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# Focus of attention execution of form, anxious performance and consideration in imagery application

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# Focus of Attention; execution of form, anxious performance and consideration in imagery application.

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# Published work from this thesis

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**Under Review:**

Lawrence, G.P., Gottwald, V.M., & Khan, M.A. (*Under Review*). The effects of learning with different foci of attention on anxious performance and movement variability. *Journal of Sport and Exercise Psychology.*

## Additional Research Conducted during this Thesis

Lawrence, G.P., Beattie, S., Woodman, T., Khan, M.A., Hardy, L., Gottwald, V.M., & Cassell, V.E. (*Under Review*). Practice with anxiety improves performance, but only when anxious: Evidence for the specificity of practice hypothesis. *Anxiety, Stress and Coping.*

Kramer, R.S.S., Gottwald, V.M., Dixon, T.A.M., & Ward, R. (*Under Review*). Different signals of personality and health from the face and gait. *Evolution and Human Behavior.*

# CHAPTER 1

# THESIS OVERVIEW

## 1.1.Background

In teaching and coaching environments we are continuously instructing or guiding athletes in order to enhance their performance. The content of these instructions often direct the athlete's attention to particular aspects of either their movements or the outcomes of the to-be-performed skill. It is therefore particularly important that we are able to discern between the efficaciousness of instructions that lead either to attention being directed to movement production or to movement outcome. Although the more prominent literature that investigates the above is relatively recent, work actually dates back to as early as the $19^{th}$ Century. Here James (1890) suggested that for successful performance in reaching and grasping tasks, attention should be directed to movement outcome as opposed to movement production.

Since then Wulf has been a proponent in the development of research in this area, namely focus of attention (FOA) (for a review see Wulf, 2007a). Her work has been pivotal in developing definitions of both internal and external foci of attention and in offering hypotheses for the efficaciousness of each (i.e., the Constrained Action Hypothesis [CAH] [Wulf, McNevin & Shea, 2001]). Wulf defines the adoption of an internal FOA as occurring when participants focus on their body movements during performance. For example, the snapping motion of the wrist in basketball during the free throw action. On the other hand, external FOA is defined as attention that is directed towards the movement effects of action e.g., the trajectory of the ball during the free throw action. The CAH suggests that attending to movements can interfere with normally automatic response programming and disrupt performance, whereas attending to the outcome of action promotes movement automaticity and serves to enhance performance. Support for this suggestion has been shown across a variety of sporting domains and populations (for a review see Wulf, 2007a).

## 1.2. Outline of the thesis

This thesis endeavours to fill some of the more pertinent gaps within the FOA literature. Chapter 3 attempts to determine whether the benefits of an external FOA can be extended to performance in form sports where movement effects are not always so salient. The subsequent chapter has considered the attentional focus literature in conjunction with the anxiety literature and investigated the effects of learning with different foci of attention on anxious performance. Furthermore, since much of the work within both the FOA and the anxiety literature has measured performance via movement outcome, the research is fundamentally limited in its ability to describe the effects of each on movement production. As such, this chapter included dependent variables to investigate the variability of both the velocity and the distance travelled of limbs at various time points during movement production. This was achieved via Vicon Motion Analysis software and the application of a novel variability methodology adapted from the work of Khan and colleagues on target directed movement (for a review see Khan et al., 2006). Finally, chapter 5 investigated whether FOA can be incorporated within specific psychological skills (namely imagery) to enhance their effectiveness.

### 1.3. Thesis format

This thesis is made up of an overall review of the literature, three research papers and a general discussion. All three manuscripts are written as stand alone research articles. The first has been published in Research Quarterly for Exercise and Sport, the second submitted for publication to the Journal of Sport and Exercise Psychology and it is anticipated that the third and final experimental chapter will be submitted for consideration to a similar international psychology or motor learning journal. All manuscripts are written in the style adopted by the School of Sport, Health and Exercise Sciences, Bangor University, which is described in the American Psychological Association Publication Manual ($6^{th}$ Ed.) and the current recommendations of Bangor University thesis preparation. For the same reason all citations are included in a single section at the end of this thesis and illustrations are numbered consecutively. Abbreviations have been defined at their first appearance within each chapter of the thesis to facilitate reading. The contributions of the co-authors to each original manuscript are detailed in the ‘acknowledgments’ and ‘published work from this thesis’ sections. As all the manuscripts included in this thesis are independent but linked, at times there is a necessary overlap in the content between chapters.

# CHAPTER 2

# INTRODUCTION: REVIEW OF LITERATURE

## 2.1. General Overview

Effective skill acquisition is a fundamental part of achieving success in sport. It is imperative to establish a learning environment which promotes not only optimal performance during acquisition, but also one which takes into account the retention and transfer of learning in future performances. Fitts and Posner (1967) proposed three phases of learning which all individuals must progress through during the learning process. Each phase differs in terms of cognitive demands, skill execution and fluidity of performance. Learning begins in the cognitive phase where performance requires a substantial amount of conscious control, resulting in inefficient and erratic movement execution. With training, novices are able to progress into the associative phase of learning, during which movement execution becomes more effective but still requires some conscious control. Finally, through extensive practice learners advance to the autonomous phase of learning where performance does not require conscious control and movements are fluid, aesthetically pleasing and precise. Simon and Chase (1973) estimate that 10 years of deliberate practice is necessary before achieving true expertise and thus it is in the athlete's interest to minimise this lengthy time period through effective and efficient skill acquisition.

Verbal instruction is an essential moderator of successful progression through these stages and thus the content of these instructions are of avid interest to the researcher. Regardless of which phase an individual is currently situated, learners are often informed of where best to direct their attention during skill execution, in order to achieve optimal skill development. Coaches and teachers continually strive to direct the learner's attention to specific movement mechanics, movement effects or simply the environment, but unfortunately these instructions do not always result in optimal performance and in some cases may actually hinder skill acquisition. The current thesis examined the effect of FOA on the acquisition, retention and transfer of performance execution.

