.09). The CFA model representing the CTAI-2 confidence subscale also revealed a slightly poor fit to the data, χ^2 (27) = 110.77, $p < .001$, CFI = .90, TLI = .87, SRMR = .06, RMSEA = .12 (90% CI = 0.10 - 0.15). Inspection of the modification indices and factor loadings revealed one problematic item[2] which was removed to improve model fit, χ^2 (20) = 44.06, $p = .001$, CFI = .96, TLI = .95, SRMR = .05, RMSEA = .07 (90% CI = 0.05 - 0.11). Modifications to the factor structures did not affect the internal reliability of the confidence (CR = .89, AVE = .50) or the threat (CR = .94, AVE = .67) subscales.

To improve the variable to sample size ratio and increase the stability of the estimates, construct specific parcels were created for remaining items on the CTAI confidence subscale and CAS questionnaire (Little, Cunningham, Shahar, & Widaman, 2002). An item-to-construct balance approach was taken whereby the item with the highest factor loading was parcelled with the item with the lowest factor loading from the same subscale. The item with the second highest loading was then paired with the item displaying the second lowest loading until all items were assigned to a two-item parcel (Little et al., 2002). The measurement model as a whole with parcelled indicators revealed a satisfactory fit to the data, χ^2 (296) = 567.15, $p < .001$, CFI = .90, TLI = .90, SRMR = .05, RMSEA = .07 (90% CI = 0.07 - 0.08). Inspection of the Mardia's coefficient revealed data did not display multivariate normality

[1] The following threat items cross-loaded and displayed very low factor loadings on the threat factor: "I lack self confidence" and "I feel like a failure". Consequently both items were removed from the subsequent analysis.
[2] The confidence item "I feel comfortable" loaded poorly onto the confidence factor. Consequently it was removed from the subsequent analysis.

(normalized estimate = 12.64). Consequently the bootstrapping technique was employed in all further analysis.

Structural Model

According to our hypotheses, regression paths were drawn from all five types of imagery ability to confidence. Regression paths were also drawn from confidence to challenge appraisal, and to threat appraisal. Finally direct regression paths were added from affect and mastery imagery to challenge appraisal and from affect and mastery imagery to threat appraisal. The hypothesised model can be seen in Figure 1. The structural model demonstrated an adequate fit to the data, χ^2 (303) = 486.23, $p < .001$, CFI = .95, TLI = .94, SRMR = .05, RMSEA = .05 (90% CI = 0.05 - 0.06). Inspecting the regression weights indicated that the paths to trait confidence from skill ($p = .293$), strategy ($p = .237$), and affect ($p = .697$) imagery were all nonsignificant and therefore removed from the model. Furthermore the path from affect imagery to threat appraisal was nonsignificant ($p = .861$) and was also removed from the model. The second model revealed an almost identical fit, χ^2 (307) = 490.90, $p < .001$, CFI = .95, TLI = .94, SRMR = .05, RMSEA = .05 (90% CI = 0.05 - 0.06). This final model with standardized regression weights can be seen in Figure 2. Individuals who find it easier to image mastery imagery ($\beta = .47$, $p < .001$) and goal imagery ($\beta = .23$, $p = .009$) are more self-confident, which results in them being more likely to experience a challenge appraisal ($\beta = .42$, $p < .001$) and less likely to experience a threat appraisal ($\beta = -.47$, $p < .001$). Moreover, individuals with greater mastery ($\beta = .34$, $p < .001$) and affect ($\beta = .29$, $p < .001$) imagery ability are more likely to appraise situations as a challenge, and greater mastery imagery ability ($\beta = -.18$, $p = .020$) is less likely to result in threat appraisal. The nonsignificant change in χ^2 and the small drop in expected-cross validation index (ECVI) from 3.09 to 3.07 revealed the second model fit was more parsimonious (Byrne, 2010).

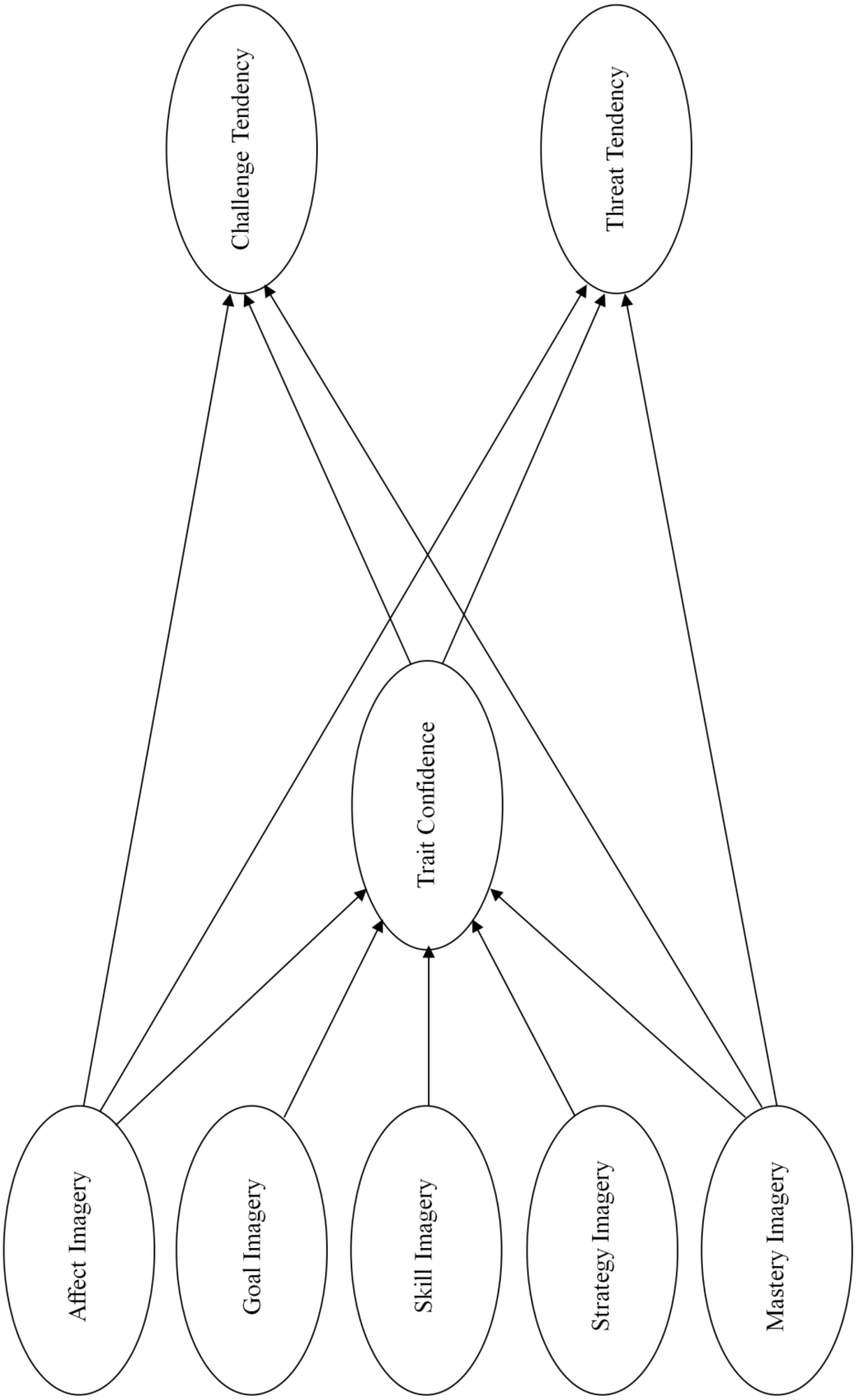


Figure 1. Hypothesised model. For visual simplicity, variances are not presented but are hypothesised as significant.

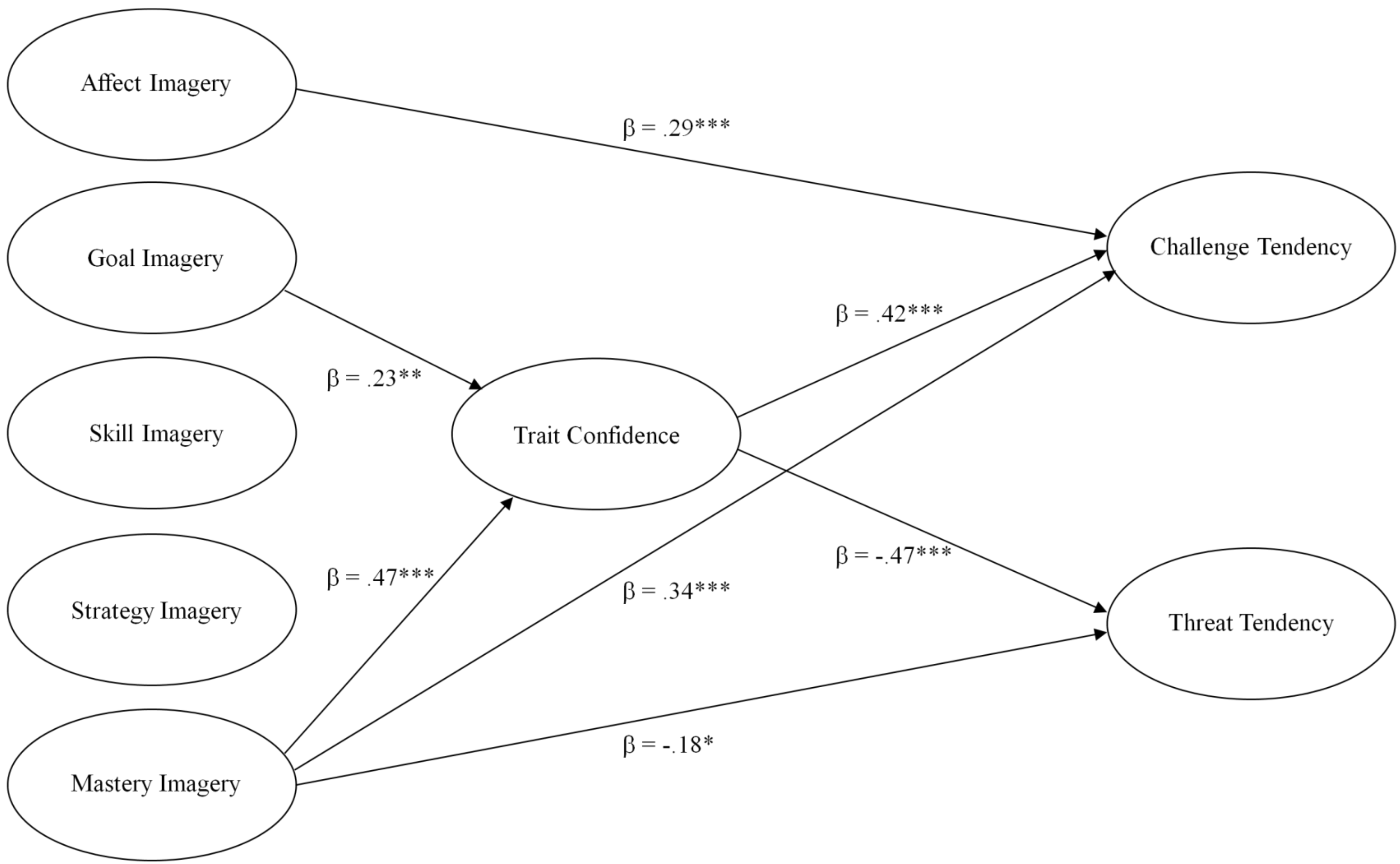


Figure 2. Final model predicting trait confidence, and challenge and threat tendency. *Note:* All coefficients are standardized. * $p < .05$, ** $p < .01$, *** $p < .001$. For visual simplicity, variances are not presented but were all significant ($p < .01$).

Testing for Mediation

In accordance with our third hypothesis, mediation analysis was conducted following Holmbeck's (1997) SEM approach. Firstly a direct effects model was tested to investigate whether there was a direct association from the predictors (i.e., goal and mastery imagery) to the outcomes (i.e., challenge and threat appraisal tendencies). A model was created whereby direct paths were inserted from goal imagery and mastery imagery to challenge appraisal and threat appraisal. This model provided an adequate fit to the data χ^2 (215) = 359.65, $p < .001$, CFI = .95, TLI = .94, SRMR = .05, RMSEA = .06 (90% CI = 0.05 - 0.07). However inspection of the beta weights revealed that the pathways from goal imagery to challenge appraisal tendency ($p = .071$), and from goal imagery to threat appraisal tendency were nonsignificant ($p = .397$) meaning mediation cannot account for potential indirect effects between goal imagery and challenge and threat appraisal tendencies (Holmbeck, 1997). Remaining pathways in the model were all significant indicating mastery imagery significantly predicted a challenge ($\beta = .55$, $p < .001$) and threat ($\beta = -.43$, $p < .001$) tendency.

The second step is to confirm the fit of the constrained model. This is to establish significant paths between the independent variable (i.e., mastery imagery) and mediator (i.e., trait confidence), and between the mediator and outcome variables (i.e., challenge and threat appraisal tendency). The constrained model provided an adequate fit to the data χ^2 (309) = 506.88, $p < .001$, CFI = .94, TLI = .93, SRMR = .06, RMSEA = .06 (90% CI = 0.05 - 0.06). Results revealed that mastery imagery significantly predicted confidence ($\beta = .49$, $p < .001$) and confidence significantly predicted a challenge ($\beta = .56$, $p < .001$) and threat ($\beta = -.59$, $p < .001$) appraisal tendency.

The final step is to examine an unconstrained model. This is when direct paths between the independent (i.e., mastery ease of imaging) and dependent (i.e., challenge and threat appraisal tendencies) variables are added to the model. Results reported earlier (Figure

2) demonstrated these significant paths which confirm the constrained model fit. The final step for determining mediation is to compare the less (i.e., unconstrained) and more restricted (i.e., constrained) models using the Satorra- Bentler χ^2 difference test (Holmbeck, 1997). If the unconstrained model does not offer an advanced representation of the data to that of the constrained model, this is evidence of trait confidence acting as a mediator (Holmbeck, 1997). Results demonstrated a significant difference indicating the unconstrained model offered a better representation of the data (χ^2 difference = 15.98, *df* difference = 2, $p < .001$). However the χ^2 difference test has received criticism as it only tests for complete mediation (Preacher & Hayes, 2008). Consequently, in a similar approach to Quested and Duda (2010), we examined the significance of the indirect effects in the model (see MacKinnon, 2000, for details of the employed method to test for significance). Results revealed that mastery ease of imaging and goal ease of imaging each had a significant indirect effect through confidence on challenge appraisal ($z > 1.96$) and mastery imagery had a significant indirect effect through confidence on threat appraisal ($z < -1.96$).

Discussion

The aim of the present study was to investigate the interplay between skill, strategy, goal, affect, and mastery imagery ability, trait confidence, and challenge and threat appraisal tendencies. More specifically, the first aim was to investigate whether each type of imagery ability predicted trait confidence, and secondly whether trait confidence in turn predicted challenge and threat appraisal tendencies. The third aim investigated whether trait confidence mediated the relationship between imagery ability and appraisal tendency. The fourth aim examined whether affect and mastery imagery ability could directly predict challenge and threat appraisal tendencies. Based on research suggesting imagery can serve as a source of vicarious experiences and performance accomplishments (Bandura, 1997; Callow & Waters, 2005), it was hypothesized that greater SIAQ imagery ability would positively predict trait confidence and this sequence would positively predict a challenge appraisal and negatively predict a threat appraisal. As such it was hypothesised confidence would mediate the relationship between imagery ability and appraisal tendency. Finally it was hypothesised that mastery and affect imagery ability would directly predict challenge and threat tendencies positively and negatively respectively, due to content of what is being imaged reflecting a challenge state.

Partly as predicted, results revealed both mastery and goal imagery ability positively predicted trait confidence. Therefore athletes who can more easily image persisting during difficult situations and achieving various goals and outcomes, display higher levels of trait sport confidence. As well as motivational imagery use being most strongly linked to confidence (e.g., Callow et al., 1998; White & Hardy, 1998), this finding also demonstrates motivational imagery ability is also most strongly linked to confidence. Opposing our hypothesis, skill, strategy, and affect imagery ability did not predict sport confidence. This was unexpected, particularly for skill and strategy imagery because easily experiencing successful task execution through imagery should convince athletes they are capable of successfully performing the task in real life (Bandura, 1997; Callow & Waters, 2005; Feltz, 1984; Martin & Hall, 1995). However, this finding is in accordance with Abma et al. (2002) who revealed trait confidence did not differ as a result of movement imagery ability as measured by the MIQ-R (i.e., a form of cognitive imagery ability). Possibly, only a greater use of cognitive imagery is associated with higher levels of confidence and not greater cognitive imagery ability.

In accordance with our hypothesis, trait confidence positively predicted a challenge appraisal and negatively predicted a threat appraisal. Individuals experience a challenge state when they perceive themselves to have the resources to meet the demands of a stress-evoking situation, and experience a threat state when resources are not adequate (Jones et al., 2009).

Encountering a stress-evoking situation with greater levels of trait confidence will likely help athletes believe they have the resources to meet the demands thus experiencing a challenge state.

Trait confidence appeared to partially mediate the relationship between mastery imagery ability and appraisal tendencies. More interesting was the size of the beta weightings for mastery imagery ability directly predicting challenge ($\beta = .34$) and threat ($\beta = -.18$) appraisal tendencies, even when indirect effects via trait confidence were accounted for. This demonstrates that mastery ease of imaging does not solely predict stress appraisal tendency through enhancing trait confidence. It was interesting that affect imagery ability directly predicted an individual's challenge appraisal tendency but did not predict trait confidence. This further supports motivational ease of imaging's capacity to predict stress appraisal tendency without being indirectly through trait confidence.

To our knowledge this is the first study to reveal both mastery and affect ease of imaging as direct predictors of challenge and threat appraisal tendencies. Individuals who find imaging mastery content (e.g., "remaining confidence in a difficult situation") easier are more likely to appraise stress-evoking situations as a challenge and less likely to perceive them as a threat. More clearly imaging this content may cause the athlete to believe they have the resources to meet the demands of stress-evoking situations, which subsequently leads to a challenge appraisal (Jones et al., 2009). In the present study, individuals who were able to easily image the feelings and emotions associated with a successful performance were more likely to appraise sport situations as a challenge. A challenge state is reflected by experiencing feelings and emotions that are positively associated with performance (see Lazarus, 1991; Jones et al., 2009). Therefore it appears more clearly imaging these positive feelings and emotions will lead to a challenge appraisal.

Mastery and affect imagery ability may also influence challenge and threat appraisal tendency through other variables not measured. The Theory of Challenge and Threat States in Athletes (TCTSA; Jones et al., 2009) proposes that perceptions of control and approach or avoidance motivation are antecedents in addition to self-efficacy that can influence whether an individual perceives they have the resources to meet the demands and thus whether a challenge or a threat state is experienced (Jones et al., 2009). Higher levels of perceived control and an emphasis on approach goals are thought to lead to a challenge appraisal. Conversely, lower levels of perceived control, and a focus on avoidance goals are thought to result in a threat appraisal (Jones et al., 2009). Mastery and affect images could influence these antecedents, namely perceived control. Mastery images such as, "remaining confident in a difficult situation", are likely to bolster feelings of maintaining control over stressful situations. Similarly a greater capacity to image affect items such as "the positive emotions I feel while doing my sport" are likely to infer feelings of being in control of the situation. Despite there currently being no standardized measure of perceived control that is frequently used, we invite future research to investigate whether mastery and affect imagery ability is able to manipulate this antecedent and influence challenge and threat appraisal tendencies.

Although a conclusive underlying explanation cannot be provided for the direct effects of mastery and affect imagery ability on challenge and threat appraisal tendency, the findings highlight the important role of imagery ability in determining motivational outcomes. As well as higher imagery ability leading to greater benefits obtained through use (e.g., Goss, Hall, Buckolz, & Fishburne, 1986; McKenzie & Howe, 1997; Robin et al., 2007), it appears higher imagery ability can also lead to adaptive approaches to performance without the need for an imagery intervention. Merely possessing a higher level of mastery and affect imagery ability more likely leads to a challenge appraised state and is less likely to result in a threat state. The present study findings also further validates the SIAQ and highlight its usefulness when investigating the relationship between imagery ability and various outcomes. Only motivational imagery ability predicted confidence and appraisal tendencies. It is likely if a movement imagery ability questionnaire had assessed imagery ability, due to being different content, the influence of imagery ability on trait confidence and appraisal tendencies would have been overlooked. The SIAQ's capability at assessing imagery ability of different cognitive and motivational imagery content supports its use in research and applied work.