**2.2. Focus of Attention**

Attentional focus plays a significant role in governing several characteristics of skill execution such as efficiency, consistency and accuracy (Wulf, 2007b). What individuals pay attention to whilst executing a skill can influence their rate of progression through the phases of learning (Wulf, 2007b). Early researchers (Deikman, 1969; James, 1980) have previously studied the effects of FOA on performance but it is only recently that researchers such as Gabriele Wulf, a proponent in FOA research, have increased impetus for this topic. Wulf has comprehensibly classified FOA stimuli as being either internal or external (Wulf, Höb & Prinz, 1998), in order to investigate their differential effects on performance. Directing attention to specific movements, for example the swinging motion of the arms in a golf putt or the snapping motion of the wrist in basketball, has been categorised as an internal FOA, whereas focusing on movement effects, for example the swinging motion of the club-head in a golf putt or the ideal trajectory of the ball in a basketball free throw, has been categorised as an external FOA.

Differential effects of an internal and external FOA were first examined in a principle paper by Wulf et al. (1998) utilising a ski-simulator task. Participants focused either on the pressure applied from their feet (internal focus) or on the pressure applied to the simulator wheels situated below their feet (external focus). Findings revealed that adopting an external FOA enhanced performance (exhibited through larger amplitude movements) over and above that of the internal focus group and control group. This finding was subsequently replicated in a balance stabilometer task where participants adopting an external FOA displayed lower root mean square error (RMSE) than the internal group at retention. This was initially accounted for with Prinz's (1997) action-effect principle which emphasizes a compatible relationship between planning and outcome. Thus, if actions are planned and controlled in relation to their effects, then focusing externally should facilitate performance by enhancing congruence between movement programming and the obligatory response.

The Constrained Action Hypothesis (CAH) (Wulf, McNevin, & Shea, 2001) was then proposed in order to describe the differential performance effects between the adoptions of either an internal or external FOA. Here, it was hypothesised that whilst an external FOA facilitates the programming and response relationship, an internal FOA serves to disrupt the organisation between the two. It was rationalised that support for this suggestion would be evident if attentional demands associated with adopting an external FOA were reduced compared to those of an internal FOA. To investigate this, Wulf et al., (2001) had participants conduct a probe reaction time (RT) task simultaneous to a balance stabilometer task. Results revealed that participants adopting an external FOA demonstrated enhanced balance performance, as measured by lower RMSE and higher mean power frequency (MPF) adjustments, and exhibited reduced probe RTs compared to those adopting an internal FOA. As such, the first empirical support for the proposal of the CAH was presented. That is, external FOA facilitates the organisation of response programming requiring less attention demands, whereas focusing on movement execution interferes with normally automatic response programming, disrupts performance and reduces attention to secondary tasks.

Early research within the FOA area has often neglected to include control groups (Wulf et al., 1998, exp. 2; Wulf et al., 2001). As a consequence it is ambiguous whether it is an external FOA which enhances performance or an internal FOA which constrains performance, relative to adopting no explicit focus. One study that has addressed this issue was conducted by Wulf and Su (2007) who asked both novice and expert participants to perform a golf drive task under either an internal, external or control (no focus) condition. Findings revealed that adopting an external FOA did in fact enhance performance, with no differences between the control and internal groups. The extension of these findings to a diversity of ability classifications is of great magnitude. Wulf and colleagues have competently demonstrated that the performance benefits of adopting an external FOA are robust for individuals at both ends of the expert-novice continuum (Maddox, Wulf & Wright, 1999; Wulf, McConnel, Gärtner & Schwarz, 2002; Wulf & Su, 2007). However, a second line of research is at odds with the findings that novice performance is enhanced by the adoption of an external FOA. This body of research suggests that novice performance is actually facilitated by a self-focus on movement execution (Beilock, Carr, McMahon & Starkes, 2002; Ford, Hodges & Williams, 2005). Beilock et al. (2002) revealed that novice performance in a football dribbling task was superior when participants were able to focus on their movements as opposed to when distracted from attending to movement execution through a dual task. Beilock et al. accounted for this finding with the de-automisation of skills hypothesis, which suggests that because novice performance is not yet automatic, motor programming cannot be disrupted through conscious control induced by a self-focus and in fact focusing on movement execution only serves to facilitate the step by step control of movements.

In an ambitious study, Castaneda and Gray (2007) further analysed the effect of FOA and expertise on baseball batting performance. A within-subjects design examined skill execution under multiple attention conditions as well as a control condition. Specially, participants performed the batting task under the following conditions; skill internal (where focus was on hand movements), skill external (where focus was on the bat motion), environmental irrelevant (where focus was on auditory tones), environmental external (where focus was on the ball leaving the bat) and control (no focus instructions). Thereby, the internal and external conditions proposed by Wulf et al., (1998) were included as well as the skill and environmental (or dual-task) conditions proposed by Beilock et al., (2002). Consistent with the CAH, findings revealed that expert performance was superior when attentional focus was directed to the ball leaving the bat i.e., an external FOA compared to the adoption of an internal FOA. However, novice performance was more ambiguous since performance was superior when adopting a skill focus directed to either the motion of the hand or to that of the bat. This was explained via the de-automisation of skills hypothesis (Beilock et al., 2002) by suggesting that novice performance is optimal when participants are able to attend to step-by-step processes of the skill. According to Wulf et al., (1998) the hand and the bat represent internal and external stimuli, relatively, whereas Beilock et al., (2002) would classify both stimuli as skill focused as both contain more salient information regarding the mechanics of the skill comparative to an environmental or distal focus. Due to the methodological differences between attentional focus manipulations, (i.e., Wulf and colleagues' internal and external verbal instructions versus Beilock and colleagues' self-focus and distraction based dual tasks) it is difficult to truly compare findings. Due to the relevant nature of teaching and coaching pedagogy, which assiduously utilises verbal instruction to enhance performance and subsequently underlies the motivation behind this thesis, the current thesis has adopted Wulf's method in manipulating attentional focus (Wulf et al., 2001).