Future research should continue investigating the role imagery ability has on various cognitive and motivational outcomes. Using the SIAQ and Sport Imagery Questionnaire (SIQ; Hall et al., 1998) researchers could investigate the extent outcomes are influenced by imagery ability and imagery use, and whether this is general or specific to one type of imagery. Future research should also use the SIAQ as a screening tool to assess imagery ability when studies use imagery similar in content to the SIAQ items. This will to produce a more accurate reflection of the individual's imagery ability of images used in the intervention.

Considering the method of analysis used in this study, a limitation could be the relatively small sample size. However, Boomsma (as cited in Tabachnick & Fidell, 2007) suggested that a sample size of 200 is sufficient for medium sized models. Furthermore constructing parcels for items on the CAS subscales and CTAI confidence subscale was done to improve the variable to sample size ratio, and increase the stability of the estimates (Little et al., 2002). As such we believe the approach taken was more appropriate than running multiple regressions increasing the likelihood of a type I error.

In conclusion, results revealed mastery and goal imagery positively predicted trait confidence which positively predicted a challenge appraisal and negatively predicted a threat appraisal tendency. Although trait confidence partially mediated the relationship between ease of mastery imaging and appraisal tendency, affect and mastery imagery ability directly predicted a challenge appraisal and mastery imagery ability directly predicted threat appraisal.

Findings highlight the importance of maximizing an individual's imagery ability. Significant predictions were only evident for motivational imagery ability and not skill or strategy images, demonstrating imagery ability's influence depends on its content. Future research should continue using the SIAQ to examine the relationship between imagery ability of different content and other cognitive and motivational outcomes. Due to its more comprehensive assessment of sport imagery ability, the SIAQ should also be used as a screening measure for athletes in studies using imagery of a motivational content that are not assessed by frequently employed movement imagery ability questionnaires.

Chapter 6

The Use of Imagery to Manipulate Challenge and Threat Appraisal States in Athletes

An edited version of this manuscript has been published under the following reference:

Williams, S.E., Cumming, J., & Balanos, G.M. (2010). The use of imagery to manipulate challenge and threat appraisal stated in athletes. *Journal of Sport and Exercise Psychology, 32*, 339-358.

Abstract

The present study investigated whether imagery could manipulate athletes' appraisal of stress-evoking situations (i.e., challenge or threat) and whether psychological and cardiovascular responses and interpretations varied according to cognitive appraisal of three imagery scripts: challenge, neutral, and threat. Twenty athletes (M_{age} = 20.85; *SD* = 1.76; 10 female, 10 male) imaged each script while heart rate, stroke volume, and cardiac output were obtained using Doppler echocardiography. State anxiety and self-confidence were assessed following each script using the Immediate Anxiety Measures Scale. During the imagery, a significant increase in heart rate, stroke volume, and cardiac output occurred for the challenge and threat scripts ($p < .05$). Although there were no differences in physiological response intensities for both stress-evoking scripts, these responses, along with anxiety symptoms, were interpreted as facilitative during the challenge script and debilitative during the threat script. Results support using imagery to facilitate adaptive stress appraisal.

The Use of Imagery to Manipulate Challenge and Threat Appraisal States in Athletes

By its very nature, the sporting environment evokes a stress response by placing many demands on competing athletes (Jones, 1995). How individuals appraise stress as a challenge or threat provides insight into why some athletes excel in performance situations whereas others fail or underperform (Cerin, Szabo, Hunt, & Williams, 2000). Challenge and threat are motivational states reflecting how an individual engages in a meaningful situation. Whereas a challenge appraisal is characterized by a more adaptive approach to coping, a threat appraisal is more maladaptive (Blascovich & Mendes, 2000). Moreover, appraising a situation as a challenge can lead to better performance over individuals appraising the same situation as a threat (Blascovich, Seery, Mugridge, Norris, & Weisbuch, 2004). Together with research investigating personal and situational characteristics that dictate challenge and threat appraisals, these findings have led to theories and models describing similarities and differences between the two states, including the *biopsychosocial model of challenge and threat* (Blascovich & Tomaka, 1996), the model of *adaptive approaches to competition* (Skinner & Brewer, 2004), and the more recent *Theory of Challenge and Threat States in Athletes* (TCTSA; Jones, Meijen, McCarthy, & Sheffield, 2009).

The TCTSA is specific to athletes in competitive sport environments, and not only amalgamates and extends previous models of challenge and threat (Blascovich & Tomaka, 1996; Skinner & Brewer, 2004), but also includes Jones's (1995) model of debilitative and facilitative state anxiety. It attempts to explain (1) why athletes may appraise an encounter as a challenge or as a threat, (2) how athletes respond physiologically and psychologically to challenge and threat states, and (3) how the appraised state (i.e., challenge or threat) influences subsequent sporting performance. Self-efficacy beliefs, perceptions of control, and goal orientations are proposed as three interrelated antecedents to challenge and threat appraisals. It is predicted that athletes who feel efficacious, in control, and focus on approach goals in achievement situations will experience a challenge state. By comparison, a threat state is thought to occur when individuals possess low levels of self-efficacy and perceived control, and focus on avoidance goals.

When experiencing a stress-evoking situation, the TCTSA proposes athletes will experience variations in physiological responses depending on how the situation is appraised. A challenge-appraised situation is thought to be characterized by increases in sympathetic-adreno-medullary (SAM) activity, producing an increase in heart rate (HR) and stroke volume (SV), which combined produce an increase in cardiac output (CO). SAM activity also causes vasodilatation (widening of the blood vessels), thus reducing total peripheral resistance (TPR). A threat-appraised situation also elicits an increase in SAM activity, but is also characterized by an increase in pituitary-adreno-cortial (PAC) activity. This PAC activation releases the adrenocorticotrophic hormone, which results in corticosteroids secreted by the adrenal cortex into the bloodstream. Combined SAM and PAC activation is thought to produce changes (i.e., increases in HR, SV, and resulting CO) similar- albeit smaller- to those experienced during a challenge-appraised state (Blascovich, Mendes, Hunter, & Salomon, 1999). TPR is thought to remain unchanged or increase and be accompanied by the release of cortisol during a threat-appraised situation (Jones et al., 2009). In addition, the TCTSA proposes that emotions (e.g., anxiety) experienced in the situation will be differently interpreted depending on its appraisal.

Although higher anxiety levels have traditionally been associated with poorer performance (e.g., Spielberger, 1989), recent work has indicated that the directional perceptions of anxiety symptoms experienced (i.e., whether symptoms are considered to be facilitative or debilitative to subsequent performance) is more influential (e.g., Hanton & Jones, 1999a). Thomas, Maynard, and Hanton (2007) demonstrated that facilitative interpretations of anxiety symptoms associated with higher levels of self-confidence produced greater performance standards compared with more debilitative interpretations. In addition, Hanton and Jones (1999b) used a mental skills intervention to alter athletes' interpretation of their anxiety symptoms from debilitative to a facilitative, which resulted in an improvement in performance for the athletes. The TCTSA suggests that facilitative interpretations of anxiety symptoms will occur when individuals appraise a situation as a challenge whereas a threat appraisal will result in more debilitative interpretations.

The TCTSA suggests a challenge state is developed by targeting self-efficacy, perceived control, and approach goals. Jones et al. (2009) explain that by manipulating an athlete's perceptions of situational characteristics previously evaluated to be a threat, the athlete can reappraise the situation as a challenge. This would lead to more adaptive behavioural tendencies associated with successful performance (Blascovich et al., 2004).

A strategy to modify cognitions and to change undesirable emotional responses is the use of imagery (for reviews, see Cumming & Ramsey, 2009; Martin, Moritz, & Hall, 1999). Athletes have described using imagery to overcome negative interpretations of anxiety symptoms both directly, by viewing them as controllable and facilitative to performance, and indirectly through confidence enhancement (e.g., Hanton, Mellalieu, & Hall, 2004; Thomas et al., 2007). Jones, Mace, Bray, MacRae, and Stockbridge (2002) found that imagery, with an emphasis on remaining in control of emotions and feeling confident and focused, led to lower perceived stress and higher levels of self-efficacy during a climbing task. Specifically using imagery to manipulate cognitive appraisals, Hale and Whitehouse (1998) instructed participants to observe a video and then image themselves experiencing the same scenario of taking a soccer penalty kick. The observed video was identical in both instances apart from the accompanying caption "pressure situation" or "challenge situation". Despite the intensity of HR and self-reported anxiety symptoms being similar in both instances, symptoms were perceived as facilitative for the challenge situation and debilitative for the pressure situation.

Although participants were explicitly informed of which stress appraisal to adopt, the results indicate that cognitive appraisal can be altered by manipulating the imagery's meaning. Consequently, imagery appears to be a viable strategy for promoting a challenge appraised state in athletes.

In support of the TCTSA, both imagery scenarios from Hale and Whitehouse's (1998) study were characterized by elevations in HR. However, it is unclear whether the increased cardiac activity was due to imaging the stressful nature of the imagery or the action of taking a penalty kick. Imaging physical activity can induce physiological responses reflective of actual performance (e.g., Wuyam et al., 1995). Thus inclusion of a control imagery condition is necessary for clarification. In addition, instructing participants to adopt a particular appraisal does not permit conclusions to be drawn as to whether they can appraise the same scenario as a challenge or threat depending on the manipulation of the imagery content's meaning. In sum, research is needed to investigate whether imagery can manipulate antecedents of challenge and threat appraisals within the same individual resulting in physiological activity reflective of those appraisals.

A recent within-subject designed study conducted by Cumming, Olphin, and Law (2007) investigated HR and anxiety responses (intensity and direction) of different imagery scenarios describing the moments before competition. Scenarios were developed based on bioinformational theory's (Lang, 1979) proposal that imagery is composed of stimulus, response, and meaning propositions. Stimulus propositions describe the characteristics of the imagery scenario (e.g., specific details about the competition venue). Response propositions describe the physiological responses an athlete would experience when exposed to the real-life stimulus (e.g., an increase in HR). Finally, meaning propositions explain the relationship between the stimulus and response propositions to the athlete. For example, entering the competition venue may elevate HR in an athlete who interprets this as excitement and anticipation associated with competing. Studies demonstrate response propositions within imagery scenarios can induce actual physiological responses, thereby supporting bioinformational theory (Bakker, Boschker, & Chung, 1996). However, most neglect the meaning of the stimulus and response propositions to the participant. Cumming et al. (2007) investigated whether the interpretation of imagery scenarios containing the same response propositions could differ depending on their meaning to the athlete. Scripts contained identical stimulus information determined by the individual based on a past competitive experience. As expected, HR and anxiety responses reflected imagery response propositions with increases from baseline found only for scripts describing elevated physiological responses. Although two scripts contained an identical description of anxiety symptoms, one included additional information of feeling efficacious and in control of the situation. As expected, anxiety symptoms were perceived as more facilitative to the upcoming performance during this scenario. The absence of imaged physical activity more conclusively supports Hale and Whitehouse's (1998) findings that a challenge- or threat-apprised state will elicit increased HR (Jones et al., 2009). Increased HR during the scenarios describing elevated physiological responses supports Lang's (1979) assumption that responses will reflect the actual situation. Interestingly, when Cumming et al. (2007) manipulated challenge/threat appraisal antecedents (i.e., self-efficacy and perceived control) through imagery, it altered an individual's perceptions of physiological and psychological responses experienced. By altering the meaning of a stress evoking image's stimulus and response propositions through manipulation of the characteristics proposed to influence how a situation is appraised, an athlete could learn to reappraise the stressful scenario as a challenge rather than a threat.

Although Cumming et al. (2007) identified an increase in HR as a result of anxiety inducing imagery, the TCTSA suggests additional cardiovascular responses will be elicited. As previously mentioned, both appraisals are characterized by an increase in HR and SV, producing an increase in calculated CO, although to a lesser extent during a threat appraised state (Jones et al., 2009). Research has supported these predicted cardiovascular patterns (e.g., Blascovich et al., 2004; Blascovich & Tomaka, 1996), but limited research has investigated these responses to stress evoking situations elicited through imagery beyond that of HR. Additional measures have primarily investigated cardiovascular responses to imaged physical activity (e.g., Wuyam et al., 1995). To fill this gap, research should more comprehensively investigate cardiovascular responses to stress-inducing imagery exploring whether elicited responses are reflective of the actual scenario and in accordance with TCTSA during challenging and threatening imagery situations (i.e., increases in HR and SV but overall discrepancies in CO).

The primary aim of our study was to investigate whether imagery could be used to manipulate antecedents proposed by the TCTSA to produce a challenge- or threat-appraised state as reflected by self-reported psychological responses compared to a neutral script (i.e., a script that describes feeling calm and relaxed before competition). By including a more in-depth assessment of cardiovascular responses to different imagery scenarios (HR, SV, and calculation of CO) than previously done (Cumming et al., 2007; Hale & Whitehouse, 1998), a second aim was to examine whether psychological and cardiovascular responses and their interpretations vary according to the cognitive appraisal of three imagery scripts.

It was hypothesised that both stress-evoking scripts would elicit psychological and cardiovascular responses reflective of the imagery content and in accordance to the TCTSA predictions. Specifically, it was hypothesised that although both scripts would elicit increases in symptoms associated with anxiety, HR, SV, and CO, a threat-appraised script would produce a smaller CO increase compared with a challenge-appraised script due to variations in SAM and PAC activation. Moreover, it was hypothesised that elicited responses would be interpreted differently depending on the appraisal of each imagery script. When athletes image a script describing a combination of challenge appraisal characteristics (i.e., having the resources to meet the demands of the situation by feeling efficacious and in control of the situation, and focusing on approach goals), it was expected that they would perceive the physiological and anxiety symptoms experienced as more facilitative to a hypothetical competition. Conversely, imaging a script describing a combination of threat appraisal characteristics (i.e., not having the resources to meet the demands of the situation by not feeling efficacious and in control, and focusing on avoidance goals) would result in athletes perceiving the same symptoms as debilitative to performance. It was predicted that imaging a neutral script would result in no changes in physiological and anxiety level responses.

Method

Participants

Twenty healthy competitive athletes (10 males, 10 females) with a mean age of 20.85 (*SD* = 1.76) years participated in the study. Participants were all club level athletes representing nine different sports with the majority recruited from rugby (*n* = 5), soccer (*n* = 4), lacrosse (*n* = 3), and swimming (*n* = 3), and had competed in their chosen sport for an average of 8.60 years (*SD* = 4.43). None of the participants smoked, had a known history of cardiovascular or respiratory diseases, were currently experiencing illness or infection, nor were they taking prescribed medication other than taking oral contraception by female participants.

Self-Report Measures

Demographic Information. Participants provided information about their age, gender, sport played, competitive level, and years of playing experience. In addition, participants answered questions related to their general health to identify whether they suffered from any known cardiovascular or respiratory diseases or infections.

Imagery Ability. Participants were screened for their imagery ability by completing the Sport Imagery Ability Questionnaire (SIAQ; Williams & Cumming, in press). The SIAQ is a 15-item questionnaire that assesses participants' ease of generating 5 types of imagery content; (1) skill images (e.g., refining a particular skill), (2) strategy images (e.g., creating a new event/game plan), (3) goal images (e.g., myself winning), (4) affect images (e.g., the positive emotions I feel while doing my sport), (5) mastery images (e.g., giving 100% effort even when things are not going well). Ratings are made on a 7-point Likert type scale ranging from 1 *(very hard to image)* to 7 *(very easy to image).* The SIAQ has been identified as a valid and reliable method of imagery ability assessment (Williams & Cumming, in press). For the current study it was important that participants were able to image feelings and emotions associated with performance. Consequently the affect subscale of the questionnaire was used to screen participants. Internal reliability for affect imagery in the present study was good with the CR value being .75, and AVE value being .52.

Cognitive and Somatic State Anxiety and Self-Confidence. Following each imagery scenario the Immediate Anxiety Measurement Scale (IAMS; Thomas, Hanton, & Jones, 2002) assessed the intensity and directional perception of anxiety symptoms and self-confidence experienced by participants. This questionnaire is composed of three items measuring the intensity and direction of cognitive anxiety, somatic anxiety, and self-confidence experienced by the athlete. The IAMS was reworded to assess how anxious and confident athletes felt during each imagery scenario. Participants rated each construct on a 7-point Likert-type scale from 1 *(not at all)* to 7 *(extremely)* for intensity and from -3 *(very debilitative/negative)* to +3 *(very facilitative/positive)* for direction. The IAMS provides definitions of each construct to enable individuals to fully understand the meaning of each one. Thomas et al., (2002) have identified the IAMS to be a valid and reliable measure to assess state cognitive and somatic anxiety and self confidence intensity and direction.

Imagery Manipulation Checks. Participants also filled in a post script evaluation form comprised of four items rated on a 7-point Likert-type scale after each imagery script. The first two items, used by Cumming et al. (2007), assessed the ease participants could generate the imaged scenario and degree of emotion experienced during the imagery. The anchors for these items were 1 *(very hard/no emotion)* to 7 *(very easy/strong emotion)*. The third item assessed how well athletes could relate to the scripts and how meaningful they were perceived to be, ranging from 1 *(not at all meaningful or able to relate)* to 7 *(completely meaningful and able to relate)*. The fourth item assessed how helpful the script was in relation to a hypothetical performance, ranging from -3 *(very hurtful)* to +3 *(very helpful).*

Cognitive Appraisal of Imagery Scripts. To assess the extent participants perceived each imagery situation as challenging or threatening, six items were developed from items employed by McGregor and Elliot (2002). Each described how an individual may feel about an upcoming competition, with the wording modified so that participants appraised the previously heard competitive imagery scenario. The three items reflecting a challenge appraisal included, "I viewed the competition as a challenge", "the situation presented itself as a challenge to me", and "I felt challenged by the situation". The three items representative of a threat appraisal were identical apart from inserting the word "threat" to replace the word "challenge" (e.g., "I viewed the competition as a threat"). Consequently two subscales were produced for the questionnaire. Participants rated the extent to which they agreed with each item ranging from 1 *(not at all true)* to 7 *(very true)*. Adequate reliability for each subscale following each imagery script can be seen in Table 1, with Cronbach's alpha coefficient being .78 or above.

Postexperiment Manipulation Check. Following the experiment all participants selected the script they thought would be most helpful in preparing them for an actual competition. The final part of the questionnaire asked participants to indicate the extent the overall scanning procedure disrupted their imagery. Responses ranged from 0% *(not at all disruptive)* to 100% *(completely disruptive)*.

Apparatus and Physiological Measurements.

Heart Rate (HR). Heart rate was monitored continuously using a single lead electrocardiogram (Micromon, Charter-Kontron Ltd).

Stroke Volume (SV). Stroke volume was measured using Doppler echocardiography from an apical five-chamber view of the heart to identify systolic blood flow through the aortic valve. The velocity profile of aortic blood flow was obtained using a pulsed-wave spectral mode at a screen sweep speed of 100 $mm \cdot s^{-1}$. Doppler measurements of blood flow were taken immediately below the orifice of the aortic valve using a Philips Sonos 7500 ultrasound machine equipped with an S3 two-dimensional transducer (1-3 MHz). Continuously recorded digital spectral waveform images were obtained and used in later analysis for each minute. An additional measurement of the aortic valve diameter was obtained from a parasternal long axis view during the second visit to calculate aortic valve area (A) and subsequently SV.

Physiological Calculations

Aortic blood flow was automatically quantified using the velocity time integral (VTI). This is the mean distance blood travels through the aortic valve during ventricular contraction. A VTI measurement for each minute was obtained by averaging three or more spectral waveforms recorded during that minute from the Doppler ultrasound machine. Similarly, HR for each minute was obtained by averaging the beats per minute provided with the same spectral waveforms used to calculate VTI. Aortic blood flow measurements and HR were therefore averaged across 60-s intervals. Aortic valve diameter was used to calculate A using the following formula: $A = \pi r^2$. SV was then calculated using the following formula: VTI × A. Finally, CO was calculated using the following formula: HR × SV. A value of HR, SV, and

CO for the 9 min of each imagery trial was calculated. Following this procedure, the 3 min of baseline and 3 min of recovery were each averaged, providing a baseline and recovery value. Consequently, physiological data was statistically analyzed over five time points: baseline, 3 min of imagery, and recovery.

Procedures

Development and Pilot Testing of Imagery Scripts. Three imagery scripts describing the moments before a hypothetical competition were developed for the study. These were all devised based on the recommendations of Lang's (1979) bioinformational theory and available examples from the literature (e.g., Cumming et al., 2007). Content to specifically manipulate a challenge or a threat appraisal was based on characteristics proposed by the TCTSA (Jones et al., 2009). Before data collection, these scripts were pilot tested with five competitive athletes and then slightly modified based on feedback received.

Scripts were designed to make the content personally meaningful for each athlete while keeping certain instructions consistent across participants. Similar to Cumming et al. (2007), individuals were asked to recall a previous competitive experience and base their imagery on this memory to create specific stimulus propositions within each script. Unlike the personalized stimulus propositions, response propositions were manipulated during the study, and with the exception of the neutral script, described a series of events creating a stress-evoking situation requiring a cognitive appraisal to be made (e.g., "you feel the adrenalin rush through your body reaching all your muscles"). The neutral script also described the moments before competition. However, its response propositions were not intended to be stress evoking but referred to feeling calm and confident before the competition (e.g., "any anxiety you previously experienced has completely evaporated from your body"). Stress-evoking scripts described disturbances in athlete preparation and emphasized the importance of the upcoming competition with the odds being against the athlete. Both contained the exact same characteristics and occurrence of events (stimulus) and the way the athlete physiologically responded to each of these (response propositions). Only the meaning of these responses differed between the challenge- and threat-appraised scripts. The challenge script emphasised a challenge appraisal by indicating the athlete's resources met demands of the situation, and included feelings of high efficacy (e.g., "you have confidence in your own ability to perform") and control (e.g., "demonstrating your sporting competence"), and emphasised a potential to gain (e.g., "there is real potential to achieve everything"; Jones et al., 2009). Conversely, the threat script emphasized a threat appraisal indicating that the athlete's resources did not meet demands of the imaged situation, which included feelings of low efficacy (e.g., "you cast doubts about your own ability to perform") and control (e.g., "concerned about revealing your weaknesses"), and emphasised a potential of loss (e.g., "there is real potential to lose everything"; Jones et al., 2009). A copy of all three scripts can be found in the appendix of this thesis.

During the first visit, participants imaged each script whilst attached to the equipment measuring physiological responses. This was to ensure a spectral trace was obtainable from all participants and they were able to image the different aspects of the scenarios. All scripts were delivered to participants in a counterbalanced order which remained consistent for both laboratory visits.

Recruitment. Following ethical approval of the study from the ethics committee at the university where the authors are based, participants were recruited from different sports clubs. Participation comprised two visits to the laboratory each 24 hr apart, with the first and second visits lasting approximately 90 and 60 min respectively. All participants were tested on an individual basis and refrained from consuming food and caffeine within 3 hr and consuming alcohol or partaking in exercise within 12 hr of each laboratory visit. All females participated within the first 14 days of their menstrual cycle or during a day when oral contraception was consumed.

Visit 1. The first visit was divided into two parts. Participants were first given an information sheet and explained the requirements of the study by an investigator. Those who agreed to participate understood it was voluntary and signed a written consent form. Participants then provided their demographic and general health information to ensure they were suitable to participate. A definition of mental imagery was then provided (White & Hardy, 1998) and participants were screened for their imagery ability by completing the SIAQ. Participants then took part in a training exercise based on the recommendations of Lang, Kozak, Miller, Levin, and McLean (1980) to show participants how they can maximize the effectiveness of imagery (i.e., stimulus and response training). Participants were made aware of specific stimulus details within an imagined scenario and then encouraged to consider how these details might make them respond physiologically and emotionally. They were then asked to recreate these feelings and responses in subsequent images of the described scenario. Finally participants were introduced to the IAMS, post script evaluation form, and script appraisal questionnaires and it was explained that all were to be completed following each script.

The second part of Visit 1 was to familiarise participants to the equipment used to record physiological responses. The electrocardiogram leads were attached to the participant to provide a HR value and a spectral trace of the participant's heart was obtained. Individuals reclined on a couch tilted to the left to provide an easily obtainable trace. Participants listened to the imagery scripts via headphones whilst physiological measurements were obtained to familiarize themselves with the process. All imagery scripts were prerecorded and played on a Samsung YP-U1 MP3 player through headphones.

Each imagery script's trial included a baseline, imagery, and recovery phase. Before the baseline, participants maintained the correct reclined position and were reminded of the stimulus and response training they received previously. They were instructed to image the scenario as clearly and vividly as possible from their preferred imagery perspective (Hall, 1997) with their eyes open or closed. During 3 min of baseline recording, participants were asked to breathe deeply and relax so stable baseline rates could be maintained and ensure that any changes during the imagined scenario would be more clearly detected (Lang et al., 1980). Following baseline, the imagery scripts began to play automatically and lasted 3 min in duration. After each script, a further 3 min of physiological recordings were obtained during the recovery phase, during which time the participant was instructed to relax and clear their mind of the imagery just experienced. Consequently, any changes in physiological responses during the imagery phase could be observed returning to baseline level. At the end of the recovery phase physiological recording stopped and from a sitting position participants completed the IAMS, post script evaluation form, and cognitive appraisal of the imagery script. The process was then repeated for the remaining two scripts. All data obtained in Visit 1 was to familiarize participants to the equipment and protocol of the study, consequently data were not included in the analysis.

Visit 2. The second visit was nearly identical to the second part of Visit 1. Upon arrival to the laboratory, participants were reintroduced and attached to the equipment used during the first visit, and reminded of the stimulus and response training received. Participants adopted the same reclined position, and baseline recordings were obtained. The procedures described for Visit 1 were followed for each imagery script. After the IAMS, post script evaluation form, and imagery script appraisal were completed for the final script, participants were asked to complete the postexperimental manipulation check before their aortic valve diameter was measured to quantify A and calculate SV. Finally, participants were debriefed about the study and thanked for their participation.

Results

Preliminary Analyses

Statistical Analyses. Repeated-measures ANOVAs and repeated-measures MANOVAs were used for the preliminary and main data analyses. Pillai's trace was always reported as it is considered the most robust of multivariate significance tests (Olson, 1976). When appropriate, Mauchly's test of sphericity was used to examine the equality of the within-subject factor. If data violated the assumption of homogeneity of the variance-covariance matrices ($p < .05$), the degrees of freedom of the subsequent univariate tests were reduced by reporting the Greenhouse-Geisser correction (Greenhouse & Geisser, 1959).

Imagery Screening. Participants' ease of imaging feelings and emotions was assessed using the SIAQ affect subscale. Participants reported a mean score of 6.22 (SD = 0.68). Furthermore, all participants scored 5 *(somewhat easy to image)* or above meaning no participants were excluded from the study.

Imagery Manipulation Checks. Participants' ease of imaging the challenge, neutral, and threat, imagery scripts was assessed following each one. Participants reported a mean score of 5.25 (5 = *somewhat easy to image*) or above for ease of imaging each imagery script and 4.70 (4 = *moderate emotion*) or above for how emotive the scripts were. A repeated measures MANOVA revealed no significant differences between the three imagery scripts for ease of imaging or emotion produced (dependent variables; observed power = 66%). Athletes reported all scripts to be meaningful and they were able to relate to the content in each script with mean scores of 4.65 or above (4 = *moderately meaningful and able to relate*) for each script. A repeated-measures ANOVA revealed no significant differences in how meaningful and how well athletes could relate to the scripts (observed power = 45%). A repeated-measures ANOVA identified significant differences between imagery scripts in their perceived helpfulness in relation to a hypothetical performance, $F(2, 38) = 31.19$, $p < .001$, $\eta^2 = .62$, observed power = 100%. Post hoc analysis indicated the threat script was perceived as significantly less helpful than the challenge and neutral scripts. Means and standard deviations of the post script evaluation form for each script are reported in Table 1.

Table 1.

Cognitive appraisal and post script manipulation checks for each imagery script.

a) Post Intervention Imagery Evaluation		Scripts		
		Challenge	Neutral	Threat
Ease of imaging (1 = *very hard*, 7 = *very easy*)	*M*	5.55	5.35	5.25
	SD	1.00	0.99	0.85
Strength of emotion (1 = *very hard*, 7 = *very easy*)	*M*	5.25	4.07	5.05
	SD	1.02	1.49	1.23
Extent image was relatable and meaningful (1 = *not at all meaningful*, 7 = *very meaningful*)	*M*	5.25	4.65	4.65
	SD	1.07	1.38	0.81
Perceived Helpfulness (-3 = *very hurtful*, +3 = *very helpful*)	*M*	1.75 [a]	1.15 [a]	-1.35
	SD	0.91	1.60	1.14
b) Cognitive appraisal		**Scripts**		
		Challenge	Neutral	Threat
Challenge Appraisal (1 = *not at all true*, 7 = *very true*)	*M*	4.88 [b]	2.87	4.88 [b]
	SD	0.94	1.30	1.02
	α	0.86	0.83	0.92
Threatening Appraisal (1 = *not at all true*, 7 = *very true*)	*M*	2.78 [b]	1.73	4.73 [bc]
	SD	1.06	0.53	1.29
	α	0.91	0.78	0.96

Note. [a] = significantly greater than the threat script ($p < .001$), [b] = significantly greater than the neutral script ($p < .001$), [c] = significantly greater than the challenge script ($p < .001$).

Postexperimental manipulation checks. When indicating which script would be considered most helpful for performance, 70% of participants selected the challenge script and the remaining 30% of participants selected the neutral script. No participants chose the threat script to be most helpful. During the experiment, a mean score of 36% (40%= *somewhat disruptive*) indicated the extent participants felt the physiological equipment disrupted their imagery.

Cognitive Appraisal of Imagery Scripts. A repeated-measures MANOVA determined whether any differences existed in perceptions of how challenging or threatening the imagery scripts were to participants. Gender was included as a between-subject variable due to previous studies identifying differences in how males and females appraise situations (e.g., Folkman & Lazarus, 1980). Results revealed no significant difference due to gender (observed power = 62%) and no significant interaction between gender and imagery script (observed power = 52%). There was however a significant multivariate effect due to imagery script, Pillai's trace = 1.13, $F(4, 72) = 23.35$, $p < .001$, $\eta^2 = .57$, observed power = 100%. Results examined at the univariate level revealed a significant difference in challenge appraisal, $F(2, 36) = 23.28$, $p < .001$, $\eta^2 = .56$, observed power = 100%, and threat appraisal, $F(2, 36) = 65.77$, $p < .001$, $\eta^2 = .79$, observed power = 100%. As can be seen in Table 1, post hoc analysis revealed both challenge and threat scripts were perceived as more challenging compared with the neutral script. The threat script was also perceived to be more threatening than the challenge script, which in turn, was perceived to be more threatening than the neutral script.

Main Analyses

Three separate 3 (imagery script) x 5 (time points) repeated-measures ANOVAs were carried out to assess differences in HR, SV, and CO elicited as a result of the 3 imagery scripts. Because all three cardiovascular measures are correlated, to reduce the likelihood of a type I error, a Bonferroni adjustment was performed to set a more conservative significance level of $p < .017$. Post hoc analysis on significant effects determined differences among the 5 time points: baseline, 3 min of imagery, and recovery. An additional 3 (imagery script) x 5 (IAMS subscales) repeated-measures MANOVA assessed differences in state cognitive and somatic anxiety intensity and direction and self-confidence following each script. For significant effects, post hoc analysis was again carried out between the three scripts.

HR Response. Results revealed a significant main effect for time, $F(2.63, 49.88) = 10.18$, $p < .001$, $\eta^2 = .35$, observed power = 99%. Although there was no main effect for script, there was a significant time by script interaction, $F(4.42, 84.01) = 6.09$, $p = .001$, $\eta^2 = .24$, observed power = 99%. Post hoc analysis comparing the imagery scripts at each time point (i.e., between scripts) revealed at Time Points 3 and 4 (2nd and 3rd minutes of imagery) HR was significantly higher during the challenge and threat scripts compared with the neutral script. In addition, post hoc analysis comparing both the challenge and threat script across all 5 time points (i.e., within script) revealed HR at points 3 and 4 (2nd and 3rd minute of imagery) was significantly higher than at Points 1 and 5 (baseline and recovery). Furthermore, HR at Time Point 2 of the threat script (1st minute of imagery) was significantly higher than at Point 5 (recovery). Finally, post hoc analysis for the neutral script revealed no significant differences across all 5 time points. Means and standard errors of HR can be seen in Figure 1.

SV Response. Results revealed a significant main effect for time, $F(2.10, 39.87) = 80.03$, $p < .001$, $\eta^2 = .81$, observed power = 100%, and a significant main effect for script, $F(2, 38) = 17.40$, $p < .001$, $\eta^2 = .48$, observed power = 100%. There was also a significant time by script interaction, $F(8, 152) = 19.42$, $p < .001$, $\eta^2 = .51$, observed power = 100%. Inspection of post hoc analysis comparing all three scripts at each time point (i.e., between script) revealed SV was significantly higher during the challenge and threat scripts compared to the neutral script during all three minutes of imagery (Time Points 2, 3, and 4). Post hoc analysis comparing SV of the each script across all time points (i.e., within script) revealed for the challenge and threat scripts, the three minutes of imagery (Time Points 2, 3, and 4) elicited a significantly higher SV compared to baseline (Minute 1) and recovery (Minute 5). In addition, the third minute of imagery (Time Point 4) during the challenge and threat script produced a significantly higher SV than the first minute of imagery (Time Point 2). No significant differences in SV were found across the 5 time points for the neutral script. Means and standard errors for SV can be seen in Figure 1.

CO Response. Results revealed a significant main effect for time, $F(2.16, 41.01) = 47.90$, $p < .001$, $\eta^2 = .72$, observed power = 100% and a significant main effect for script, $F(2, 38) = 7.19$, $p = .002$, $\eta^2 = .27$, observed power = 91%. There was also a significant time by script interaction, $F(4.65, 88.31) = 22.60$, $p < .001$, $\eta^2 = .54$, observed power = 100%. Post hoc analysis comparing all three scripts at each time points (i.e., between scripts) revealed CO to be significantly higher for the challenge and threat scripts compared to the neutral script during Time Points 3 and 4 (2^{nd} and 3^{rd} minute of imagery). Post hoc analysis comparing CO for each script across the 5 time points (i.e., within script) revealed that for the challenge and threat scripts, all three minutes of imagery (Time Points 2, 3, and 4) elicited a significantly higher CO compared to baseline and recovery. In addition, the second and third minute of imagery (Time Points 3 and 4) during the challenge script produced a significantly higher CO than the first minute of imagery (Time Point 2) and the second minute of imagery (Time Point 3) during the threat script produced a significantly higher CO compared with the first minute of imagery (Time Point 2). There were no differences across the time points with regards to the neutral script. Means and standard errors of CO are presented in Figure 1.

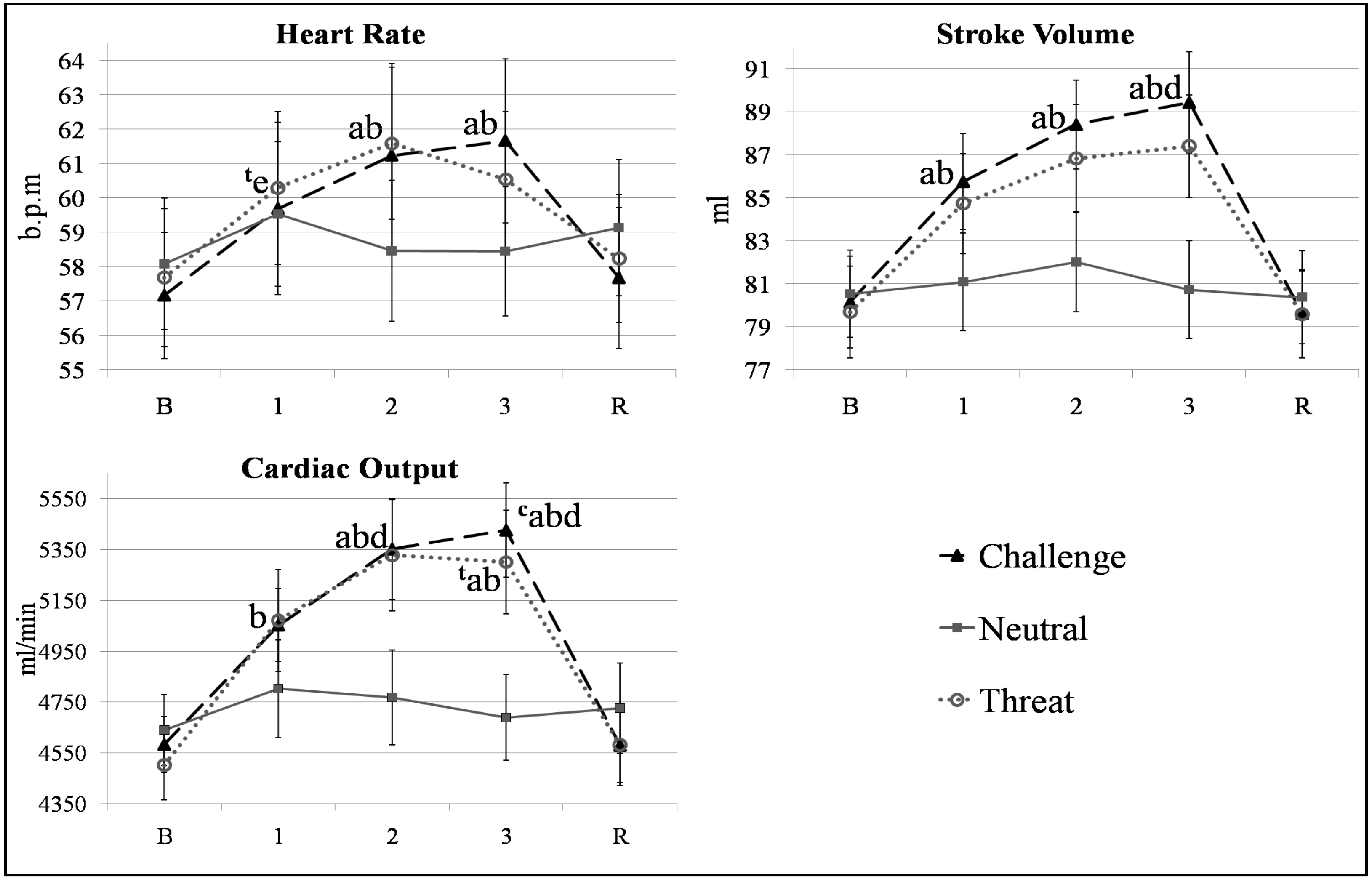


Figure 1. Mean heart rate, stroke volume, and cardiac output values for each imagery script during the 5 time points. Letters represent the challenge and threat scripts significantly differing (p < .05) from the neutral script (a), baseline and recovery (b), 1st minute of imagery (d), and recovery only (e). Any differences for only one script are characterized by a preceding c or t to represent a challenge or threat script respectively. Error bars represent standard errors.

Table 2.

Mean and standard deviations for cognitive and somatic anxiety symptoms intensity and direction and self-confidence intensity.

	Script Scores					
	Challenge		Neutral		Threat	
IAMS Dimensions	*M*	*SD*	*M*	*SD*	*M*	*SD*
Cognitive anxiety intensity	4.05 [a]	1.00	2.15	0.99	5.15 [ab]	0.81
Somatic anxiety intensity	4.50 [a]	1.36	2.30	0.98	4.70 [a]	1.26
Self-confidence intensity	5.15 [c]	0.75	5.05 [c]	1.23	2.80	1.20
Cognitive anxiety direction	1.40 [c]	0.88	1.25 [c]	1.55	-0.55	1.57
Somatic anxiety direction	1.00 [c]	1.30	0.65	1.53	-0.30	1.22

Note. [a] = significantly greater than the neutral script ($p < .001$), [b] = significantly greater than the challenge script ($p < .001$), [c] = significantly greater than the threat script ($p < .01$).