Wulf and colleagues have since endeavoured to extend these findings to a variety of sporting domains i.e., basketball (Al-Abood, Bennett, Hernandez, Ashford, & Davids, 2002; Zachry, Wulf, Mercer, & Bezodis, 2005), jumping (Wulf, Zachry, Granados, & Dufek, 2007), golf (Wulf, Lauterbach, & Tool, 1999), balance (Wulf, McNevin, & Shea, 2001), and leg cycling (Totsika & Wulf, 2003) as well as different skill sets (Bell & Hardy, 2009; Wulf & Su, 2007) and populations ie., individuals with movement disorders such as stroke patients (Fasoli, Trombly, Tickle-Degnen, & Verfaellie, 2002) and Parkinson's disease patients (Landers, Wulf, Wallmann, & Guadagnoli, 2005). There are various implications from these findings, especially from an instructional coaching perspective, i.e., being conscious of where best to direct learners' and experts' FOA in order to maximise performance in different tasks. Considering the effects of adopting an external FOA in different sports, it becomes apparent that there are often multiple options for a potential external focus for example in golf there is the club and the ball, in tennis the racket and the ball and basketball there is the ball and the basket.

McNevin, Shea and Wulf (2003) deliberated this issue in an attempt to resolve whether adopting external foci with varying proximities to the body would result in further performance differences. The rationale being that both the action effect principle and the CAH propose that an external FOA serves to enhance the programming and response relationship by promoting attention towards the movement outcome. Thus, the closer the external focus is towards the eventual outcome, the more facilitated the action-effect relationship. Similarly, the CAH proposes that an internal FOA serves to disrupt the normally automatic processing involved in movement production and results in a constraining of actions. As such, the further away from the body ones' attention is directed the less likely actions are to be constrained. To investigate this possibility, McNevin et al. (2003) utilised a balance stabilometer task and instructed participants to adopt either an internal FOA on the motion of their feet or an external FOA either on markers positioned on the far outer edge of the board (distal external focus) or on markers positioned on the far inner area of the board (proximal external focus). Consistent with the CAH, movement modifications were lower in amplitude but higher in frequency when an external focus was employed. In addition, the benefits of an external FOA were greater when the focus was more distal in nature i.e., further from the body. McNevin et al. reasoned that adopting a focus of this nature serves to facilitate differentiation from an internal focus and enhance the action-effect relationship resulting in optimal performance.

As well as investigating the proximity of an external focus, research has sought to investigate the type of external focus. Wulf, McNevin, Fuchs, Ritter and Toole (2000) addressed the question of whether it is sufficient to focus attention on any external object or whether performance is only optimised when attention is focused on the movement effect. A tennis stroke was selected as the task and although all participants focused on the ball, some were focusing on it as it travelled towards them and others focused on the predicted trajectory of the ball once it had left the racket. Results revealed that performance was superior when focusing on the predicted trajectory of the ball, supporting the notion that focus should be directed to movement effects. In a second experiment Wulf, et al. (2000) investigated differential effects in attending to any movement effect compared to focusing on a movement effect more relevant to movement technique. Participants were instructed to hit golf balls at a target area, with one group focusing on a movement effect relating to form (club movement) and the other group focusing on a movement effect unrelated to technique (ball trajectory and the target). Previous research (McNevin et al., 2003) has suggested that an external focus more distal to the body serves performance better but these findings suggest that actually as long as the external focus is far enough from the body that it can be distinguished from body movements, then actually an external focus more relevant to technique is favourable. In McNevin et al.'s (2003) study it appears that a focus on the board directed proximal to the feet might have been more difficult to distinguish from movements and thus did not facilitate action-effect automaticity as well as a more distal focus. However, Wulf et al. (2000) adopts an external focus on the golf club versus the ball and target and because the golf club is easily differentiated from movements, although proximal, it actually serves as a better focus due to it being more relevant to successful skill execution.

Supplementary to instructions directing movement execution, athletes are also given regular feedback in the form of verbal instructions, in order to reinforce good or bad technique. This feedback can encourage a particular attentional focus, for example feedback regarding knowledge of performance (KP feedback) encourages an internal FOA whilst feedback regarding knowledge of results (KR feedback) encourages an external FOA (Schmidt & Lee, 2005). Shea and Wulf (1999) investigated the potential different performance effects of providing feedback that promotes either an external or internal FOA in a balance stabilometer task. An internal focus feedback group was given feedback regarding the movement of their feet, an external focus feedback group was given feedback regarding movement of the board and two control groups were given no feedback but adopted either an internal or external FOA. Although feedback groups were not explicitly instructed to adopt a particular FOA, it was anticipated that the feedback given would likely induce either an internal or external FOA. Consistent with the CAH (Wulf et al., 2001), results revealed that performance was superior for participants instructed to use an external FOA and also participants who were given external focus feedback. Shea and Wulf reasoned that the external focus feedback must have encouraged participants to attend to movement effects.

Wulf, McConnel, Gärtner & Schwarz (2002) further examined the effect of feedback inducing differential foci of attention on performance but additionally were able to examine movement form. There is only a limited amount of research investigating the effects of attentional focus on form tasks and movement technique with those that have examined technique only doing so as a secondary dependent variable (Wulf, et al., 2002). Here, participants performed volleyball serves and received feedback about their performance (both on serve accuracy and movement technique) from either an internal or external focus. In line with previous research, results revealed that the accuracy of the serve (i.e., the outcome performance measure) was enhanced in the external focus feedback group compared to that of the internal focus feedback group. However, contrary to these results, the analysis of the technique and form of the participants' movements did not significantly differ between the two groups. This provokes a further need to investigate movement form under differential attentional foci.

Although research has been generalised to include several sports, for example basketball (Al-Abood et al., 2002; Zachry et al., 2005), jumping (Wulf et al., 2007), golf (Wulf et al., 1999), balance (Wulf et al., 2001), and leg cycling (Totsika & Wulf, 2003), it is still not entirely clear what occurs during movement execution to create these robust performance differences since the majority of previous research has only investigated movement outcome. One study that did attempt to investigate movement production was that of Zachry et al., (2005). They examined the relationship between FOA (internal or external), movement outcome and movement production (electromyography (EMG)) in a basketball free throw task. Results revealed that shooting was more accurate and movement more efficient when an external FOA was adopted. This was reflected by a greater number of scored baskets and lower EMG activity in the flexor carpi radialis, biceps brachii, triceps brachii and the deltoid of the shooting arm, respectively. These findings provided evidence for the notion that an external focus of control results in more accurate and efficient performance.