IAMS. Results revealed a significant multivariate effect, Pillai's trace = 1.41, $F(12, 68) = 13.59$, $p < .001$, $\eta^2 = .71$, observed power = 100%. Inspection at the univariate level for anxiety symptom intensity revealed a significant effect for cognitive anxiety, $F(2, 38) = 58.61$, $p < .001$, $\eta^2 = .76$, observed power = 100%, and somatic anxiety, $F(2, 38) = 41.60$, $p < .001$, $\eta^2 = .69$, observed power = 100%. Post hoc analysis revealed the challenge and threat scripts produced significantly higher scores compared to the neutral script for the intensity of both cognitive and somatic anxiety symptoms. The threat script also produced a significantly higher cognitive anxiety score compared to the challenge script. Inspection of the univariate level findings for anxiety symptom direction revealed a significant effect for both cognitive direction, $F(2, 38) = 12.86$, $p < .001$, $\eta^2 = .40$, observed power = 100%, and somatic direction, $F(2, 38) = 5.22$, $p = .01$, $\eta^2 = .22$, observed power = 80%. Post hoc analysis indicated that symptoms associated with cognitive anxiety experienced after the challenge and neutral scripts was perceived as more facilitative to performance compared with the threat script anxiety symptoms. Furthermore, somatic anxiety experienced after the challenge script was perceived as more facilitative compared with the threat script symptoms. Lastly, inspection at the univariate level revealed a significant effect for self-confidence intensity, $F(2, 38) = 47.87$, $p < .001$, $\eta^2 = .72$, observed power = 100%. Post hoc analysis revealed participants felt significantly more confident following the challenge and neutral scripts compared with the threat script. Means and standard deviations are presented in Table 2.

Discussion

The aim of the study was to investigate whether imagery could be used to manipulate antecedents producing a challenge- and threat-appraised state as reflected in self-reported psychological responses. A second aim was to include an in-depth assessment of cardiovascular responses to investigate whether psychological and cardiovascular responses varied in magnitude and interpretation according to cognitive appraisal and in line with the TCTSA (Jones et al., 2009). It was hypothesised that in accordance to the TCTSA predictions, both stress-evoking imagery scripts would elicit increases in symptoms associated with anxiety, HR, SV, and CO. It was also proposed that calculated CO during the threat-appraised script would be lower than that calculated during a challenge appraised imagery scenario. Finally, it was hypothesised responses would be interpreted as facilitative and debilitative to performance following a challenge- and threat-apprised scenario, respectively.

Screening participants for their imagery ability meant that all participants were able to image the feelings and emotions associated with participation – a characteristic previously identified as influencing physiological responses to imagery (e.g., Guillet Collet, & Dittmar, 2004). Furthermore, ease of imaging ratings for all three scripts revealed no significant differences, indicating that variations in physiological responses was not due to differences in the ability to image scripts. Script stimulus propositions were individualized to produce more meaningful imagery (Lang, 1979). Although response and meaning propositions were manipulated, manipulation checks revealed athletes could relate to all three scenarios identifying them to be meaningful and emotive. An interesting finding was that the neutral script was perceived to be as emotive and meaningful as the challenge and threat scripts. A somewhat low statistical power resulting from the analysis could mean that the sample size was too small to detect statistical differences between scripts. However, previous research has suggested that imagery with personalized propositions can elicit more emotion from an individual (Lang, 1979). As all three scripts were equally personalized with individualized stimulus propositions, it is possible that these personally meaningful stimulus propositions were sufficient to enable participants to experience an emotive scenario to a similar extent in all three scripts.

In support of our hypothesis, the challenge and threat scripts caused an increase in anxiety intensity compared to the neutral script. Consistent with Hale and Whitehouse (1998), a greater intensity of cognitive anxiety was experienced during the threat script compared with the challenge script. It is suggested that a greater cognitive intensity was experienced during the threat scenario due to the script containing more thoughts of concern and worry (e.g., "…you are concerned about the possibility of revealing your weaknesses"). Such elements are described by the IAMS as symptoms of cognitive anxiety. Unlike Hale and Whitehouse (1998), results revealed a similar intensity of somatic anxiety symptoms for both the challenge and threat scripts. This finding, which is similar to previous studies using stress-evoking imagery (Cumming et al., 2007), is likely due to both scripts containing the same response propositions describing physiological activation being experienced. Such responses are described on the IAMS questionnaire as symptoms reflective of somatic anxiety. A more important finding is that the increased anxiety, similarly to the neutral script, was perceived as facilitative during the challenge script but debilitative during the threat script. These findings comply with previous studies investigating interpretation of anxiety symptoms in response to stress appraising imagery (Cumming et al., 2007; Hale & Whitehouse, 1998). Moreover, athletes perceived the challenge and neutral imagery scripts to be significantly more helpful to sporting performance compared with the threatening script. In addition, 14 athletes (70%) selected the challenge script as most helpful towards performance, indicating that although not all participants perceived a higher level of arousal and activation facilitative towards performance, the majority of athletes in this sample preferred it to a relaxed state (neutral script). In accordance with the TCTSA, results suggest negative emotions can be experienced during a challenge state but will facilitate performance (Jones et al., 2009). By comparison, the similar somatic anxiety intensity experienced during a threat appraised scenario is perceived as more debilitative to performance. Together, these findings further reinforce the interpretation of anxiety symptoms being an important factor in predicting successful performance (e.g., Hanton & Jones, 1999b; Thomas et al., 2007).

Differences in self-confidence between scripts indicated the challenge and neutral scripts produced higher levels compared to the threat scenario. This provides partial support to the TCTSA, which predicts a challenge appraisal is more likely if the athlete possesses high levels of self-efficacy - a more specific form of self-confidence (Bandura, 1977). Self-confidence differences are consistent with Cumming et al. (2007) and support Martin et al.'s (1999) suggestion that imagery can protect against debilitative interpretations of anxiety by maintaining high levels of self-confidence or allowing athletes to perceive symptoms as controllable and facilitative (also see Hanton et al., 2004; Thomas et al., 2007).

An increase in HR, SV, and CO occurred during the challenge and threat scripts but not during the neutral script. This increase in cardiovascular responses during both stress evoking scripts replicates previous findings (Hale & Whitehouse, 1998). The lack of measurable response during the neutral script is supportive of Lang's proposal (1979) that elicited responses will reflect the imagery script content as this script contained no response propositions referring to increases in physiological activation. The observed increases in SV and CO provide a more comprehensive insight into the physiological responses elicited through psychological stress-evoking imagery. Heart rate and SV increases support our hypothesis, aligning with the biopsychosocial model of challenge and threat and TCTSA, that imagery appraised as a challenge or a threat will produce an increase in HR and SV, resulting in an overall increase in CO (Blascovich et al., 2004; Jones et al., 2009). Contrary to our hypothesis and predictions of the biopsychosocial model of challenge and threat and TCTSA, we were unable to detect any discrepancies in CO between the challenge and threat scripts. According to both models, a challenge-appraised situation is thought to be characterised by a larger increase in CO compared with a threat-appraised state (Blascovich et al., 2004; Blascovich & Tomaka, 1996; Jones et al., 2009).

A possible explanation for a lack of distinguishable differences in CO could be due to the cognitive appraisal of the challenge and threat script. Although results of the cognitive appraisal revealed the threat script was appraised to be significantly more threatening than the challenge script, both were perceived to be equally challenging. The discrepancies in threat appraisal might have influenced different response interpretations whereas the similar challenge appraisal may have led to indistinguishable cardiovascular responses (HR and SV), resulting in no CO discrepancies between threat and challenge scripts. A second explanation surrounds the nature of the stressor. Compared with active stressors which directly engage individuals in the situation, imagery is more suitably classed as a passive stressor. During imagery, the person is typically removed from the actual situation but still exposed to emotionally evocative stimulus materials. Because passive stressors may inhibit challenge appraisals, the physiological responses obtained may be explained by the nature of the stressor rather than the situation appraisal (Tomaka, Blascovich, Kelsey, & Leitten, 1993).

Despite no physiological distinction between both stress-evoking scenarios, the results nevertheless have applied implications. By attempting to manipulate self-efficacy, perceived control, and achievement goals through stress-evoking imagery, athletes varied in their cognitive appraisal of the upcoming hypothetical competition. Despite experiencing elevations in competitive anxiety, this was perceived as facilitative to performance when athletes imaged themselves feeling efficacious and in control of the situation, and sensed a potential to gain from the experience. Thus, athletes susceptible to a threat appraisal of stressful scenarios could use imagery to alter cognitive appraisals and associate experienced physiological and psychological responses as facilitative to performance. As a result of a more adaptive coping approach, improvements in performance might then occur.

Despite the contribution of novel findings, the study is not without its limitations. Although it is a strength that we incorporated a more sophisticated technique assessing cardiovascular indices to stress-evoking images, the procedure may be have been intrusive and distracting to the imagery process. The recorded physiological and psychological responses may have therefore been somewhat inhibited and not fully representative of those elicited through stress-evoking imagery. It should be noted, however, that the first visit to the laboratory was designed to acclimatise the participants to imaging under these conditions. Furthermore, participants rated that the scanning procedure on average only “somewhat” disturbed their imagery. In addition, to obtain a clear VTI trace, participants were required to adopt a supine position and roll slightly to their left side. Although this physical position is not equivalent to the position adopted by the individual in the real-life situation (e.g., Holmes & Collins, 2001), it was necessary in the current study to obtain such detailed cardiovascular responses. Despite this less-than-ideal physical position, discernable responses were found between the stress-evoking and neutral imagery scripts. Secondly, a somewhat small sample size may explain the slightly low observed power in some of the preliminary analysis.

Despite this issue, the statistical power was more than sufficient for the main analysis. Finally, the similarity in challenge appraisals for the challenge and threat scripts suggests a possible lack of internal validity due to some overlap occurring. However, the significant difference in threat appraisal for both scripts indicates that participants did distinguish between the scripts. Future improvements could be made by attempting to more clearly distinguish the appraisal of stress-evoking imagery scenarios appraised as a challenge or threat.

Results from the study suggest possible avenues of future research. Other responses thought to discriminate between challenge and threat states includes TPR reduction due to SAM activity releasing epinephrine relaxing blood vessels during a challenge state, and the release of cortisol with unchanged or increased TPR due to increased PAC activity during a threat state (Jones et al., 2009). Future imagery research may expand the measurement of physical responses to include such measures to provide other objective indications of imagery content as well as how imagery scenarios are appraised. An additional next step would be to examine the effects of stress-evoking imagery on actual performance. When compared to a threat-appraised imagery scenario, our findings indicate that challenge-appraised imagery leads to more positive interpretations of responses and is considered more helpful towards an upcoming performance. Unknown is whether these interpretations will translate to a more successful performance. To our knowledge there is no direct evidence to demonstrate that challenge images can produce better performance. However, research suggests this might occur owing to the fact that imagery containing characteristics reflective of a challenge (e.g., facilitative perceptions of anxiety) can produce performance improvements. In conclusion, results from the present study indicate imagery to be effective in altering an athlete’s appraisal of a stressful situation. By having athletes image a stressful scenario, we demonstrated that manipulating the meaning of stimulus and response propositions can alter an athlete’s perception of a potentially stressful event, which may be harmful to psychological well-being and performance. A threat-appraised scenario produced debilitative interpretations whereas a challenge appraisal led to facilitative interpretations of responses experienced. We identified stressful imagery, without reference to physical activity, to elicit increases in SV as well as HR which supported assumptions of the TCTSA. However, indistinguishable differences in CO between a challenge and threat script opposes existing literature (Blascovich et al., 2004; Jones et al., 2009). Nevertheless imagery can be used by athletes to alter their stress appraisal and produce more facilitative interpretations of responses resulting in more adaptive coping strategies.

Chapter 7

General Discussion

Elements of this manuscript have been accepted for publication under the following reference: Cumming, J. & Williams, S. E. (in press). The role of imagery in performance. In S. Murphy (Ed), *Handbook of Sport and Performance Psychology*. New York, NY: Oxford University Press.

The aim of this thesis was to extend the existing literature on an individual's capacity to create and control vivid images known as "imagery ability". It aimed to establish a more comprehensive assessment of movement imagery ability and sport imagery ability, investigate how imagery ability can be improved, and examine the influence of imagery ability on various psychological and physiological responses. This was done by refining a measure of movement imagery ability and developing a new measure of athlete imagery ability, with both assessments extensively validated across five empirical chapters.

Summary of Results

Chapter 2

Using a multitrait multimethod (MTMM) approach to confirmatory factor analysis (CFA), Chapter 2's first study comprehensively validated the Movement Imagery Questionnaire-Revised (MIQ-R) as a measure of visual and kinaesthetic movement imagery ability. The questionnaire was extended in Study 2 to provide a more comprehensive assessment of visual imagery (VI) ability by separately assessing external visual imagery (EVI) and internal visual imagery (IVI) alongside kinaesthetic imagery (KI). The modified MIQ-R, known as the Movement Imagery Questionnaire-3 (MIQ-3), was then validated using MTMM CFA.

The best fitting model in Study 1 was a correlated trait-correlated uniqueness (CTCU) model that acknowledged the MIQ-R assesses two imagery traits (i.e., VI and KI) with the same 4 methods (i.e., knee lift, jump, arm movement, and waist bend). Method effects were accounted for by including correlated error terms derived from items of the same measurement method (e.g., correlations between the error terms of the two knee lift items). Unlike Monsma, Short, Hall, Gregg, and Sullivan's (2009) findings, results in Chapter 2 revealed the CTCU model did not differ for males and females. This discrepancy between studies may be due to Chapter 2's MTMM approach that considers method effects. This procedure was not previously employed by Monsma et al. (2009). Finally, invariant latent mean structures of males and females revealed no significant differences in VI and KI ability due to gender.

Once the MIQ-R factor structure was established, the questionnaire was modified to comprehensively assess visual movement imagery ability. Instructions were adapted so the same 4 items separately assessed EVI and IVI alongside the already existing KI subscale. To reflect measurement of three imagery traits, the questionnaire was named the MIQ-3. Results of the MTMM CFA, gender invariance testing, and comparison of latent means structures were similar to Study 1. The CTCU model provided the best fit to the data, which was again invariant across gender, and latent mean scores of EVI, IVI, and KI ability also did not differ between males and females. The CTCU model was compared with two alternative 2-factor models to ensure EVI, IVI, and KI were all separate traits of imagery ability and clarify dispute in the literature as to whether VI and KI are related constructs (see Lorant & Nicholas, 2004; Monsma et al., 2009). Poor model fit for alternative models supported the 3-factor structure of the MIQ-3. Finally significant correlations between each MIQ-3's subscale and its respective subscale on the VMIQ-2 confirmed the MIQ-3's concurrent validity. In sum, Chapter 2 developed and validated a more comprehensive measure of movement imagery ability which is not influenced by recency effects or discrepancies between the actual and required imagery content (Lequerica, Rapport, Axelrod, Telmet, & Whitman, 2002).

Chapter 3

Chapter 3 aimed to investigate potential effects the MIQ-3 has on reported imagery ability by accounting for any recency effects. Because imagery can activate and prepare neurons to fire more accurately during execution (Murphy, Nordin, & Cumming, 2008), prior physical performance could possibly activate and prepare neurons to fire more accurately during imagery, thus improving movement imagery ability. Due to similar neural activity areas between movement imagery, observation and execution (Buccino et al., 2001; Ehrsson, Geyer, & Naito, 2003), Chapter 3 also investigated whether observation could similarly influence reported imagery ability. Participants completed the MIQ-3 under four conditions: (1) movement only whereby the MIQ-3 was completed in its usual format where physical performance preceded imagery; (2) external observation in which observing the movement from an external perspective replaced physical performance; (3) internal observation whereby observing the movement from an internal perspective replaced physical performance; and (4) image only whereby participants completed the MIQ-3 with no prior movement or observation.

Greater ease of imaging was reported during the movement and observation conditions compared to the image only confirming movement and observation both prime imagery ability. Interestingly, observation only primed VI ability when the imagery and observation perspectives were congruent (i.e., external observation primed EVI, and internal observation primed IVI). This highlights the benefits movement and observation can have when used prior to imagery as imagery is more beneficial for individuals with higher levels of imagery ability (e.g., Goss Hall, Buckolz, & Fishburne, 1986; McKenzie & Howe, 1997). However, the chapter also demonstrates for observation to facilitate VI ability, observation perspective must match the VI perspective adopted.

Chapter 4

The aim of Chapter 4 was to create and validate a sport specific imagery ability measure that addressed the gap between images athletes use and the existing measures of assessment. The Sport Imagery Ability Questionnaire (SIAQ), was designed to assess athletes' ability to image content representative of the five imagery functions highlighted by Hall, Mack, Paivio, and Hausenblas (1998) (i.e., CS, CG, MS, MG-A, and MG-M imagery) when developing the Sport Imagery Questionnaire (SIQ). Initial items were developed from existing SIQ items. Extensive pilot testing reduced the initial 35 items to 20 that underwent further wording modifications. These 20 items were distributed to another heterogeneous sample of athletes assessing ease of imaging different imagery content. Principle axis factoring with oblimin rotation revealed 12 items contributed to 4 meaningful factors which measured ease of imaging skill, strategy, goal, and affect images.

Study 2's CFA confirmed the four-factors identified in Study 1. In Study 3 the three items that almost loaded on a fifth factor in Study 1 were modified and added to the 12-item questionnaire to examine whether a fifth factor existed. CFA confirmed a first order correlated five-factor questionnaire which assessed skill, strategy, goal, affect, and mastery imagery. To ensure no model provided a better fit, the 5-factor model was compared to alterative ones. These included a one-factor model, a five-factor uncorrelated trait model, and a two-factor correlated trait (CT) model. A poor fit emerged for all three alterative models, confirming the SIAQ measures imagery ability of five separate but related types of sport specific imagery. Finally a second order model tested whether all five-factors were represented by a global measure of sport imagery ability. A similar fit to the data to the first order CT model was evident. Although the second order model is more parsimonious (Byrne, 2010), if researchers want to separately assess five types of imagery ability, the first order CT model should be used.

Study 3 of Chapter 4 also demonstrated the SIAQ's invariant factor structure for males and females and its temporal reliability. It was also able to distinguish between different athlete populations with males finding it significantly easier to image mastery images compared to females, and higher competing athletes finding it easier to image skill, strategy, goal, and mastery images. Finally, results of Study 3 identified that ease of imaging varies depending imagery content. Affect imagery is significantly easier to image than skill imagery which was significantly easier to image than strategy, goal, and mastery imagery. This demonstrates imagery ability of one content cannot be generalised to imagery ability of another, and highlights the necessity to assess different content with the SIAQ. Study 4 established the SIAQ's convergent validity by demonstrating significant bivariate correlations between the SIAQ and the MIQ-3 which was previously validated in Chapter 2. The moderate-sized correlations suggest that although a similar trait (i.e., ease of imaging) is measured by both questionnaires, this SIAQ is tapping the ability to image different content – reinforcing Study 3's finding that imagery ability of different content will vary for an individual. Overall, the findings of Chapter 4 conclusively support the SIAQ as a measure of sport imagery ability.

Chapter 5

Chapter 5 further validated the SIAQ by demonstrating its predictive validity. It investigated how cognitive and motivational imagery ability related to trait confidence and stress appraisal. Structural equation modelling (SEM) examined whether ease of imaging skill, strategy, goal, affect, and mastery images predicted trait confidence, if trait confidence in turn predicted challenge and threat appraisal tendencies, and whether trait confidence mediated the relationship between imagery ability and appraisal tendencies. Finally, it was investigated whether affect and mastery imagery ability directly predicted challenge and threat appraisal tendencies.

Results revealed only goal, and mastery imagery ability predicted trait confidence, which in sequence predicted appraisal tendencies. Also, trait confidence only partially mediated the relationship between imagery ability and appraisal tendencies. Interestingly, mastery and affect imagery ability directly and positively predicted challenge appraisal tendency, and mastery imagery ability directly and negatively predicted threat appraisal tendency. Athletes who find it significantly easier to image positive feelings and emotions associated with performance are likely to appraise stressful situations as a challenge, and those who find it significantly easier to image performing well and persisting in difficult situations are likely to appraise stressful situations as a challenge and less likely to appraise them as a threat. Findings support the validity of the SIAQ and support the need to assess imagery ability of varying content to further understand the influence of imagery ability.