## 2.3. Anxiety

The notion that attending too closely to well-learnt movements disrupts performance is not a novel evocation. Henry and Rogers' (1960) 'memory drum theory' indicated that attempts to consciously control movements can obstruct automaticity of response programming, thus hampering performance. This suggestion was supported by numerous early researchers for example James (1980) in a simple reaching task, Eysenck (1982) in stair walkings and Schmidt (1982) in a complex piano playing task. Wulf et al.'s (2001) CAH shares similar theoretical implications with research into stress and performance. Essentially, attending too closely to well-learnt movements during skill execution can have negative implications on performance, often resulting in an athlete choking (Baumeister, 1984; Masters, 1992). This has been defined as "performance decrements under circumstances that increase the importance of good or improved performance" (Baumeister, 1984, p.610). There are two key lines of research, which have been applied to account for these findings; distraction and self-focus theories. Eysenck's (1992) distraction theory suggests that under pressure, worry consumes the central executive component of working memory, which would normally be used in information processing, thus disrupting performance. Eysenck observed that when anxious, performers often apply increased levels of effort in an attempt to compensate for the effects of performance pressure. An increased application of effort can maintain performance, but as a consequence, efficiency is sacrificed. Unfortunately an objective measure of effort is difficult to attain accurately and thus this notion is problematic to test empirically (Eysenck, 1992). Baumeister (1984) proposed an alternative explanation, suggesting that anxiety causes performers to become self-conscious and focus on performance processing. In a similar manner to adopting an internal FOA with regard to CAH (Wulf et al., 2001), this interferes with the usually automatic information processing, causing a decrease in performance.

Self-focus theories suggest that a decline in anxious performance is often due to a breakdown in proceduralised knowledge so that skills can be controlled in a step-by-step declarative manner (Masters, 1992). Masters' (1992) conscious processing hypothesis (CPH) has been the foundation for the large majority of self-focus anxiety research, with a principle study considering the impact of stress on skills learnt both implicitly and explicitly. Masters' work reflects on Fitts and Posner's (1967) early theory of learning, which suggests that as a consequence of transitioning from novice to expert, knowledge used to control movement execution, evolves from explicit to implicit. "Explicit knowledge is made up of facts and rules of which we are specifically aware and therefore able to articulate and implicit knowledge is made up of that which we 'know' yet are not aware of and thus cannot articulate" (Masters, 1992, p.341). Masters hypothesised that if it is the re-investment of conscious control over explicit knowledge that disrupts anxious performance, then minimising this information during acquisition, should prevent a breakdown of automatic processes under stress, as there will be no access to explicit knowledge. A golf putt was selected as the task, with implicit learning manipulated using random letter generation (RLG) simultaneous to performance, and explicit learning induced using specific written instructions dictating how exactly to perform the putt. Beilock and Carr (2001) suggest that golf putting is an appropriate task in this kind of study due to its proceduralised nature following extensive training. Learning occurred over 400 acquisition trials before participants were subjected to stress, induced by a combination of social evaluation and monetary loss. Results demonstrated that stress had a detrimental effect on performance when skills had been learnt explicitly but not implicitly. CPH (Masters, 1992) was utilised to account for these findings, rationalising that acquisition of explicit knowledge was limited by the RLG when learning implicitly. Therefore when subjected to pressure, participants were unable to reinvest in step by step control over declarative knowledge as they had no access to it, and thus choking was inhibited.

Hardy, Mullen and Jones (1996) emulated Masters' study suggesting that the reason Masters' implicit learning group's performance did not suffer under stress could actually have been due to diminished task difficulty as opposed to CPH, as the RLG was performed through acquisition but not in transfer, during the anxiety condition. Therefore Hardy et al. included an additional implicit learning group, in an otherwise similar study methodologically, with just one of the implicit learning groups performing RLG in the stress test. Results were consistent with Masters' (1992) research showing a detrimental effect on performance for the explicit learning group only, supporting CPH.

Bright and Freedman (1998) also insinuated that Masters' findings were a result of reduction in task difficulty, due to implicit learners not having to perform RLG during the anxiety test and not down to CPH as Masters proposed. However, in conflict to Hardy et al.'s (1996) findings Bright and Freedman's findings were actually consistent with this notion. After replicating Masters' (1992) study, the only benefits to anxious performance came from an implicit learning group who were not required to perform RLG in the anxiety condition and not from the implicit learning group who did have to perform RLG in the anxiety condition. This finding elicited doubts concerning Masters' (1992) original findings, Hardy et al.'s (1996) findings and thus CPH.

With these equivocal findings in mind, Mullen, Hardy and Oldham (2007) endeavoured to re-examine the anxiety-performance relationship in an attempt to establish the validity of CPH. Methodological differences between Hardy et al.'s (1996) study and Bright and Freedman's (1998) study were identified as a plausible explanation for differential findings. Whilst Hardy et al. (1996) were able to closely replicate Masters' (1992) study, Bright and Freedman (1998) made methodological modifications. In particular acquisition trials were condensed from 400 to 160, an arguably substantial reduction. Additionally, some participants may not have been complete novices and may have already acquired explicit knowledge regarding the execution of a golf putt, thus confounding true implicit learning. Mullen et al. (2007) therefore replicated Masters' (1992) original study, maintaining methodological proximity and found that results were consistent with the notion that when skills are learnt implicitly they are more robust under pressure. This finding emphasized support and validity for CPH (Masters, 1992).

Mullen and Hardy (2000) offered further support for CPH but for higher ability performers only. Weaker performers did not suffer the effects of anxiety, which was accounted for with the notion that because novice performance is not yet automatic (Fitts & Posner, 1967) it cannot be disrupted by conscious control as movements are already processed in a step-by-step fashion. This substantiates Mullen et al.'s (2007) proposition that Bright and Freedman (1998) were negligent in reducing the quantity of acquisition trials when testing the effects of pressure on implicit and explicit learning.