Chapter 6

Chapter 6 investigated whether individuals scoring highly on the SIAQ's affect subscale experienced physiological and psychological responses reflective of stress-evoking imagery. Due to the relationship between imagery ability and appraisal tendencies established in Chapter 5, a second aim was to investigate whether altered meaning of the imagery could influence whether a situation is appraised as a challenge or threat by manipulating the Theory of Challenge and Threat States in Athletes' (TCTSA; Jones, Meijen, McCarthy, & Sheffield, 2009) antecedents self-efficacy and perceived control. It was thought stress appraisal would influence physiological and psychological responses aligned with the TCTSA predictions.

Compared to the neutral script, participants experienced increases in heart rate (HR), stroke volume (SV), and cardiac output (CO), and felt significantly more cognitively and somatically anxious during stress-evoking scripts. The threat script also produced significantly more cognitive anxiety compared to the challenge script. Unlike the TCTSA predictions, there were no discrepancies in CO between the challenge and threat scripts, but participants felt anxiety symptoms were significantly more facilitative to performance and felt significantly more confident following the challenge imagery compared with the threat. Challenge and threat scripts were perceived to be significantly more challenging and threatening than the neutral script, and the threat script was perceived to be significantly more threatening than the challenge script. Despite differences in situation appraisal, both challenge and threat scripts contained the same stimulus and response propositions. Results support the importance of an imagery scenario's meaning, and demonstrate altering the meaning of a stress-evoking situation can alter its appraisal and produce positive interpretations of physiological and psychological responses. The physiological responses experienced by participants, supports the validity of the SIAQ as studies demonstrate self-report and objective measures to reflect imagery ability (e.g., Guillot et al., 2009).

Strengths and Limitations

A strength of this thesis is the strong theoretical underpinning and use of existing frameworks to form the basis of each chapter. To avoid superficial research questions often addressed due to imagery's elusive nature, the thesis pulled from various theories, frameworks, and models, attempting to amalgamate them when developing research questions and designing studies. These include functional equivalence (Decety, 1996), Paivio's (1985) framework of imagery use, and the applied model of imagery use (Martin, Mortiz, & Hall, 1999). For example, observation and imagery were proposed to have a greater impact on performance than imagery due to the co-activation and functional equivalence between the two processes. This increased imagery ability, as predicted by the applied model (Martin et al., 1999), is likely to improve imagery's effects on performance. Similarly, the SIAQ's development was based on Paivio's (1985) conceptual framework later revised by Hall et al. (1998) in which athletes use imagery for both cognitive and motivational purposes. This combined with the applied model's premise "what you see, really is what you get" (p. 260) led to SIAQ items to reflect imagery content frequently used by athletes. Following the SIAQ's establishment, further theories were incorporated to validate the questionnaire including Lang's bioinformational theory (1977, 1979), and Jones et al.'s TCTSA (2009).

A second major strength is the variation in study design and measures obtained. Cross-sectional and experimental research were combined to extensively establish questionnaire validity, investigate relationships between imagery ability and outcomes, improve imagery ability, and examine whether imagery meaning can be manipulated. The combination of self-report and objective measures of imagery ability, in addition to validating the SIAQ, is the first study to demonstrate increases in SV and CO resulting from stress-evoking imagery.

The final strength was the multi-study approach taken in certain chapters to ensure research questions were sufficiently addressed. For example, the pilot study and additional six studies within Chapters 4-6 extensively validated the factor structure and reliability of the SIAQ. Consequently, despite being in its infancy, the SIAQ is already an extensively validated measure of imagery ability. Altogether, the 10 studies reported in this thesis provide substantial insight into imagery ability and imagery use.

To avoid repetition, study limitations acknowledged in previous chapters are not discussed again and only broader limitations raised here. Probably the most notable thesis limitation is the participants' age range (18 and 25 years old) and healthy status which reflects the university population where the majority of individuals were recruited from. Results may not represent different movement capability and age range populations as some research suggests imagery ability can decline with age (Campos, Pérez-Fabello, & Gómez-Juncal, 2004). The majority of the studies contained in this thesis focused on sport specific imagery and targeted athletes. Most athletes are healthy and between the age of 18 and 25, meaning the recruited participants likely represent the intended population. However, Chapters 2 and 3 were not sport specific and particularly these findings have implications for clinical and rehabilitation populations.

Imagery is employed for pain management and to increase strength and flexibility following athletic injury (e.g., Driediger, Hall, & Callow, 2006; Guillot, Tolleron, & Collet, 2010). It is also considered to be a cost effective intervention for aiding individuals' recovery from lost function and motor skill relearning following stroke or spinal cord injury (e.g., Cramer, Orr, Cohen, & Lacourse, 2007; Malouin & Richards, 2010; Page, 2010), and support movement development in those with cerebral palsy, developmental coordination disorder and Parkinson's disease (Lim et al., 2006; Mutsaarts, Steenbergen, & Bekkering, 2007; Wilson, Thomas, & Maruff, 2002). Due to the range of age and movement capabilities, these populations are not well represented in this thesis. Although beyond the scope of this thesis, future research can extend the validity of the MIQ-3 to ensure it accurately measures EVI, IVI, and KI ability for such heterogeneous populations and establish whether similar increases in imagery ability are achieved through the use of movement and observation before imaging.

The second limitation is participants within this thesis are relatively good imagers with questionnaire scores generally above the mid-point of rating scales. Chapter 6 specifically recruited individuals with high imagery ability, but similar scores were also obtained by participants in other Chapters. Because research demonstrates imagery can have little or no effect on individuals with low imagery ability (e.g., Goss et al., 1986; McKenzie & Howe, 1997; Robin et al, 2007), future research could replicate some Chapters and investigate whether findings can be extended to low imagery ability individuals. For example, Chapter 3 can be replicated to establish whether observation and movement similarly prime ease of imaging for participants displaying poor imagery ability.

Finally, although the varying study designs, employment of inter-disciplinary techniques and adopting a multi-study approach are considered as strengths in this thesis, some may also view them as limitations. The need to initially establish comprehensive measures of imagery ability to answering intriguing and important research questions regarding imagery ability meant certain areas of follow up work were not able to be included. Such is the nature of research; each question answered in this thesis provoked additional questions and the potential for follow up studies. For example, the seven SIAQ studies provided avenues of future research meaning the thesis could have focussed entirely on the development of this questionnaire. However, choosing to do so would have meant important findings of observation and movement execution priming imagery ability would have been overlooked. Further research questions, beyond the scope of this thesis, can be extensively explored in future studies, some of which have already been addressed but due to space limitations, are not integrated.

Applied Implications

Specific applied implications of studies are addressed within each chapter and consequently not discussed in depth here. However it is important to reiterate that the thesis validated a more comprehensive movement imagery ability assessment (MIQ-3), and developed a comprehensive measure of sport specific imagery ability (SIAQ) that have enormous potential for assessing imagery ability. This could be for imagery screening or monitoring changes over time. Hall's (1998) suggestion that imagery ability could vary for different content was supported in Chapter 4. Consequently, researchers can choose between the MIQ-3 or the SIAQ to most accurately reflect the type of imagery ability required for the intervention (i.e., movement imagery ability or sport imagery). An intervention including images of performing well in difficult situations should use the SIAQ as the screening tool, whereas a movement imagery intervention to recuperate arm function should use the MIQ-3. The SIAQ's capacity to assess imagery ability of five types of imagery athletes' use allows research to investigate imagery ability's influence on various outcomes. Research can examine specifically which types of athlete imagery ability (i.e., skill, strategy, goal, affect or mastery) influence various cognitive and motivational outcomes.

Beyond MIQ-3 and SIAQ development the thesis demonstrated observation can prime and immediately improve imagery ability, and manipulating an image's meaning can influence a stress appraisal. Observation can be used to improve imagery ability during interventions which could subsequently improve their effectiveness (e.g., Hall, Buckolz, & Fishburne, 1992; Robin et al., 2007). However if observation is to be used for this purpose, the VI perspective must be congruent with the observation clip. Finally individuals, who find certain situations stressful and potentially threatening, can use imagery to manipulate the meaning of the situation resulting in a more positive reappraisal.

Future Directions

The broad nature of the thesis and results from each chapter opened numerous avenues for future research. Although subsequent thesis studies addressed some of these, many remain unexplored. Although impossible to address all potential avenues of future research, the more important possibilities that were either overlooked or not sufficiently addressed in previous chapters are now discussed.

Although the MIQ-3 and SIAQ were validated in multiple ways, other types of validity are yet to be displayed, particularly for the MIQ-3 which was validated with only one sample of participants. Although some may argue modification from an existing questionnaire does not require the MIQ-3 validation process be as extensive as the novel SIAQ, earlier versions of the MIQ-3 were not sufficiently validated. Furthermore the MIQ-3's predictive validity and temporal reliability are yet to be established. Research demonstrates that athletes of a higher competitive level generally possess higher levels of VI and KI ability (e.g., Mumford & Hall, 1985; Roberts, Callow, Hardy, Markland, & Bringer, 2008), similarly to the SIAQ, it could be investigated whether the MIQ-3 can distinguish between different competitive levels athletes. The MIQ-3 and SIAQ can be subjected to further invariance testing to ensure the factor structures are maintained between individuals grouped by age, sport type (i.e., team or individual), competitive level, and even movement capabilities (e.g., athletes vs. patients). Invariant findings would support use of the questionnaires by heterogeneous groups of individuals.

An individual's imagery ability is represented by an amalgamation of components and characteristics (Morris, Spittle, & Watt, 2005). However, a frequently overlooked characteristic is performers' 'meta-imagery' processes, which refers to their knowledge of their imagery skills and experiences, and the control they have over these (for review see MacIntyre & Moran, 2010). An athlete more aware of their imagery capabilities is likely to have a greater understanding of the most beneficial imagery type, and be able to self-regulate and maximize their imagery experiences (e.g., use the viewing perspective most suitable for the task demands) to achieve desired outcomes. Nordin and Cumming (2008) found more frequent imagers also found imagery more effective for various functions and easier to generate. This suggests greater imagery ability is related to other imagery characteristics such as its frequency and extent it is structured and deliberately practiced. To further validate the MIQ-3 and SIAQ, research could investigate whether these characteristics are associated with higher questionnaire scores, while obtaining a greater insight of the characteristics associated with higher imagery ability.

Because interventions can produce greater performance improvements for individual's displaying higher imagery ability (Goss et al., 1986; Robin et al., 2007), the relationship between MIQ-3 and SIAQ imagery ability, and performance should be examined. Researchers can investigate whether MIQ-3 and SIAQ imagery ability can predict actual performance such as golf handicap level or running times, and whether higher imagery ability results in greater performance improvements when using imagery to learn a new skill or task.

The novel finding that observation primes and enhances imagery ability encourages research to further investigate the relationship between imagery and observation. As discussed in Chapter 3, the priming effect was evident in self-report MIQ-3 responses. Because imagery ability can be reflected in numerous ways (Hall, 1998; Morris et al., 2005), research can investigate whether observation's priming effect is also reflected in other self-report characteristics of imagery ability, and through methods of objective imagery ability assessment such as neuroimaging techniques.

It would also be interesting to investigate current stage of learning and movement capabilities on observations priming of imagery. Research suggests you must have previously experienced certain task elements to elicit an overlap in neural activation between movement imagery and execution (Olsson & Nyberg, 2010) and that activation during movement imagery is less functionally equivalent with that required to physically perform the movement if the individual does not have the motor representation to perform a skill (Olsson, Jonsson, Larsson & Nyberg, 2008). Similarly, Calvo-Merino, Glaser, Grezes, Passingham and Haggard (2005) demonstrated when observing movements, motor systems are only accessed during observation of dance moves within the dancers' repertoire. Because imagery is frequently used to acquire new skill and movement patterns that are not yet performable, it would be interesting to investigate whether observation can also prime ease of imaging a completely novel movement beyond an individual's performance capabilities.

This thesis demonstrated imagery can be primed using observation and prior movement execution, to create an image thought to be more functionally equivalent to movement execution. Future research should investigate whether additional methods can enhance the functional equivalence between movement imagery and execution, and provide similar improvements in imagery ability. But despite research highlighting the importance of imagery ability (e.g., Holmes & Collins, 2001; Martin et al., 1999), surprisingly very little attention has been paid to how it is effectively developed.

The PETTLEP model encourages individuals to create imagery conditions that mimic the circumstances of physical practice or performance as closely as possibly (Holmes & Collins, 2001, 2002). Gould and Damarjian (1996) suggest holding a piece of equipment and replicating the physical movements made during execution (i.e., physical element of the model) might increase imagery vividness by enabling performers to more easily recall appropriate kinaesthetic sensations. Therefore research should investigate whether incorporating the PETTLEP elements can increase the overlap in neural activation between real and imaged behaviours and improve imagery ability.

Based on bioinformational theory (Lang, 1977, 1979; Lang, Kozak, Miller, Levin, & McLean, 1980), stimulus and response training and creating imagery in layers are becoming more popularly employed (e.g., Cumming, Olphin, & Law, 2007; Evans, Jones, & Mullen, 2004) with the suggestion that a layering approach to build up images can improve its quality or vividness (e.g., Calmels, Berthoumieux, & d'Arripe-Longueville, 2004; Nordin & Cumming, 2005b). Such methods are likely to increase the functional equivalence between imagery and the actual experience. For example, response training can encourage a focus on the feel of specific muscle activity in the legs previously overlooked during imagery despite occurring during task execution. Neural areas responsible for this leg activity may then become active during imagery and improve the function equivalence between imagery and execution which is thought to lead to more effective imagery (e.g., Smith & Holmes, 2004; Smith, Wright, Allsopp, & Westhead, 2007).

Following Chapter 6's finding that imagery can alter the appraisal of an imagery situation, research has investigated whether manipulating an imagery scenario's meaning propositions can also alter the stress appraisal of an actual situation (Williams & Cumming, 2011). Imagery with an emphasis on a challenge appraisal led to a dart throwing task being perceived as significantly less of a threat, and more facilitative interpretations of anxiety symptoms compared to imagery with a threat appraisal emphasis. However many areas remain unexplored which include investigating other responses reflective of a stress-evoking situation, in particular blood pressure and total peripheral resistance, which according to the TCTSA and BPS model are thought to vary depending on whether the situation is perceived as a challenge or a threat (e.g., Blascovich, Seery, Mugridge, Norris, & Weisbuch, 2004; Blascovich & Tomaka, 1996; Jones et al., 2009).

Measuring imagery's physiological responses can also be used to validate the SIAQ and MIQ-3. Chapter 6 demonstrated that individuals who found affect imagery at least "somewhat easy to image" experienced HR, SV, and CO increases reflective of the imagery scenario. In future, physiological responses could be extended to compare individuals with high and low imagery ability by investigated whether correlations exists between SIAQ scores and imagery physiological response magnitude or brain activity (e.g., Cremades & Pease, 2007; Cui, Jeter, Yang, Montague, & Eagleman, 2007). If this exists, research can investigate the SIAQ's ability to predict physiological responses and whether the best predicting subscale reflects the imagery content. For example, affect imagery ability for HR reflective of stress imagery, and skill imagery ability for electromyogram (EMG) reflective of movement imagery). The predictive nature of the MIQ-3 can also be examined through physiological responses such as EMG obtained during imagery of the MIQ-3 movements to see whether reported scores are able to predict the physiological responses generated.

Although this thesis combined self-report and physiological responses to represent imagery ability, one characteristic beyond the scope of this thesis, but discussed in Chapter 1 as a measure of imagery ability is chronometric assessment. The functional equivalence between movement imagery and execution is reflected in similar temporal characteristics (for review see Guillot & Collet, 2005) with a smaller discrepancy between the two processes reflective of greater imagery ability (e.g., Guillot et al., 2009; McAvinue & Robertson, 2009-2010). Due to limitations of measuring imagery ability discussed in Chapter 1, researchers are beginning to combine self-report, physiological responses, and chronometric assessment to provide a comprehensive measure of imagery ability (e.g., Guillot et al., 2009; Roure et al., 1999). The SIAQ and MIQ-3 can be validated using chronometric assessment. For MIQ-3 validation, questionnaire movements can be timed during execution and imaging and then comparisons between the two investigated. Chronometric assessment could also examine the extent observation can prime imagery ability. Imaged movement duration can be compared to duration of the movement image following observation to see whether priming effects of observation are reflected in less discrepant durations between movement imagery and execution, or whether priming imagery ability is only represented in self-report scores.

Conclusion

In conclusion, this thesis aimed to more extensively investigate and further understand the role imagery ability plays in imagery's use. This was done by obtaining self-report and physiological indicators of imagery ability in various cross-sectional and experimental designed studies. To gain a more comprehensive representation of movement imagery ability and sport imagery ability, two questionnaires were developed and extensively validated, known as the MIQ-3 and SIAQ. Using these to examine the influence of imagery ability and imagery use provided a number of novel contributions to the imagery literature. Chapter 3 is the first study to demonstrate that movement execution and observation can prime and improve reported imagery ability reflected by MIQ-R scores. As well as creating a new questionnaire, Chapter 4 is the first to reveal imagery ability will differ depending on the content. The novel findings of Chapter 5 are that imagery ability of motivational content can directly predict trait confidence and appraisal tendencies. Finally Chapter 6 is the first study to reveal that imagery can manipulate stress appraisal and stress-evoking imagery can elicit an increase in SV and CO. Although much work is still to be done regarding imagery ability, researchers now have access to two valid and reliable questionnaires that provide an accurate and comprehensive assessment of imagery ability which will aid this research.

References

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

Albrecht, R. R. and Feltz, D. L. (1987). Generality and specificity of attention related to competitive anxiety and sport performance. *Journal of Sport Psychology, 9*, 231–248.

Amedi, A., Malach, R., & Pascual-Leone, A. (2005). Negative BOLD differentiates visual imagery and perception. *Neuron, 5,* 859-872.

Arbuckle, J. L. (1999). *AMOS (Version 16.0)*. Chicago: Smallwaters Corporation. [Computer software].

Atienza, F., Balaguer, I., & Garcia-Merita, M. L. (1994). Factor analysis and reliability of the Movement Imagery Questionnaire. *Perceptual and Motor Skills, 78,* 1323-1328.

Baddeley, A. D., & Andrade, J. (2000). Working memory and the vividness of imagery. *Journal of Experimental Psychology. General, 129*, 126-145.

Bakker, F. C., Boschker, S. J., & Chung, T. (1996). Changes in muscular activity while imaging weight lifting using stimulus or response propositions. *Journal of Sport and Exercise Psychology, 18,* 313-324.

Bandura, A. (1977). Self-efficacy: Toward a unifying theory of behavioral change. *Psychological Review, 84,* 191-215.

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. *International Journal of Sport Psychology, 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 Sports Sciences, 20,* 697-705.

Bentler, P. M. (1990). Comparative fit indexes in structural models. *Psychological Bulletin*, *107*, 238–246.

Bentler, P. M. (1995). *EQS structural equations program manual.* Encino, CA: Multivariate Software Inc.

Bentler, P. M. (2009). Alpha, dimension-free, and model-based internal consistency reliability. *Psychometrika, 74*, 137-143.

Bernier, M. & Fournier, J. F. (2010). Functions of mental imagery in expert golfers. *Psychology of Sport and Exercise, 11,* 444-452.

Biddle, S. J. H., Markland, D., Gilbourne, D., Chatzisarantis, N. L. D., & Sparkes, A. C. (2001). Research methods in sport and exercise psychology: Quantitative and qualitative issues. *Journal of Sport Sciences, 19*, 777-809.

Blascovich, J. & Mendes, W. B. (2000). Challenge and threat appraisals. The role of affective cues. In J.P.Forgas (Ed.), *Feeling and thinking: The role of affect in social cognition* (1st ed., pp. 59-82). New York: Cambridge University Press.

Blascovich, J., Mendes, W. B., Hunter, S. B., & Salomon, K. (1999). Social "facilitation" as challenge and threat. *Journal of Personality and Social Psychology, 77,* 68-77.

Blascovich, J., Seery, M. D., Mugridge, C. A., Norris, R. K., & Weisbuch, M. (2004). Predicting athletic performance from cardiovascular indexes of challenge and threat. *Journal of Experimental Social Psychology, 40,* 683-688.

Blascovich, J. & Tomaka, J. (1996). The biopsychosocial model of arousal regulation. *Advances in Experimental Social Psychology, 28,* 1-51.