Beilock and Carr (2001) provided supplementary evidence to reinforce the explanation of why anxiety only diminishes performance of well-learnt skills. It was hypothesised that if expert programming is automatic but novice programming requires attention, then novices should have better memory of performance comparative to experts who should suffer from “expertise-induced amnesia” (p.703). Findings revealed that experts did in fact have fewer and less detailed memories of particular putts, indicating the proceduralised nature of expert performance. This reinforces the notion that the step-by-step programming, caused by an anxiety-induced self-focus is unfamiliar and damaging for expert performance. A further experiment examined the possibility that self-consciousness training could be used as an intervention, in order to diminish the negative effects of anxious performance. Results revealed that learning skills whilst simultaneously adopting a self-focus can actually limit the effects of choking in future performances. This finding results in positive implications in terms of reducing an individual’s predisposition to choking under pressure. This may be due to distraction hypothesis (Wine, 1971) in that the self conscious condition resulted in attention being directed towards the threat stimuli of the manipulation used to induce the self conscious state. As such, this served to prevent the development of explicit rules during learning similar to the RLG tasks adopted in the work of Hardy and colleagues.

Additional confirmation was provided for CPH with Hardy, Mullen and Martin’s (2001) research which investigated Masters’ (1992) suggestion that performance decrements will be evident under anxiety conditions combined with the presence of task-relevant cues. Although results were consistent with this theory, Hardy et al. (2001) provided an alternative explanation concerning attentional capacity. If anxiety consumes one chunk of attention and attending to task relevant cues (coaching points) consumes another chunk, then attentional capacity may be reduced to the point that performance is hindered.

The aforementioned assessment of the literature previously indicated that CPH (Masters, 1992) and the CAH (Wulf et al., 2001) share underpinning theoretical foundations. There has since been an innovative study (Bell & Hardy, 2009) which has examined the FOA literature in conjunction with anxiety. Bell and Hardy investigated anxious chipping performance under differential attentional foci. Specifically, experts were assigned to one of three experimental groups; an internal focus (arm/wrist motion), a proximal external focus (clubface) or a distal external focus (ball flight). Participants performed a golf chipping task under low (natural) and high anxiety conditions. Results revealed that performance was greatest when adopting an external FOA under both natural and high-anxiety conditions. These findings were supportive of the CAH and distraction theory was adopted to account for inhibited choking under pressure when employing an external focus. Researchers suggested that as an external FOA consumes less working memory (Wulf et al., 2001) then stress has a more severe impact when using an internal FOA. That is, the presence of anxiety consumes aspects of working memory and reduces that which is available for completion of the goal directed task. Since the attention demands under an external FOA are less than those of an internal FOA, the presence of anxiety did not consume enough working memory to negatively impact the performance of the golf chipping task.

## 2.4. Imagery

Contemporary research has been steadfast in exhibiting the benefits of psychological skills to enhance performance. In particular, mental rehearsal has been prevalent as a psychological tool used to supplement physical expertise in a variety of sports and domains (Feltz & Landers, 1983; Murphy & Martin, 2002; White & Hardy, 1998). Research as early as the 1980's has documented its popularity. Orlick and Partington (1988) reported that 99% of Canadian Olympians were using some form of imagery on a regular basis. Mental rehearsal can be a powerful tool to the extent that it can actually stimulate muscle activity, even when isolated from physical practice (Hale, 1982; Bakker, Boschker & Chung, 1996). It should not however, be used as a substitute for physical practice but instead used in conjunction with it. Ryan and Simmons (1982) examined the effects of both imagery and practice on performance, revealing that physical practice lead to the biggest improvements in performance but mental rehearsal was better than no practice.

Neuroscience research has revealed similar areas of the brain are activated during both physical practice and motor imagery (Holmes & Collins, 2001). In particular, the supplementary motor area (SMA), cerebellum and basal ganglia share common activation (Ingvar & Philipsson, 1977; Decety & Ingvar, 1990). This goes some way in explaining the substantial benefits of motor imagery.

Bio-informational theory (Lang, 1977, 1979) explores the precise nature of how imagery works. Lang makes the assumption that an image is a structure stored by the brain, containing two primary types of coded information; stimulus propositions (what can be seen during mental rehearsal e.g. the ball, the basket and the crowd, when shooting a game-deciding free throw in a major basketball competition) and response propositions (physiological responses e.g. muscle tension or increased heart rate). Although separated through proposition, this coded information is highly inter-related and so retrieval of one proposition can easily instigate the retrieval of another. Thus, muscle activity can be triggered as a consequence of producing a mental representation of a skill. When using mental rehearsal in practice, scripts are often created to regulate effective imagery. The implications of bio-informational theory highlight the importance of including both stimulus propositions and response propositions when creating imagery scripts, so that more vivid images can be formed as a consequence (Weinberg & Gould, 2003). Hale (1982) reasons that images that contain response propositions as well as stimulus propositions will result in more kinaesthetic responses, generating more life-like imagery.

Empirical research has been robust in exhibiting the use of imagery to enhance performance through different functions, for example increasing confidence, emotion regulation, improving concentration, skill acquisition, strategy development and coping with injury (Hall, Mack, Paivio, & Hausenblas, 1998). More specifically, Paivio (1985) identified two primary functions of imagery as being either motivational or cognitive and further to this he suggested that imagery can be directed towards either specific or general goals. Examples of motivational goals include imaging oneself winning to increase arousal or imaging a relaxing environment to relieve stress and cognitive goals could include imaging successful skill execution or imaging a particular play or strategy.

Mahoney and Avener (1977) have defined two different visual imagery perspectives, which athletes have reported using to enhance performance. Imaging from a 1$^{st}$ person perspective has been defined as an internal visual imagery perspective, where the athlete sees themselves perform the skill as if through their own eyes. Imaging from a 3$^{rd}$ person perspective has been defined as external visual imagery. Here, the athlete sees themselves perform as if watching a video. Traditionally, researchers believed that adopting an internal visual imagery perspective was preferable for optimal performance (Weinberg, 1988), reasoning that this view is more consistent with what is seen during real-life skill execution. Mahoney and Avener's (1977) findings supported this concept, revealing that successful elite gymnasts expressed using internal imagery more frequently than unsuccessful elite gymnasts.

In addition, studies have reported that adopting an internal imagery perspective activates higher EMG activity in the muscles (Hale, 1982), which would suggest that it is perhaps more effective. However, more recent research suggests that actually optimal visual perspective is dependent on the task being executed (White & Hardy, 1995). This research suggests that adopting an internal imagery perspective can enhance the acquisition and performance of open skills such as downhill skiing, where perception and line are important. This view provides the performer with additional information regarding both the environment and precise timings required to execute the skill successfully. Conversely, adopting an external imagery perspective can enhance the acquisition and performance of sports where form is important such as gymnastics. A 3rd person perspective enables the performer to view the precise body positions and movement kinetics necessary for successful performance.

Evidently the individual's ability to create a vivid and controllable image will affect the extent to which performance is enhanced (Ryan & Simmons, 1982; Isaac, 1992). Imagery in itself is a skill and can therefore be improved through practice (Rodgers, Hall & Buckholz, 1991). Empirical evidence has shown the benefits of imagery interventions in improving performance (Weinberg & Williams, 2001). However, in order to measure variations in imagery ability it is imperative that researchers are able to measure imagery ability accurately. A recently validated method utilised in the current thesis is the Vividness of Movement Imagery Questionnaire–2 (VMIQ-2) (Roberts, Callow, Hardy, Markland & Bringer, 2008). This questionnaire requires athletes to form images of a variety of movements and then rate the vividness of each image. Specifically, the measure contains 12 items and participants are asked to image each item from a specific imagery perspective and rate the image on 5 point Likert scale according to the degree of clearness and vividness (the scale ranges from 1; perfectly clear to 5; no image at all). The 12 items are then added together to give a score for that imagery perspective. A lower score indicates greater imagery ability. This process is completed separately for external visual imagery, internal visual imagery and kinaesthetic imagery perspectives. Finally, participants are given an image of a person and required to indicate from which area/angle of body they have imaged (see appendix G).

### 2.5. Purpose of Experiments

The first experimental chapter of this thesis was intended to test whether the benefits of an external FOA can be extended to form sports. The underlying premise behind the CAH (Wulf at al., 2001) is that focusing on movement effects can facilitate performance by enhancing congruence between response programming and the resultant actions. However, if there is no salient movement effect to begin with, the current researchers are lead to question whether this will this still be the case. In a pure form sport such as gymnastics there is no ball or target to focus on. Proficient performance is instead determined by correct technique, aesthetically pleasing movements and fluidity of execution. Although these factors influence the outcome of performance in sports such as tennis, basketball, football and golf, it is possible to have a successful outcome in these sports at the same time adopting an undesirable technique. As such the performance benefits of adopting an external FOA during these sports may actually be due to focusing on the salient external object that the performer is directly influencing (i.e., the ball, racket, club) and thus less efficacious when interaction with an object is absent during the skill.

The subsequent chapter investigated the effect of learning under differential foci of attention on anxious performance and movement variability. The CAH (Wulf et al., 2001) suggests that attending too closely to movements during execution can be detrimental to performance. This notion shares theoretical premise with Masters' (1992) CPH, which advocates an unfavourable self-focus mediated through stress. Through Vicon motion analysis, this research was able to investigate effects on dependent variables associated with both movement outcome and movement kinematics of the adopted action.

The final chapter examined whether it is possible to utilize FOA to further enhance imagery effectiveness. Extensive research has demonstrated the robust benefits of adopting imagery interventions but the current study endeavoured to foster performance further by the creation of imagery scripts which induce an external FOA.

# CHAPTER 3

# INTERNAL AND EXTERNAL FOCUS OF ATTENTION IN A NOVICE FORM SPORT

There is now a large body of research that has investigated how a performer's FOA influences motor learning and control (for reviews see Wulf & Prinz, 2001; Wulf, 2007a). The results of much of this research are concurrent with early suggestions by James (1890) who stated "keep your eye at the place aimed at, and your hand will fetch the target; think of your hand, and you will likely miss your aim" (p.520). Here it is proposed that adopting a focus on the body will negatively impact on performance whereas adopting a focus on the effects that one's movements have on the environment (i.e., the place aimed at or target) will enhance performance. In more recent research, these different foci have been defined as internal (focusing on particular body parts while executing a skill) and external FOA (focusing on a movement effect) (Wulf, McNevin, Fuchs, Ritter, & Toole, 2000).

The benefit of adopting an external FOA has been demonstrated in a variety of motor skills, for example, basketball (Al-Abood et al., 2002; Zachry et al., 2005), jumping (Wulf et al., 2007), golf (Wulf et al., 1999), balance (Wulf et al., 2001), and leg cycling (Totsika & Wulf, 2003). Furthermore, this benefit has been observed for both novice and expert performers (Bell & Hardy, 2009; Wulf & Su, 2007) and for individuals with movement disorders such as stroke patients (Fasoli et al., 2002) and Parkinson's disease patients (Landers et al., 2005). In this past research performance was measured via an outcome criterion (e.g., speed & accuracy). In the present experiment, we examined the performance of novices in a gymnastics routine under different foci of attention to examine if the previous findings can be generalised to form-based tasks where technique rather than outcome is the primary determinant of performance.

According to the action-effect principle (Prinz, 1997) there is a compatible relationship between planning and outcome, with "actions planned and controlled in terms of their effects" (p.152). Thus, if movements are planned in relation to their outcome then focusing on movement effects should augment performance, by enhancing efficiency of motor programming (Wulf et al., 1998). Wulf et al. (2001) combined the notion of the action-effect principle with research involving focus of attention and proposed the constrained action hypothesis (CAH). Consistent with Prinz's (1997) action-effect principle, the CAH maintains that if performers focus on their movements, the congruence between movement programming and response diminishes. As a result, attending to movements of the body disrupts the organisation of motor programming and interferes with normally automatic control processes. In contrast, adopting an external FOA enhances the efficiency of motor programming (by both increasing the relationship between movement planning and movement outcome and by preventing participants from consciously processing movements) and promotes automatic processing leading to increased performance.

Wulf et al. (2001) investigated the proposal that an external FOA prevents participants from consciously processing movements by assessing the attention demands of adopting either an internal or an external focus during movement execution. To this end, participants performed a balance task simultaneously with a probe reaction time task. Results at retention revealed that the external focus group displayed lower attention demands and superior balance performance compared to the internal focus group, thus supporting the CAH with respect to the predicted lower cognitive demands associated with an external focus.