Bollen, K. A. (1989). *Structural equations with latent variables.* New York: Wiley.

Brass, M., Bekkering, H., & Prinz, W. (2001). Movement observation affects movement execution in a simple response task. *Acta Psychologica, 106,* 3-22.

Browne, M. W., & Cudeck, R. (1993). In K. A. Bollen, & J. S. Long (Eds.), Alternative ways of assessing model fit. *Testing structural equation models* (pp. 136–162). Newbury Park, CA: Sage.

Buccino, G., Binkofski, F., Fink, G. R., Fadiga, L., Fogassi, L., Gallese, V., … Freund, H.-J. (2001). Action observation activates premotor and prietal areas in a somatotopic manner: An fMRI study. *European Journal of Neuroscience, 13,* 400-404.

Burgess, N. (2006). Spatial memory: How egocentric and allocentric combine. *Journal of Experimental Psychology: Learning, Memory and Cognition, 32,* 867-882.

Byrne, B. M. (2010). *Structural equation modeling with AMOS: basic concepts, applications, and programming* (2nd ed.). New York: Taylor and Francis.

Caliari, P. (2008). Enhancing forehand acquisition in table tennis: The role of mental practice. *Journal of Applied Sport Psychology, 20,* 88-96.

Callow, N., & Hardy, L. (2001). Types of imagery associated with sport confidence in netball players of varying skill levels. *Journal of Applied Sport Psychology*, *13*, 1-17.

Callow, N., Hardy, L., & Hall, C. (1998). The effect of a motivational-mastery imagery intervention on the sport confidence of three elite badminton players. *Journal of Applied Sport Psychology, 10,* 135S.

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.

Callow, N. & Roberts, R. (2010). Imagery research: An investigation of three issues. *Psychology of Sport and Exercise, 11,* 325-329.

Callow, N., Roberts, R., & Fawkes, J. Z. (2006). Effects of dynamic and static imagery on vividness of imagery, skiing performance, and confidence. *Journal of Imagery Research in Sport and Physical Activity, 1(1)*.

Callow, N., & Waters, A. (2005). The effect of kinesthetic imagery on the sport confidence of flat-race horse jockeys. *Psychology of Sport and Exercise, 6,* 443-459.

Calmels, C., Berthoumieux, C., & d'Arripe-Longueville, F. (2004). Effects of an imagery training program on selective attention of national softball players. *The Sport Psychologist, 18,* 272-296.

Calmels, C., Holmes, P., Berthoumieux, C., & Singer, R. N. (2004). The development of movement imagery vividness through a structured intervention in softball. *Journal of Sport, 27,* 307-322.

Calvo-Merino, B., Glaser, D. E., Grezes, J., Passingham, R. E., & Haggard, P. (2005). Action observation and acquired motor skills: an fMRI study with expert dancers. *Cerebral Cortex, 15,* 1243-1249.

Campos, A., Pérez-Fabello, M. J., & Gómez-Juncal, R. (2004). Gender and age differences in measured and self-perceived imaging capacity. *Personality and Individual Differences, 37,* 1383-1389.

Castiello, U., Lusher, D., Mari, M., Edwards, M., & Humphreys, G. W. (2002). Observing a human or a robotic hand grasping an object: differential motor priming effects. *Common Mechanisms in Perception and Action, 19,* 315-333.

Cerin, E., Szabo, A., Hunt, N., & Williams, C. (2000). Temporal patterning of competitive emotions: A critical review. *Journal of Sports Sciences, 18,* 605-626.

Cheung, G. W., & Rensvold, R. B. (2002). Evaluating goodness-of-fit indexes for testing measurement invariance. *Structural Equation Modeling, 9,* 233–255.

Clark, S., Tremblay, F., & Ste-Marie, D. (2003). Differential modulation of corticospinal excitability during observation, mental imagery and imitation of hand actions. *Neuropsychologia, 42,* 105-112. doi: 10.1016/S0028-3932(03)00144-1

Costello, A. B., & Osborne, J. W. (2005). Best practices in exploratory factor analysis: Four recommendations for getting the most from your analysis. *Practical Assessment, Research & Evaluation, 10*, 1-9.

Cramer, S. C., Orr, E. L., Cohen, M. J., & Lacourse, M. G. (2007). Effects of motor imagery training after chronic, complete spinal cord injury. *Experimental Brain Research, 177*, 233-42.

Cremades, J. G., & Pease, D. G. (2007). Concurrent validity and reliability of lower and upper alpha activities as measures of visual and kinesthetic imagery ability. *International Journal of Sport and Exercise Psychology, 2*, 187-202.

Cudeck, R., & Brown, M. W. (1983). Cross-validation of covariance structures. *Multivariate Behavioral Research, 18,* 147-167.

Cui, X., Jeter, C. B., Yang, D., Montague, P. R., & Eagleman, D. M. (2007). Vividness of mental imagery: Individual variability can be measured objectively. *Vision Research, 47,* 474-478.

Cumming, J. (2008). Investigating the relationship between exercise imagery, leisure time exercise behavior, and self-efficacy. *Journal of Applied Sport Psychology, 20*, 184-198.

Cumming, J., Clark, S. E., Ste-Marie, D. M., McCullagh, P., & Hall, C. (2005). The Functions of Observational Learning Questionnaire. *Psychology of Sport and Exercise, 6*, 517-537.

Cumming, J., & Hall, C. (2002a). Athletes' use of imagery in the off-season. *The Sport Psychologist, 16,* 160-172.

Cumming, J., & Hall, C. (2002b). Deliberate imagery practice: The development of imagery skills in competitive athletes. *Journal of Sport Sciences, 20*, 137–145.

Cumming, J., Olphin, T., & Law, M. (2007). Self-reported psychological states and physiological responses to different types of motivational general imagery. *Journal of Sport & Exercise Psychology, 29,* 629-644.

Cumming, J., & Ramsey, R. (2009). Imagery interventions in sport. In S.D Mellalieu & S. Hanton (Eds.), *Advances in applied sport psychology: A review* (pp. 5-36). London: Routledge.

Cumming, J., & Ste-Marie, D. M. (2001). The cognitive and motivational effects of imagery training: A matter of perspective. *The Sport Psychologist*, *15*, 276-287.

Cupal, D. D., & Brewer, B. W. (2001). Effects of relaxation and guided imagery on knee strength, reinjury anxiety, and pain following anterior cruciate ligament reconstruction. *Rehabilitation Psychology, 46,* 28-43.

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

Driediger, M., Hall, C., & Callow, N. (2006). Imagery used by injured athletes: a qualitative analysis. *Journal of Sport Sciences*, *24*, 261-272

Edwards, M. G., Humphreys, G. W., & Castiello, U. (2003). Motor facilitation following action observation: A behavioural study in prehensile action. *Brain and Cognition, 53,* 495-502. doi: 10.1016/S0278-2626(03)00210-0

Ehrsson, H. H., Geyer, S., & Naito, E. (2003). Imagery of voluntary movement of fingers, toes, and tongue activates corresponding body-part-specific motor representations. *Journal of Neurophysiology, 90,* 3304-3316. doi: 10.1152/jn.01113.2002

Eid, M. (2000). A multitrait-multimethod model with minimal assumptions. *Psychometrika, 65*, 241-261.

Evans, L., Jones, L., & Mullen, R. (2004). An imagery intervention during the competitive season with an elite rugby union player. *The Sport Psychologist, 18,* 252-271

Fadiga, L., Buccino, G., Craighero, L., Fogassi, L., Gallese, V., & Pavesi, G. (1999). Corticospinal excitability is specifically modulated by motor imagery: A magnetic stimulation study. *Neuropsychologia, 37,* 147-158.

Fadiga, L., Fogassi, L., Pavesi, G., & Rizzolatti, G. (1995). Motor facilitation during action observation - A magnetic stimulation study. *Journal of Neurophysiology, 73,* 2608-2611.

Feltz, D. L. (1984). Self-efficacy as a cognitive mediator of athletic performance. In W. F. Straub & J. M. Williams (Eds.), *Cognitive sport psychology* (1st ed., pp. 191-198). Lansing, NY: Sport Science Associates.

Folkman, S. & Lazarus, R. S. (1980). An analysis of coping in a middle-aged community sample. *Journal of Health and Social Behavior, 21,* 219-239.

Fourkas, A., Avenanti, A., Urgesi, C., & Aglioti, S. (2006). Corticospinal excitability during first and third person imagery. *Experimental Brain Research, 68,* 143-151.

Gallese, V., & Goldman, A. (1998). Mirror neurons and the simulation of mind reading. *Trends in Cognitive Sciences, 2,* 493-501.

Glisky, M. L., Williams, J. M., & Kihlstrom, J. F. (1996). Internal and external imagery perspectives and performance on two tasks. *Journal of Sport Behavior, 19,* 3-18.

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

Gould, D., & Damarjian, N. (1996). Imagery training for peak performance. In J.L.Van Raalte & B. W. Brewer (Eds.), *Exploring sport and exercise psychology* (1st ed., pp. 25-50). Washington, DC: American Psychological Association.

Gould, D. R., & Weiss, M. R. (1981). The effects of model similarity and model talk on self-efficacy and muscular endurance. *Journal of Sport Psychology, 3,* 17-29.

Greenhouse, S. W., & Geisser, S. (1959). On methods in the analysis of profile data. *Psychometrika, 55*, 431-433.

Gregg, M., & Hall, C. (2006). Measurement of motivational imagery abilities in sport. *Journal of Sports Sciences, 24*, 961-971.

Gregg, M., Hall, C., & Butler, A. (2007). The MIQ-RS: A suitable option for examining movement imagery ability. *Evidence-based Complementary and Alternative Medicine.* doi:10.1093/ecam/nem170.

Grèzes, J. & Decety, J. (2001). Functional anatomy of execution, mental stimulation, observation, and verb generation of actions: A meta analysis. *Human Brain Mapping, 12,* 1-19.

Guillot, A. & Collet, C. (2005). Duration of mentally simulated movement: A review. *Journal of Motor Behavior, 37,* 10-20.

Guillot, A., Collet, C., & Dittmar, A. (2004). Relationship between visual vs. kinesthetic imagery, field dependence-independence and complex motor skills. *Journal of Psychophysiology, 18,* 190-198.

Guillot, A., Collet, C., Nguyen, V. A., Malouin, F., Richards, C., & Doyon, J. (2008). Functional neuroanatomical networks associated with experitise in motor imagery. *NeuroImage, 41,* 1471-1483.

Guillot, A., Collet, C., Nguyen, V. A., Malouin, F., Richards, C., & Doyon, J. (2009). Brain activity during visual verses kinesthtic imagery: an fMRI study. *Human Brain Mapping, 30*, 2157-2172.

Guillot, A., Lebon, F., Rouffet, D., Champely, S., Doyon, J., & Collet, C. (2007). Muscular responses during motor imagery as a function of muscle contraction types. *International Journal of Psychophysiology, 66,* 18-27.

Hair, J. F., Anderson, R. E., Tatham, R. L., & Black, W. C. (1998). *Multivariate data* *analysis*. Upper Saddle River, NJ: Prentice Hall.

Hale, B. D. & Whitehouse, A. (1998). The effects of imagery manipulated appraisal on intensity and direction of competitive anxiety. *The Sport Psychologist*, *12,* 40-51.

Hall, C. R. (1997). Lew Hardy's third myth: a matter of perspective. *Journal of Applied Sport Psychology, 9,* 310-313.

Hall, C. R. (1998). Measuring imagery abilities and imagery use. In J.L. Duda (Ed.), *Advances in sport and exercise psychology measurement* (pp. 165-172). Morgantown, WV: Fitness Information Technology.

Hall, C. R. (2001). Imagery in sport and exercise. In R.N.Singer, H. A. Hausenblas, & C. M. Janelle (Eds.), *The handbook of sport psychology* (2nd ed., pp. 529-549). New York: John Wiley & Sons Inc.

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

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

Hall, C., & 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., & Pongrac, J. (1983). *Movement imagery questionnaire*. London, Ontario: University of Western Ontario.

Hanton, S. & Jones, G. (1999a). The acquisition and development of cognitive skills and strategies. I: Making the butterflies fly in formation. *The Sport Psychologist, 13,* 1-21.

Hanton, S. & Jones, G. (1999b). The effects of a multimodal intervention program on performers: II. Training the butterflies to fly in formation. *The Sport Psychologist*, *13,* 22-41.

Hanton, S., Mellalieu, S. D., & Hall, R. (2004). Self-confidence and anxiety interpretation: A qualitative investigation. *Psychology of Sport and Exercise, 5,* 477-495.

Hardy, L. (1997). The Coleman Roberts Griffith address: Three myths about applied consultancy work. *Journal of Applied Sport Psychology, 9,* 277–294.

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 & Exercise Psychology, 21,* 95-112.

Hars, M., & Calmels, C. (2007). Observation of elite gymnastic performance: Processes and perceived functions of observation. *Psychology of Sport and Exercise, 8,* 337-354.

Heyes, C., Bird, G., Johnson, H., & Haggard, P. (2005). Experience modulates automatic imitation. *Cognitive Brain Research, 22*, 233-240.

Hofmann, R. (1995). Establishing factor validity using variable reduction in confirmatory factor analysis. *Educational and Psychological Measurement, 55*, 572-582.

Holmbeck, G. N. (1997). Toward terminological, conceptual, and statistical clarity in the study of mediators and moderators: Examples from the child-clinical and pediatric psychology literatures. *Journal of Consulting and Clinical Psychology, 65*, 599-610.

Holmes, P. S. & Calmels, C. (2008). A neuroscientific review of imagery and observation use in sport. *Journal of Motor Behavior, 40*, 433-445.

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

Holmes, P. & Collins, D. (2002). Functional equivalence solutions for problems with motor imagery. In I. Cockerill (Ed.), *Solutions in sport psychology* (1st ed., pp. 120-140). London: Thomson.

Holmes, P. S., Cumming, J., & Edwards, M. G. (2010). Movement imagery, observation, and skill. In A. Guillot & C. Collet (Eds), *The neurophysiological foundations of mental and motor imagery*. Oxford, UK: Oxford University Press.

Hu, L., & Bentler, P. M. (1999). Cutoff criteria for fit indices in covariance structure analysis: Conventional criteria versus new alternatives. *Structural Equation Modelling, 6,* 1–55.

Ievleva, L., & Orlick, T. (1991). Mental links to enhanced healing: An exploratory study. *The Sport Psychologist, 5,* 25-40.

Issac, A. R., Marks, D. F., & Russell, D. G. (1986). An instrument for assessing imagery of movement. The vividness of movement imagery questionnaire. *Journal of Mental Imagery, 10,* 23-30.

Jackson, P. L., Lafleur, M., Malouin, F., Richards, C. L., & Doyon, J. (2001). Potential role of mental practice using motor imagery in neurological rehabilitation. *Archives of Physical Medicine and Rehabilitation, 82,* 1133-1141.

Jackson, P. L., Meltzoff, A. N., & Decety, J. (2006). Neural circuits involved in imitation and perspective-taking. *NeuroImage, 31,* 429-439.

Jeannerod, M. (2001). Neural simulation of action: A unifying mechanism for motor cognition. *NeuroImage, 14,* 103-109.

Johnson, P. (1982). The functional equivalence of imagery and movement, *The Quarterly Journal of Experimental Psychology, 34,* 349-365.

Jones, G. (1995). More than just a game: Research developments and issues in competitive anxiety in sport. *British Journal of Psychology, 86,* 449-478.

Jones, G., Hanton, S., & Swain, A. (1994). Intensity and interpretations of anxiety symptoms in elite and non-elite performers. *Personality and Individual Differences, 17,* 657-663.

Jones, G., & Swain, A. (1995). Predispositions to experience debilitative and facilitative anxiety in elite and non-elite performance. *The Sport Psychologist, 9,* 201-211.

Jones, M. V., Mace, R. D., Bray, S. R., MacRae, A. W., & Stockbridge, C. (2002). The impact of motivational imagery on the emotional state and self-efficacy levels of novice climbers. *Journal of Sport Behavior, 25,* 57-73

Jones, M. V., Meijen, C., McCarthy, P. J., Sheffield, D. (2009) A theory of Challenge and Threat States in Athletes. *International Review of Sport and Exercise Psychology*, *2*, 161-180.

Jöreskog, K. G. (1993). Testing structural equation models. In K.A. Bollen & J.S. Long (Eds.), *Testing structural equation models* (pp. 294-316). Newbury Park, CA: Sage.

Jöreskog, K. G., & Sörbom, D. (1993). *LISREL 8 user's reference guide*. Chicago: Scientific Software.

Kenny, D. A., & Kashy, D. A. (1992). Analysis of the multitrait-multimethod matrix by confirmatory factor analysis. *Psychological Bulletin, 112*, 165-172.

Kline, R. B. (2005). Principles and practice of structural equation modeling (2nd ed.). New York: Guilford.

Kosslyn, S. M. (1994). *Image and brain.* Cambridge, MA: MIT Press.

Kosslyn, S. M., Brunn, J., Cave, K. R., & Wallach, R. W. (1984). Individual differences in mental imagery ability: A computational analysis. *Cognition, 18,* 195-243.

Kosslyn, S. M., Ganis, G., & Thompson, W. L. (2001). Neural foundations of imagery. *Nature Reviews Neuroscience, 2,* 635-739.

Kosslyn, S. M., Thompson, W. L., & Alpert, N. M. (1997). Neural systems shared by visual imagery and visual perception: a positron emission tomography study. *NeuroImage, 6,* 320-334.

Kosslyn, S. M., Thompson, W. L., & Ganis, G. (2006). *The case for mental imagery*. New York: Oxford University Press.

Koufteros, X., Babbar, S., & Kaighobadi, M. (2009). A paradigm for examining second-order factor models employing structural equation modeling. *International Journal of Production Economics, 120*, 633-652.

Lang, P. J. (1977). Imagery in therapy: An Information-processing analysis of fear. *Behavior Therapy, 8,* 862-886.

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

Lang, P. J., Kozak, M. J., Miller, G. A., Levin, D. N., & McLean, JR, A. (1980). Emotional imagery: Conceptual structure and pattern of somato-visceral response. *Psychophysiology, 17,* 179-192.

Lazarus, R. S. (1991). *Emotion and adaptation.* New York: Oxford University Press.

Lequerica, A., Rapport, L., Axelrod, B. N., Telmet, K., & Whitman, R. D. (2002). Subjective and objective assessment methods of mental imagery control: Construct validation of self-report measures. *Journal of Clinical and Experimental Neuropsychology, 24,* 1103-1116.

Lim, V. K., Polych, M. A., Holländer, A., Byblow, W. D., Kirk, I. J., & Hamm, J. P. (2006). Kinesthetic but not visual imagery assists in normalizing the CNV in Parkinson's disease. *Clinical Neurophysiology, 117*, 2308-2314.

Little, T. D., Cunningham, W. A., Shahar, G., & Widaman, K. F. (2002). To parcel or not to parcel: Exploring the question, weighing the merits. *Structural Equation Modeling, 9,* 151-173.

Liu, K., Chan, C., Lee, T. M., & Hui-Chan, C. W. (2004). Mental imagery for promoting relearning for people after stroke: A randomized controlled trial. *Archives of Physical Medicine and Rehabilitation, 85,* 1403-1408.

Lorant, J. & Nicholas, A. (2004). Validation de la traduction française du Movement Imagery

Questionnaire-Revised (MIQ-R). *Science & Motricite, 53*, 57-68.

Lotze, M. & Halsband, U. (2006). Motor imagery. *Journal of Physiology Paris, 99*, 386-395.

Lotze, L., Montoya, M., Erb, M., Hulsmann, E., Flor, H., Klause, U. et al. (1999). Activation of cortical and cerebella motor areas during executed and imagined hand movements: An fMRI study. *Journal of Cognitive Neuroscience, 11,* 491-501.

Lutz, R. S. (2003). Covert muscle excitation is outflow from the central generation of motor imagery. *Behavioural Brain Research, 140,* 149-163.

Lynn, M. R. (1986). Determination and quantification of content validity. *Nursing Research, 35*, 382-385.

MacCallum, R. C. (2003). Working with imperfect models. *Multivariate Behavioral Research, 38*, 113-139.

MacIntyre, T. & Moran, A. (2010). Meta-imagery processes among elite sports performers. In A. Guillot & C. Collet (Eds), *The neurophysiological foundations of mental and motor imagery*. (pp. 227-244) Oxford, UK: Oxford University Press.

MacKinnon, D. P. (2000). Contrasts in multiple mediator models. In J. Rose, L. Chassin, C. C. Presson, & S. J. Sherman (Eds.), *Multivariate applications in substance use research* (pp. 141-160). Mahwah, NJ: Erlbaum.

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

Malouin, F., Belleville, S., Richards, C. L., Desrosiers, J., & Doyon, J. (2004). Working memory and mental practice outcomes after stroke. *Archives of Physical Medicine and Rehabilitation, 85,* 177-183.

Malouin, F. & Richards, C. L. (2010). Mental practice for relearning locomotor skills. *Physical Therapy, 90,* 240-251.

Malouin, F., Richards, C. L., Jackson, P. L., & Doyonm J. (2010). Motor imagery for optimizing the reacquisition of locomotor skills after cerebral damage. In A. Guillot & C. Collet (Eds), *The neurophysiological foundations of mental and motor imagery*. (pp. 161-176) Oxford, UK: Oxford University Press.

Malouin, F., Richards, C. L., Jackson, P. L., & Lafleur, M. F., Durand, A., & Doyon, J. (2007). The kinesthetic and visual imagery questionnaire (KVIQ) for assessing motor imagery in persons with physical disabilities : A reliability and construct validity study. *Journal of Neurologic Physiotherapy, 31*, 20-29.

Mardia, K. V. (1970). Measures of multivariate skewness and kurtosis with applications. *Biometrika, 57,* 519-530.

Markland, D. (2007). The golden rule is that there are no golden rules: A commentary on Paul Barrett's recommendations for reporting model fit in structural equation modelling. *Personality and Individual Differences, 42,* 851–858.

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

Marsh, H. W. (1987). The hierarchical structure of self-concept and the application of hierarchical confirmatory factor analysis. *Journal of Educational Measurement, 24,* 17–39.

Marsh, H. W. (1989). Confirmatory factor analysis of multitrait-multimethod data: Many problems and a few solutions. *Applied Psychological Measurement, 13,* 335-361.

Marsh, H. W., & Grayson, D. (1995). Latent variable models of multitrait-multimethod data. In R.H. Hoyle (Ed.), *Structural equation modeling: Concepts issues and applications* (pp. 177-198). Thousand Oaks, CA: Sage.

Marsh, H. W., Hau, K. -T., & Wen, Z. (2004). In search of golden rules: Comment on hypothesis-testing approaches to setting cutoff values for fit indexes and dangers in overgeneralizing Hu and Bentler's (1999) findings. *Structural Equation Modeling, 11,* 320–341.

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

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

McAvinue, L. P. & Robertson, I. H. (2009-2010). An evaluation of a movement imagery training scheme. *Imagination, Cognition and Personality, 29*, 99-114.

McGregor, H. A. & Elliot, A. J. (2002). Achievement goals as predictors of achievement-relevant processes prior to task engagement. *Journal of Educational Psychology, 94,* 381-395.

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.

Monsuma, E. V., & Overby, L. Y. (2004). Competitive anxiety and imagery in ballet dance auditions. *Journal of Dance Medicine and Science, 8*, 156-165.

Monsma, E. V., Short, S. E., Hall, C. R., Gregg, M., & Sullivan, P. (2009). Psychometric properties of the revised Movement Imagery Questionnaire (MIQ-R). *Journal of Imagery Research in Sport and Physical Activity, 4,* 1-12.

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

Morris, T., Spittle, M., & Watt, A. P. (2005). *Imagery in sport*. Champaign, IL: Human Kinetics.

Mulder, T., Zijlstra, S. & Zijlstra, W., Hochstenbach, J. (2004). The role of motor imagery in learning a totally novel movement. *Experimental Brain Research, 154,* 211-217.

Mumford, B. & Hall, C. (1985). The effects of internal and external imagery on performing figures in figure skating. *Canadian Journal of Applied Sport Sciences, 10,* 171-177.

Munroe, K., 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.

Munzert, J., Lorey, B., & Zentgraf, K. (2009). Cognitive motor processes: the role of motor imagery in the study of motor representations. *Brain Research Reviews*, *60*, 306-326

Murphy, S., Nordin, S. M., & Cumming, J. (2008). Imagery in sport, exercise and dance. In T. Horn (Ed.), *Advances in sport and exercise psychology* (3rd ed., pp. 297-324). Champaign, IL: Human Kinetics.

Mutsaarts, M., Steenbergen, B., & Bekkering, H. (2007). Impaired motor imagery in right hemiparetic cerebral palsy. *Neuropsychologia, 45*, 853-859.

Nordin, S. M. & Cumming, J. (2005a). More than meets the eye: Investigating imagery type, direction, and outcome. *The Sport Psychologist, 19,* 1-17.

Nordin, S. M., & Cumming, J. (2005b). Professional dancers describe their imagery: Where, when, what, why, and how. *The Sport Psychologist, 19,* 395-416.

Nordin, S. M., & Cumming, J. (2008). Types and functions of atheltes' imagery: Testing prediction from the applied model of imagery use by examining effectiveness. *International Journal of Sport and Exercise Psychology*, *6*, 189-206.

Ntoumanis, N. (2001). *A step-by-step guide to SPSS for sport and exercise studies.* London: Routledge.

Oldfield, R. C. (1971). Assessment and analysis of handedness - The Edinburgh inventory. *Neuropsychologia, 9,* 97-113.

Olson, C. L. (1976). On choosing a test statistic in MANOVA. *Psychological Bulletin, 83,* 579-586.

Olsson, C. J., Jonsson, B., Larsson, A., & Nyberg, L. (2008). Motor representations and practice affect brain systems underlying imagery: an fMRI study of internal imagery in novices and active high jumpers. *Open Neuroimaging Journal, 2,* 5–13.

Olsson, C. J., & Nyberg, L. (2010). Motor imagery: if you can't do it, you won't think it. *Scandanavian Jouranl of Medicine & Science in Sports, 20*, 711-715.

Orlick, T., & Partington, J. (1988). Mental links to excellence. *The Sport Psychologist, 2,* 105-130.

Page, S. J. (2010). An overview of the effectiveness of motor imagery after stroke: A neuroimaging approach. In A. Guillot & C. Collet (Eds), *The neurophysiological foundations of mental and motor imagery*. (pp. 145-159) Oxford, UK: Oxford University Press.

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

Quested, E. & Duda, J. L. (2010). Exploring the social-environmental determinants of well- and ill-being in dancers: A test of basic needs theory. *Journal of Sport & Exercise Psychology, 32*, 39-60.

Ramsey, R., Cumming, J., Eastough, D., & Edwards, M. G. (2010). Incongruent imagery interferes with action initiation. *Brain and Cognition, 74*, 249-254.

Ramsey, R., Cumming, J., & Edwards, M. G. (2008). Exploring a modified conceptualisation of imagery direction and golf putting performance. *International Journal of Sport and Exercise Psychology, 6,* 207-223.

Ramsey, R., Cumming, J., Edwards, M. E., Williams, S., & Brunning, C. (2010). Examining the emotion aspect of PETTLEP based Imagery and penalty taking performance in football. *Journal of Sport Behavior, 33,* 295-315.

Richardson, A. (1977). The meaning and measurement of memory imagery. *British Journal of Psychology, 68,* 29-43.

Rizzolatti, G., & Craighero, L. (2004). The mirror-neuron system. *Annual Review of Neuroscience, 27,* 169-192.

Roberts, R., Callow, N., Hardy, L., Markland, D., & Bringer, J. (2008). Movement imagery ability: Development and assessment of a revised version of the vividness of movement imagery questionnaire. *Journal of Sport & Exercise Psychology, 30,* 200-221.

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

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

Roure, R., Collet, C., Deschaumes-Molinaro, C., Delhomme, G., Dittmar, A., & Vernet-Maury, E. (1999). Imagery quality estimated by autonomic response is correlated to sporting performance enhancement. *Physiology and Behaviour, 66,* 63-72.

Ruby, P. & Decety, J. (2001). Effect of subjective perspective taking during simulation of action: a PET investigation of agency. *Nature Neuroscience, 4,* 546-550.

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

Satorra, A., & Bentler, P. M. (2001). A scaled difference chi-square test statistic for moment structure analysis. *Psychometrika, 66,* 507–514.

Schmitt, N. & Stults, D. M. (1986). Methodology review: Analyses of multitrait-multimethod matrices. *Applied Psychological Measurement, 10,* 1-22.

Shmuelof, L., & Zohary, E. (2008). Mirror-image representation of action in the anterior parietal cortex. *Nature Neuroscience, 11,* 1267-1269.

Short, S. E., Bruggeman, J. M., Engel, S. G., Marback, T. L., Wang, L. J., Willadsen, A. et al. (2002). The effect of imagery function and imagery 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.

Sijtsma, K. (2009). On the use, the misuse, and the very limited usefulness of Cronbach's alpha. *Psychometrika, 74,* 107-120.

Skinner, N. & Brewer, N. (2002). The dynamics of threat and challenge appraisals prior to stressful achievement events. *Journal of Personality and Social Psychology, 83,* 678-692.

Skinner, N. & Brewer, N. (2004). Adaptive approaches to competition: Challenge appraisals and positive emotion. *Journal of Sport and Exercise Psychology, 26,* 283-305.

Smith, D. & Holmes, P. S. (2004). The effect of imagery modality on golf putting performance. *Journal of Sport and Exercise Psychology, 26,* 385-395.

Smith, D., Wright, C. J., Allsopp, A., & Westhead, H. (2007). It's all in the mind: PETTLEP-based imagery and sports performance. *Journal of Applied Sport Psychology, 19,* 80-92.

Spielberger, C. D. (1989). Stress and anxiety in sports. In D.Hackfort & C. D. Spielberger (Eds.), *Anxiety in Sports: An international perspective* . New York: Hemisphere.

Steiger, J. H. (1990). Structural model evaluation: An interval estimation approach. *Multivariate Behavioral Research, 25,* 173–180.

Tabachnick, B. G., & Fidell, L. S. (2007). *Using multivariate statistics*. (5th ed.)

Boston: Allyn and Bacon.

Thomas, O., Hanton, S., & Jones, G. (2002). An alternative approach to short-form self-report assessment of competitive anxiety. *International Journal of Sport Psychology, 33*, 325-336.

Thomas, O., Maynard, I., & Hanton, S. (2007). Intervening with athletes during the time leading up to competition: Theory to practice II. *Journal of Applied Sport Psychology, 19,* 398-418.

Tomaka, J., Blascovich, J., Kelsey, R. M., & Leitten, C. L. (1993). Subjective, physiological, and behavioral effects of threat and challenge appraisal. *Journal of Personality and Social Psychology, 65,* 248-260.

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

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

Vincent, W. J. (1999). *Statistics in kinesiology*. Champaign, IL: Human Kinetics.

Waller, D., & Hodgson, E. (2006). Transient and enduring spatial representations under disorientation and self-rotation. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 32,* 867-882.

White, A. & Hardy, L. (1995). Use of different imagery perspectives on the learning and performance of different motor skills. *British Journal of Psychology, 86,* 169-180.

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, S. E. & Cumming, J. (in press). Measuring athlete imagery ability: The Sport Imagery Ability Questionnaire. *Journal of Sport & Exercise Psychology*.

Williams, S. E. & Cumming, J. (2011). *Challenge vs. threat: Investigating the effect of using* *imagery to manipulate stress appraisal of a dart throwing task.* Manuscript under review.

Williams, S. E., Cumming, J., & Edwards, M. G. (in press). Does the functional equivalence between movement imagery, observation, and execution influence imagery ability? Investigating different modes of MIQ-R delivery. *Research Quarterly for Exercise and Sport*.

Williams, S. E., Cumming, J., Ntoumanis, N., Nordin, S. M., Ramsey, R., & Hall, C. R. (2011). *Further validation and development of the Movement Imagery Questionnaire.* Manuscript under review.

Wilson, P. H., Thomas, P. R., & Maruff, P. (2002). Motor imagery training ameliorates motor clumsiness in children. *Journal of Child Neurology, 17*, 491-498.

Wuyam, B., Moosavi, S. H., Decety, J., Adams, L., Lansing, R. W., & Guz, A. (1995). Mental simulation of dynamic exercise produces respiratory responses which are more apparent in competitive sportsmen. *Journal of Physiology (Cambridge), 482*, 713-724.

Appendix 1: Movement Imagery Questionnaire-Revised (Chapter 2)

(MIQ-R; Hall & Martin, 1997)

This questionnaire concerns two ways of mentally performing movements, which are used by some people more than others, and are more applicable to some types of movement than others. The first is the formation of a mental (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 answers or some 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 of 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 mental image as possible of the movement just performed, or 2) attempt to positively 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 of each movement. You may choose the same rating for any number of movements "imaged" or "felt" and it is not necessary to utilise the entire length of the scale.

RATING SCALES

Visual Imagery Scale

1	2	3	4	5	6	7
Very hard to see	Hard to see	Somewhat hard to see	Neutral (not easy nor hard)	Somewhat easy to see	easy to see	Very easy to see

Kinaesthetic Imagery Scale

1	2	3	4	5	6	7
Very hard to feel	Hard to feel	Somewhat hard to feel	Neutral (not easy nor hard)	Somewhat easy to feel	easy to feel	Very easy to feel

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

   ACTION: Raise your right knee as high as possible so that you are starting on your left leg with your right leg flexed (bent) at the knee. Now lower your right leg so you are once 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 and legs together and your arms 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 both feet apart and lower your arms to your sides.

MENTAL TASK: Assume the starting position. Attempt to **see** yourself making the movement just performed. Now rate the ease/difficulty with which you were able to do this mental task.

Rating: __________

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

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

MENTAL TASK: Assume the starting position. Attempt to **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 your 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. Now rate the ease/difficulty with which you were able to do this mental task.

Rating: __________

5. STARTING POSITION: Stand with your feet and legs together and your arms 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 both 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 right knee as high as possible so that you are starting on your left leg with your right leg flexed (bent) at the knee. Now lower your right leg so you are once again standing on two feet. Perform these actions **slowly.**

MENTAL TASK: Assume the starting position. Attempt to **see** yourself making the movement just performed. 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 your hands). Now return to the starting position, standing erect with your arms extended above your head.

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

Rating: __________

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

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

MENTAL TASK: Assume the starting position. Attempt to **see** yourself making the movement just performed. Now rate the ease/difficulty with which you were able to do this mental task.

Rating: __________

Appendix 2: Movement Imagery Questionnaire-3 (Chapter 2, 3, and 4)

(MIQ-3)

This questionnaire concerns two ways of mentally performing movements, which are used by some people more than others, and are more applicable to some types of movement than others. The first is the formation of a mental (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 answers or some 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 of 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 from an internal perspective (i.e., from a 1st person perspective, as if you are actually inside yourself performing and seeing the action through your own eyes), (2) form as clear and vivid a visual image as possible of the movement just performed from an external perspective (i.e., from a 3rd person perspective, as if watching yourself on DVD), or (3) 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 of each movement. You may choose the same rating for any number of movements "seen" or "felt" and it is not necessary to utilise the entire length of the scale.

RATING SCALES

Visual Imagery Scale

1	2	3	4	5	6	7
Very hard to see	Hard to see	Somewhat hard to see	Neutral (not easy nor hard)	Somewhat easy to see	easy to see	Very easy to see

Kinaesthetic Imagery Scale

1	2	3	4	5	6	7
Very hard to feel	Hard to feel	Somewhat hard to feel	Neutral (not easy nor hard)	Somewhat easy to feel	easy to feel	Very easy to feel

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

   ACTION: Raise your right knee as high as possible so that you are starting on your left leg with your right leg flexed (bent) at the knee. Now lower your right leg so you are once 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 and legs together and your arms 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 both feet apart and lower your arms to your sides.

MENTAL TASK: Assume the starting position. Attempt to **see** yourself making the movement just performed from an **internal** visual imagery perspective. Now rate the ease/difficulty with which you were able to do this mental task.

Rating: __________

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

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

MENTAL TASK: Assume the starting position. Attempt to **see** yourself making the movement just performed from an **external** visual imagery perspective. 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 your 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: __________

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

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

	actions **slowly.**
MENTAL TASK:	Assume the starting position. Attempt to **see** yourself making the movement just performed from an **internal** visual imagery perspective. 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:	Bend down low and then jump straight up in the air as high as possible with both arms extended above your head. Land with both feet apart and lower your arms to your sides.
MENTAL TASK:	Assume the starting position. Attempt to **see** yourself making the movement just performed from an **external** visual imagery perspective. Now rate the ease/difficulty with which you were able to do this mental task.

Rating: __________

7. STARTING POSITION:	Extend the arm of your non-dominant hand straight out to your side so that it is parallel to the ground, palm down.
ACTION:	Move your arm forward until it is directly in front of your body (still parallel to the ground). Keep your arm extended during the movement, and make the movement **slowly.**
MENTAL TASK:	Assume the starting position. Attempt to **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:	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 your 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 from an **internal** visual imagery perspective. Now rate the ease/difficulty with which you were able to do this mental task.

Rating: __________

9. STARTING POSITION:	Stand with your feet and legs together and your arms at your sides.
ACTION:	Raise your right knee as high as possible so that you are starting on

your left leg with your right leg flexed (bent) at the knee. Now lower your right leg so you are once again standing on two feet. Perform these actions **slowly.**

MENTAL TASK: Assume the starting position. Attempt to **see** yourself making the movement just performed from an **external** visual imagery perspective. Now rate the ease/difficulty with which you were able to do this mental task.

Rating: __________

10. STARTING POSITION: Stand with your feet and legs together and your arms 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 both 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: __________

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

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

MENTAL TASK: Assume the starting position. Attempt to **see** yourself making the movement just performed from an **internal** visual imagery perspective. Now rate the ease/difficulty with which you were able to do this mental task.

Rating: __________

12. 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 your 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 from an **external** visual imagery perspective. Now rate the ease/difficulty with which you were able to do this mental task.

Rating: __________

Appendix 3: Vividness of Movement Imagery Questionnaire-2 (Chapter 2)

(VMIQ-2; Roberts, Callow, Hardy, Markland, & Bringer, 2008; Reverse scored)

Movement imagery refers to the ability to imagine a movement. The aim of this questionnaire is to determine the vividness of your movement imagery. The items of the questionnaire are designed to bring certain images to your mind.

You are asked to rate the vividness of each item by reference to the 5-point scale. After each item, circle the appropriate number in the boxes provided. The first column is for an image obtained watching yourself performing the movement from an external point of view (External Visual Imagery), and the second column is for an image obtained from an internal point of view, as if you were looking out through your own eyes whilst performing the movement (Internal Visual Imagery). The third column is for an image obtained by feeling yourself do the movement (Kinaesthetic imagery).

Try to do each item separately, independently of how you may have done other items. Complete all items from an external visual perspective and then return to the beginning of the questionnaire and complete all of the items from an internal visual perspective, and finally return to the beginning of the questionnaire and complete the items while feeling the movement. The three ratings for a given item may not in all cases be the same. For all items please have your eyes CLOSED.

Think of each of the following acts that appear on the next page, and classify the images according to the degree of clearness and vividness as shown on the RATING SCALE.

RATING SCALE. The image aroused by each item might be:

No image at all, you only “know” that you are thinking of the skill ……………RATING 1

Vague and dim ……………RATING 2

Moderately clear and vivid ……………RATING 3

Clear and reasonably vivid ……………RATING 4

Perfectly clear and as vivid (as normal vision or feel of movement) ……………RATING 5

	Watching yourself performing the movement (External Visual Imagery)					Looking through your own eyes whilst performing the movement (Internal Visual Imagery)					Feeling yourself do the movement (Kinaesthetic Imagery)				
Item	No image at all, you only know that you are thinking of the skill	Vague and dim	Moderately clear and vivid	Clear and reasonably vivid	Perfectly clear and vivid as normal vision	No image at all, you only know that you are thinking of the skill	Vague and dim	Moderately clear and vivid	Clear and reasonably vivid	Perfectly clear and vivid as normal vision	No image at all, you only know that you are thinking of the skill	Vague and dim	Moderately clear and vivid	Clear and reasonably vivid	Perfectly clear and vivid as normal feel of movement
1. Walking	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
2. Running	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
3. Kicking a stone	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
4. Bending to pick up a coin	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
5. Running up stairs	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
6. Jumping sideways	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
7. Throwing a stone into water	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
8. Kicking a ball in the air	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
9. Running downhill	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
10. Riding a bike	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
11. Swinging on a rope	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
12. Jumping off a high wall	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5

Appendix 4: Edinburgh Handedness Inventory (Chapter 3)

(EHI; Oldfield, 1971)

Please indicate your preferences in the use of hands in the following activities by putting a tick in the appropriate column. Some activities require both hands. In these cases the part of the task, or object for which hand preferences is wanted is indicated in brackets. Please try to answer all questions, and only leave blank if you have no experience at all of the object or task.