While Wulf and colleagues (Wulf et al., 1998; 1999; 2001; 2007) have revealed performance benefits through the adoption of an external FOA, there is a body of research that has been unsuccessful when attempting to replicate these findings (Beilock et al., 2002; Ford et al., 2005; Perkins-Ceccato, Passmore, & Lee, 2003). These equivocal results have primarily been observed in research investigating novice and expert performers (Beilock et al., 2002; Ford et al., 2005; Wulf & Su, 2007). For example, Beilock et al. (2002) required right footed expert and novice participants to perform a football dribbling task under differing foci of attention; self-focus, where participants focused on their movements, and dual task, where participants were distracted from focusing on their movements in order to prevent explicit monitoring of the skill. Whereas novice performance was superior in the self-focus condition, optimal focus for expert performance was dependent on the use of either the dominant or non-dominant foot. When using their dominant foot, experts' performance was superior under the dual task (distraction) condition. However, when using their non-dominant foot experts' performance was greatest under the self-focus condition.

Similar to Beilock et al. (2002), Ford et al. (2005) investigated expert and novice performance under different foci of attention. Participants performed a similar football dribbling task under one of four focus conditions; an internal skill relevant focus, where participants focused on the foot they were dribbling with; an internal skill irrelevant focus, where focus was on the arm; a dual-task condition, where participants were distracted from focusing on their movements by having to respond to words presented audibly and a control condition. Results for experts dribbling with their dominant foot were consistent with the CAH as participants completed the dribbling task slower during both internal focus conditions compared to the dual-task condition. However, when experts were required to dribble with their non-dominant foot, this effect was reversed with movement times being slowest during the dual-task condition. For the novices, dribbling times were slower during both the dual-task (distraction) and internal irrelevant (arm) conditions compared to the internal relevant condition (foot).

The findings of both Beilock et al. (2002) and Ford et al. (2005) have been explained by the de-automization of skills hypothesis (Beilock et al., 2002). Here it is reasoned that since novice performance is not yet automatic it cannot be disrupted through conscious control and is in fact facilitated by allowing performers to attend to step-by-step processes of the skill. On the other hand, when experts adopt a self-focus, de-automisation occurs through "reinvesting actions and percepts with attention" (Deikman, 1966; p.329) resulting in decreased performance. Thus, when performance is proceduralised or automatic in nature (i.e., expert), adopting an external focus leads to enhanced performance. On the other hand, when movements are less proceduralised, as in novices and experts using a less favoured limb, performance is superior when focus is directed internally to task relevant movements.

More recently, Wulf and Su (2007) re-examined the differential effects of internal and external FOA on expert and novice performance in a golf putting task. Results revealed that both experts and novices performed better when directed to adopt an external FOA, as opposed to an internal FOA. These findings are inconsistent with the de-automisation of skills hypothesis and the previous results of Beilock et al. (2002) and Ford et al. (2005). However, it should be noted that the external FOA conditions adopted by Wulf and colleagues differs to those of Beilock et al. (2002) and Ford et al.

(2005) with the former using direct verbal instructions (i.e., “focus on…”) to manipulate external focus and the latter utilizing an indirect manipulation of attention through the use of a distracting task (i.e., word monitoring dual-task conditions). As such, the null effects of adopting an external FOA in the research of Beilock et al. (2002) and Ford et al. (2005) may be due to the method by which focus has been manipulated. For example, focusing attention externally through the use of direct verbal instructions could be considered more consistent with Prinz’s (1997) initial action-effect principle compared to adopting an indirect dual task manipulation. As such, adopting a direct manipulation is likely to lead to a clearer focus on movement effects and increased efficiency of motor programming resulting in enhanced performance (Wulf & McNevin, 2003).

The vast majority of previous research has generally been conducted using movement tasks relevant to sport skills (e.g., golf, football, basketball) in which outcome was operationalised as the primary measure of performance (e.g., speed, accuracy and movement amplitude). Consequently, it remains unclear whether the aforementioned findings generalise to other types of tasks, particularly those that can be classified as form tasks (i.e., gymnastics, karate kata, high diving). Furthermore, investigation of form based tasks would help establish whether the enhanced outcome performance observed in the previous FOA literature is due, in part, to a) the fact that previous research has utilised skills where movement effects have a direct and obvious impact on the environment (i.e., ball flight, golf club motion) and b) whether the outcome performance benefits of adopting an external FOA are a result of more efficient movement technique. Firstly, it is fundamental to both the action-effect principle (Prinz, 1997) and the CAH (Wulf et al., 2001) that attention must be directed towards a movement effect that is central to the goal of the action if performance is to be enhanced. The goal of the tasks adopted in the previous literature all result in the participants' movements having an obvious and direct impact on changing the environment (e.g., how the movement impacts on the trajectory of an object, be it a ball, balance platform, golf club etc). As a result, the adopted external foci of attention are rather salient. However, it is unclear at present whether adopting an external FOA will result in increased performance in tasks where there is less or no obvious movement outcome in terms of how performers' actions result in changes to the environment (i.e., floor routines in gymnastics, movements in a karate kata). Secondly, technique has been defined as "the motion activity specified by biomechanical principles of human motion which utilise motor features of movement and body structure to obtain the best performance" (Bober, 1981 p.502). In addition, it has been suggested that it is implicit within the concept of technique that performance will be better if a skill is performed with 'good' technique rather than 'poor' technique (Lees, 2002). Thus, it is possible that the increased performance associated with adopting an external FOA is a direct result of enhanced technique. However, there is only a limited amount of research investigating the effects of attentional focus on form tasks and movement technique with those that have examined technique only doing so as a secondary dependent variable (Wulf et al., 2002). Here, participants performed volleyball serves and received feedback about their performance (both on serve accuracy and movement technique) from either an internal or external focus. In line with previous research, results revealed that the accuracy of the serve (i.e., the outcome performance measure) was enhanced in the external focus feedback group compared to that of the internal focus feedback group. However, contrary to these results, the analysis of the technique and form of the participants' movements did not significantly differ between the two groups.