	Hand Used				
	Always Left	Usually Left	No Preference	Usually Right	Always Right
1.Writing					
2. Drawing					
3. Throwing					
4. Scissors					
5. Toothbrush					
6. Knife (without fork)					
7. Spoon					
8. Broom (upper handle)					
9. Striking Match (hand holding match)					
10. Opening box (hand holding lid)					
				L.Q	

Appendix 5: Preferred Perspective (Chapter 3)

When you image performing movements, do you generally see yourself from an internal perspective (i.e., first person viewpoint, as if you are actually inside yourself), or from an external perspective (i.e., third person viewpoint, as if watching yourself on DVD)?

	1	2	3	4	5	6	7	
Completely internal	←						→	Completely external
		Mostly internal, sometimes external		Half and half		Mostly external, sometimes internal		

Appendix 6: Perceived Model Similarity (Chapter 3)

How similar do you perceive the model performing the movements to yourself?

	1	2	3	4	5	6	7	
Not at all similar	←						→	Very similar

Why or why not? ____

Appendix 7: Example stills of a video clip from an external and internal perspective (Chapter 3)

External Perspective

Internal Perspective

Appendix 8: Sport Imagery Ability Questionnaire: 35-item version (Chapter 4, Pilot Study)

The purpose of this questionnaire is to obtain information about your ability to generate a number of images athletes use in relation to their sport.

In relation to your own sport, you are asked to bring each individual image to your mind with your eyes closed. Then rate how easy it is for you to form this image (1 = *very hard* to 7 = *very easy*) and how vivid and clear this image is (1 = *no image at all, you are just thinking about it* to 7 = *perfectly clear and vivid as normal vision*).

Move onto the next image only after you have completed the ratings for ease of imaging, and vividness and clarity.

Please be as accurate as possible and take as long as you feel necessary to arrive at the proper ratings for each image. There are no right or wrong answers, because we are simply interested in your response.

	B) How easy is it for you to form this image?	**C) How vivid and clear is this image?**
I image…	1 = *Very hard* 4 = *Neither easy or hard* 7 = *Very easy*	1 = *No image at all (just thinking about it)* 4 = *Moderately clear & vivid* 7 = *Perfectly clear & vivid as normal vision*
1. Making up new plans/strategies in my head.		
2. Achieving a personal best.		
3. Giving 100% effort.		
4. Refinements to a particular skill		
5. The positive emotions experienced.		
6. Others applauding my performance.		
7. Alternative strategies in case my event/game plan fails.		
8. The stress and anxiety associated with my sport.		
9. Myself appearing confident in front of my opponents.		
10. Other athletes congratulating me on a good performance.		
11. My skills improving.		
12. Myself being in control in difficult situations.		
13. The excitement associated with performing.		
14. Myself winning a medal.		

I image…	**B) How easy is it for you to form this image?** 1 = *Very hard* 4 = *Neither easy or hard* 7 = *Very easy*	**C) How vivid and clear is this image?** 1 = *No image at all (just thinking about it)* 4 = *Moderately clear & vivid* 7 = *Perfectly clear & vivid as normal vision*
15. Performing at the ideal intensity level for me (i.e. in the zone)		
16. Myself continuing with my game/event plan, even when performing poorly.		
17. Being unable to stay focused during a challenging situation		
18. Being interviewed as a champion.		
19. Being mentally tough.		
20. Performing a new skill perfectly		
21. Achieving my goal to win		
22. All the feelings associated with an ideal performance.		
23. Entire plays/programs/ sections just the way I want them to happen in an event/game.		
24. Making corrections to physical skills.		
25. Being focused during a challenging situation.		
26. Being motivated to achieve my goals		
27. Myself working successfully through tough situations (e.g., a player short, sore ankle, etc.)		
28. Performing a certain skill perfectly in my mind.		
29. Being anxious when performing.		
30. Staying positive after making a mistake		
31. Each section of an event/game (e.g., offense vs. defence, fast vs. slow).		
32. Getting psyched up for performing.		
33. Making a change to a skill.		
34. Persisting even when I haven’t achieved my goal to win		
35. Successfully following my game/event plan.		

Appendix 9: Sport Imagery Ability Questionnaire: 20-item version (Chapter 4, Study 1)

The purpose of this questionnaire is to obtain information about your ability to generate a number of images athletes use in relation to their sport.

For each item, bring the image to your mind with your eyes CLOSED. Then rate how easy it is for you to form this image (1 = very hard, to 7 = very easy). Circle the appropriate rating based on the scale provided.

Please be as accurate as possible and take as long as you feel necessary to arrive at the proper rating for each image. There are no right or wrong answers, because we are simply interested in your response.

In relation to my sport, how easy is it for me to image …	Very hard to image	Hard to image	Somewhat hard to image	Neutral (not easy or hard)	Somewhat easy to image	easy to image	Very easy to image
1. Making up new plans/strategies in my head.	1	2	3	4	5	6	7
2. Giving 100% effort even when things are not going well.	1	2	3	4	5	6	7
3. Refining a particular skill.	1	2	3	4	5	6	7
4. The positive emotions I feel while doing my sport.	1	2	3	4	5	6	7
5. Alternative plans/strategies.	1	2	3	4	5	6	7
6. Other athletes congratulating me on a good performance.	1	2	3	4	5	6	7
7. Being mentally tough.	1	2	3	4	5	6	7
8. The anticipation and excitement associated with my sport.	1	2	3	4	5	6	7
9. Improving a particular skill.	1	2	3	4	5	6	7
10. Myself winning a medal.	1	2	3	4	5	6	7
11. Each section of an event/game (e.g., offense vs. defence, fast vs. slow).	1	2	3	4	5	6	7
12. The excitement associated with performing.	1	2	3	4	5	6	7
13. Remaining focused during a challenging situation.	1	2	3	4	5	6	7
14. Making corrections to physical skills.	1	2	3	4	5	6	7

In relation to my sport, how easy is it for me to image …	Very hard to image	Hard to image	Somewhat hard to image	Neutral (not easy or hard)	Somewhat easy to image	easy to image	Very easy to image
15. Being interviewed as a champion.	1	2	3	4	5	6	7
16. The feelings that lead to a good performance.	1	2	3	4	5	6	7
17. Performing a skill well.	1	2	3	4	5	6	7
18. Remaining positive after a mistake.	1	2	3	4	5	6	7
19. Myself winning.	1	2	3	4	5	6	7
20. Creating a new event/game plan.	1	2	3	4	5	6	7

Appendix 10: Sport Imagery Ability Questionnaire: 12-item version (Chapter 4, Study 2)

The purpose of this questionnaire is to obtain information about your ability to generate a number of images athletes use in relation to their sport.

For each item, bring the image to your mind with your eyes CLOSED. Then rate how easy it is for you to form this image (1 = very hard, to 7 = very easy). Circle the appropriate rating based on the scale provided.

Please be as accurate as possible and take as long as you feel necessary to arrive at the proper rating for each image. There are no right or wrong answers, because we are simply interested in your response.

In relation to my sport, how easy is it for me to image …	Very hard to image	Hard to image	Somewhat hard to image	Neutral (not easy or hard)	Somewhat easy to image	easy to image	Very easy to image
1. Making up new plans/strategies in my head	1	2	3	4	5	6	7
2. Refining a particular skill	1	2	3	4	5	6	7
3. The positive emotions I feel while doing my sport	1	2	3	4	5	6	7
4. Myself winning a medal	1	2	3	4	5	6	7
5. Alternative plans/strategies	1	2	3	4	5	6	7
6. The anticipation and excitement associated with my sport	1	2	3	4	5	6	7
7. Improving a particular skill	1	2	3	4	5	6	7
8. Being interviewed as a champion	1	2	3	4	5	6	7
9. The excitement associated with performing	1	2	3	4	5	6	7
10. Making corrections to physical skills	1	2	3	4	5	6	7
11. Creating a new event/game plan	1	2	3	4	5	6	7
12. Myself winning	1	2	3	4	5	6	7

Appendix 11: Sport Imagery Ability Questionnaire: 15-item version (Chapter 4 Study 3 & 4, Chapter 5 and Chapter 6)

The purpose of this questionnaire is to obtain information about your ability to generate a number of images athletes use in relation to their sport.

For each item, bring the image to your mind with your eyes CLOSED. Then rate how easy it is for you to form this image (1 = very hard, to 7 = very easy). Circle the appropriate rating based on the scale provided.

Please be as accurate as possible and take as long as you feel necessary to arrive at the proper rating for each image. There are no right or wrong answers, because we are simply interested in your response.

In relation to my sport, how easy is it for me to image the following…	Very hard to image	Hard to image	Somewhat hard to image	Neutral (not easy or hard)	Somewhat easy to image	easy to image	Very easy to image
1. Making up new plans/strategies in my head.	1	2	3	4	5	6	7
2. Giving 100% effort even when things are not going well.	1	2	3	4	5	6	7
3. Refining a particular skill.	1	2	3	4	5	6	7
4. The positive emotions I feel while doing my sport.	1	2	3	4	5	6	7
5. Myself winning a medal	1	2	3	4	5	6	7
6. Alternative plans/strategies.	1	2	3	4	5	6	7
7. The anticipation and excitement associated with my sport.	1	2	3	4	5	6	7
8. Improving a particular skill.	1	2	3	4	5	6	7
9. Being interviewed as a champion.	1	2	3	4	5	6	7
10. Staying positive after a setback.	1	2	3	4	5	6	7
11. The excitement associated with performing.	1	2	3	4	5	6	7
12. Making corrections to physical skills.	1	2	3	4	5	6	7
13. Creating a new event/game plan.	1	2	3	4	5	6	7
14. Myself winning.	1	2	3	4	5	6	7
15. Remaining confident in a difficult situation.	1	2	3	4	5	6	7

Appendix 12: Competitive Trait Anxiety Inventory Confidence Subscale (Chapter 5)

(CTAI; Albrecht & Feltz, 1987)

The inventory you are about to complete measures how you generally feel about competition. Please complete the inventory as honestly as you can. Your answers will not be shared with anyone.

A number of statements which athletes have used to describe their feelings before competition are given below. Read each statement and then circle the appropriate number to the right of the statement to indicate how you generally feel.. There are no right or wrong answers. Do not spend too much time on any one statement, but choose the answer which describes how you generally feel about competition.

	Not at all	Somewhat	Moderately so	Very much so
1. I feel at ease	1	2	3	4
2. I feel comfortable	1	2	3	4
3. I feel self-confident	1	2	3	4
4. I feel secure	1	2	3	4
5. I am confident I can meet the challenge	1	2	3	4
6. I'm confident about performing well	1	2	3	4
7. I feel mentally relaxed	1	2	3	4
8. I'm confident because I mentally picture myself reaching my goal	1	2	3	4
9. I'm confident at coming through under pressure	1	2	3	4

Appendix 13: Cognitive Appraisal Scale (Chapter 5)

(CAS; Skinner & Brewer, 2002)

Directions: A number of statements that individuals have used to describe their **thoughts and feelings** are listed below. Read each statement and then circle the number to the right of the statement that indicates **how you usually feel** prior to competition. Please answer the questions working your way down the first column before proceeding to the second. There are no right or wrong answers. Do not spend too much time on any one statement, but choose the answer which describes your general thoughts/ feelings. You may choose the same rating for any number of statements and it is not necessary to utilise the entire length of the scale.

Statement	Strongly disagree	Disagree	Somewhat disagree	Somewhat agree	Agree	Strongly agree
1. I tend to focus on the positive aspects of any situation	1	2	3	4	5	6
2. I worry that I will say or do the wrong things	1	2	3	4	5	6
3. I often think about what it would be like if I do very well	1	2	3	4	5	6
4. I believe that most stressful situations contain the potential for positive benefits	1	2	3	4	5	6
5. I worry about the kind of impression I make	1	2	3	4	5	6
6. I am concerned that others will find fault with me	1	2	3	4	5	6
7. Overall I expect that I will achieve success rather than experience failure	1	2	3	4	5	6
8. In general I look forward to the rewards and benefits of success	1	2	3	4	5	6
9. Sometimes I think that I am too concerned with what other people think of me	1	2	3	4	5	6
10. I feel that difficulties are piling up so that I cannot overcome them	1	2	3	4	5	6
11. I lack self confidence	1	2	3	4	5	6
12. A challenging situation motivates me to increase my efforts	1	2	3	4	5	6
13. In general I anticipate being successful at my chosen pursuits, rather than expecting to fail	1	2	3	4	5	6
14. I worry what other people will think of me even when I know that it doesn’t make any difference	1	2	3	4	5	6
15. I am concerned that others will not approve of me	1	2	3	4	5	6
16. I look forward to opportunities to fully test the limits of my skills and abilities	1	2	3	4	5	6
17. I worry about what other people may be thinking about me	1	2	3	4	5	6
18. I feel like a failure	1	2	3	4	5	6

Appendix 14: Imagery Scripts (Chapter 6)

Challenging Script

You have finished your warm up and are now just a couple of minutes away from the start of your competition…you do not feel as prepared as you usually do… but are determined to demonstrate to yourself that you can still succeed…………your heart is beating faster than usual and you are breathing more deeply…………you know your opponents are of a higher standard than you but you have confidence in your own ability to perform… and relish the opportunity to compete against them…………you feel the adrenalin rush through your body reaching all your muscles…………although your muscles feel slightly tight you are adamant that you will be successful …………you have never experienced so many intense feelings prior to performance…you complete your final preparations …………your heart is now pumping so rapidly you can feel the blood flowing to every muscle…………in a similar situation you previously have not performed as well as you would have liked... but this time, you are convinced that this result will be different………… the butterflies in your stomach make you realise the importance of this event………… you look around and notice all of the people who have come to watch the competition… and savour the prospect of demonstrating your sporting competence in front of them…………you think of the outcome of this event… there is real potential to achieve everything you have worked so hard for this season…

Threatening Script

You have finished your warm up and are now only a couple of minutes away from the start of your competition… you do not feel as prepared as you usually do… and are nervous that you will not be able to succeed…………your heart is beating faster than usual and you are breathing more deeply…………you know your opponents are of a higher standard than you and this makes you cast doubts about your own ability to perform… and you fret about competing against them…………you feel the adrenalin rush through your body reaching all your muscles………… your muscles feel slightly tight and you are concerned that you will not be as successful…………you have never experienced so many intense feelings prior to performance…you complete your final preparations …………your heart is now pumping so rapidly you can feel the blood flowing to every muscle…………in a similar situation you previously have not performed as well as you would have liked… and you are worried this result will be no different…………the butterflies in your stomach make you realise the importance of this event…………you look around and notice all the people who have come to watch the competition… and you are concerned about the possibility of revealing your weaknesses…………you think of the outcome of this event… there is real potential to lose everything you have worked so hard for this season…

Neutral Script

You have finished your warm up and are now just a couple of minutes away from the start of your competition…………you find a restful area to sit quietly and gather your thoughts before you begin… you feel well prepared… and are calm about the upcoming event………… as you rest your body before the competition, you feel your heart rate begin to slow ………… you concentrate on your breathing and gradually reduce its rate by breathing slowly in…and then out again…………ignoring your opponents, you remain composed… in a state of serenity…………you feel your body begin to relax as all remaining tension gently leaves your muscles ………… eliminating all other thoughts, your heart rate continues to fall…getting slower…and slower…………ignoring everything around you, you remain in your own world………… your heart rate has gently dropped and your breathing has returned to its resting rate………… any anxiety you previously experienced has completely evaporated from your body… leaving you in a state of relaxation and contentment............ your body is now at a comfortable temperature………… you complete your final preparations… your muscles are loose and supple, and ready to perform………… you feel relaxed, stress-free, and ready to embrace the competition.

Appendix 15: Immediate Anxiety Measurement Scale (Chapter 6)

(IAMS; Thomas, Hanton, & Jones, 2002)

Modern day sport, by nature is highly competitive, which is likely to cause stress and anxiety to those who participate. There are two main types of anxiety which may be experienced at different levels in a sports player. These are cognitive and somatic anxiety. The following questionnaire asks you to respond to how cognitively anxious you are (the mental component) and how somatically anxious you are (the physical component) at this moment in time. In order to answer as accurately as possible please bear the following definitions in mind:

Cognitive Anxiety : Is the **mental** component of anxiety and maybe characterised by thoughts such as concerns or worries about your upcoming competition/match, for example about the way you perform or the importance of the event.

Somatic Anxiety : Is your **perception** of your **physical** state and maybe characterised by symptoms such as physical nervousness, butterflies in the stomach, tense muscles, and increases in heart rate.

Self Confidence : Is how **confident** you are of performing well in your upcoming competition/match and maybe characterised by factors such as achieving your competition/match goals and performing well under pressure.

Below are **3** statements reflecting the thoughts and feelings you may experience before competing. Each statement requires a response from each of the **2** sections. Section **1** asks you to respond to the **level** of cognitive anxiety and somatic anxiety (see definitions); Section **2** then asks whether you regard these anxiety level as **positive** or **negative** to your upcoming performance. Read each statement carefully and then circle the appropriate number to show how you feel **RIGHT NOW** in each of the 2 sections.

	Section 1							**Section 2**						
	To what extent were you experiencing **anxiety** and **confidence** (i.e., what **level**).							When you were experiencing this anxiety/confidence, did you regard it as positive or negative in relation to your performance in the hypothetical competition?						
During the imagery…	*Not at all*						*Extremely*	*Very debilitative (Negative)*			*Unimportant*			*Very facilitative (Positive)*
1. I was cognitively anxious	1	2	3	4	5	6	7	-3	-2	-1	0	+1	+2	+3
2. I was somatically anxious	1	2	3	4	5	6	7	-3	-2	-1	0	+1	+2	+3
3. I was self-confident	1	2	3	4	5	6	7	-3	-2	-1	0	+1	+2	+3

Appendix 16: Imagery Manipulation Checks
(Chapter 6)

Please answer the following questions with regards to the imagery scenario you just heard.

1. How easy was it for you to <u>create</u> the images described to you?

	1	2	3	4	5	6	7	
Very hard ←				Not hard/not easy				→ Very easy

2. How strong was your <u>emotional</u> experience created by the image?

	1	2	3	4	5	6	7	
No emotion ←								→ Strong emotion

3. In the hypothetical competition, would this imagery script be helpful or hurtful to your performance?

	-1	-2	-1	0	+1	+2	+3	
Very hurtful ←				Not at hurtful/not helpful				→ Very helpful

4. How well did you relate to the responses described in the imagery script?

	1	2	3	4	5	6	7	
Not at all ←								→ Completely

Appendix 17: Cognitive Appraisal of Imagery Scripts (Chapter 6)

Please answer the following questions with regards to the imagery scenario you just heard.

	During the imaged scenario…	Not at all true						Very true
1	The situation presented itself as a challenge to me	1	2	3	4	5	6	7
2	I viewed the competition as a threat	1	2	3	4	5	6	7
3	I felt threatened by the situation	1	2	3	4	5	6	7
4	I viewed the competition as a challenge	1	2	3	4	5	6	7
5	The situation presented itself as a threat to me	1	2	3	4	5	6	7
6	I felt challenged by the situation	1	2	3	4	5	6	7

Appendix 18: Post-Experiment Manipulation Check
(Chapter 6)

Part 1

Please select the imagery script that you think would be most helpful in preparing you for an actual competitive performance:

1. Challenging script ☐
2. Relaxing script ☐
3. Threatening script ☐

Part 2

To what extent was your imagery disrupted by the equipment and overall scanning procedure?

1	2	3	4	5	6	7	8	9	10

Not at all ⟷ Very much so