The goal of the current investigation was to extend our knowledge of an optimal FOA for novice performance in a form based gymnastic task, the performance of which was measured on the production of movement techniques. To achieve this, participants learnt a basic gymnastics routine under either, an external focus, an internal relevant focus, an internal irrelevant focus or a control (no focus) condition. Consistent with Wulf and colleagues, attentional focus was manipulated through the use of explicit verbal instructions. However, since previous research has criticised the absence of manipulation checks within these designs (Castaneda & Gray, 2007), we also employed a post manipulation check protocol (cf. Bell & Hardy, 2009) to ensure that conclusions based on the differing foci of attention could be attributed to the successful manipulation of participants' focus. In line with the findings for the form dependent variable of Wulf et al. (2002) and the suggestion that form based tasks offer no obvious movement effect in terms of how performers' actions result in changes to the environment, it was hypothesised that the external focus group would result in similar performance during acquisition and learning compared to both the internal foci and the control groups. However, in line with the CAH it was hypothesised that the internal relevant focus group would result in lower performance compared to the internal irrelevant focus group due to the former resulting in the constraining of actions that are more pertinent to accurate movement form and technique.

## 3.1 Method

*Participants*

Participants (mean age = 20.3 ± 1.6 yrs) with no previous experience in gymnastics volunteered to participate in this experiment (n = 40; 24 males, 16 females). All were naïve to the research hypotheses being tested and gave their informed consent prior to taking part in the investigation. The experiment was conducted in accordance with the institution's ethical guidelines for research involving human participants.

*Task and Apparatus*

The experiment took place in a laboratory in which two standard multi-purpose gymnastics mats (2m x 1m x 50mm) were set out in front of two white screens. Marker tape on the mats was used to identify the start position and movements were recorded on a Sony Digital Video Camera Recorder (DCR-DVD106) mounted onto a tripod located at a distance 3.5 metres from the participant and at an angle of $45^0$ ($0^0$ was taken as the centre of the participants navel). At the start of the experiment, participants were shown a short video ten times[1] on a television monitor (Aiwa VX-G142) of an expert gymnast performing a floor routine. Participants were instructed to practice the routine so that they could reproduce the form as accurately as possible. The routine consisted of five simplistic movement components each of comparable level of difficulty, as listed by the *Fédération Internationale de Gymnastique* (2007). Specifically these involved a starting

[1] This frequency of demonstration was in accordance with Weeks and Choi (1992) who suggest that this number has been shown to be sufficient for the performer to create an accurate depiction of the skill in their mind.

position, a lunge, an arabesque, a full turn and a finish position, which were all held for three seconds[2].

After watching the video, participants were required to perform a pre-test that consisted of one block of five trials. Following the pre-test, participants were randomly allocated to one of four attentional focus groups; external, internal relevant, internal irrelevant, and control (no focus). Focus instructions directed participants on 'what' to attend to but not 'where' to look. Participants were also asked a simple question following each trial in order to reinforce the appropriate focus. The question was dependent on which group participants were assigned. Focus instructions were constructed to be consistent with judging criteria and were in conjunction with Wulf's (2007b) suggestions based on Gentile's (1987) taxonomy of motor skills. Instructions were devised through consultancy with a UK Level 2 Gymnastics Club Coach.

*Focus Groups*

Participants in the external focus group were instructed to focus on their movement pathway as well as exerting an even pressure onto the support surface. After every trial, participants were asked, "what was your movement pathway for the previous performance?" and "did you exert an even pressure onto the support surface?"

[2] The gymnastics routine consisted of five movements. For the start position participants were required to balance on their right foot with their left leg bent and their left foot resting on their right knee. Participants had to hold their arms out horizontal in front of their body with their left arm at 45° and their right arm out in front. They had to hold their hands with their palms facing down and their fingers straight. For the lunge participants were required to step forward onto their left foot holding their right leg back straight with their body upright; arms horizontal in front of the body and palms facing down. For the arabesque participants were required to stand on their left leg, with their right leg behind, horizontal and straight, and foot pointed. They then had to circle their right arm back until straight behind the body, while holding the left arm horizontal and straight in front of the body, before returning to standing position. For the full turn participants were required to jump in the air swinging their arms forward and overhead for momentum. Participants had to turn their head in the direction of rotation (right), pulling with the opposite shoulder and hips to execute a 360° turn in the air, before landing on two feet, with their arms horizontal in front and palms facing down. The finish position was identical to the starting position.

Participants were asked to respond with either “straight” or “not straight” and “yes” or “no”, respectively. In the internal relevant focus group, participants were instructed to focus on exerting an equal force on their feet, keeping their arms out straight, level with their shoulders. The reinforcing focus question was “were your arms level with your shoulders during the previous performance?” and “did you exert an equal force on your feet?” Participants responded with either “yes” or “no”. Participants in the internal irrelevant focus group were instructed to focus attention on their facial muscles and facial expressions while performing the routine. In order to reinforce focus instructions, participants were asked, “what was your facial expression during the previous performance?” following each trial. Participants were asked to respond with either “happy”, “sad”, or “indifferent”. Participants in the control group were given no focus oriented instructions.

*Procedure*

There were four main phases included in the experiment, namely pre-test, acquisition, retention and transfer[3]. The acquisition phase of the experiment took place over two consecutive days; day one consisted of a pre-test followed by four blocks of five acquisition trials and day two consisted of another four blocks of five acquisition trials. A 45 second break was given between trials during which participants were asked their respective focus reinforcement question. Participants were given a five minute rest between blocks. Retention took place one week following acquisition and consisted of one further block of five trials, during which no attentional focus instructions were given. Immediately following retention participants completed a transfer test, again with

[3] Wulf (2007a) suggests that retention tests do not always reflect true learning as participants are likely to use the same instructions given during acquisition, thus a transfer test was used in addition to the retention test in order to ensure any learning effects were revealed.

no attentional focus instructions presented. During transfer, participants were required to complete one block of five trials using the opposite foot and arm movements to those used during acquisition. For example, when participants had previously begun the routine standing on their right foot, they now began on their left foot.

In order to assess the extent to which participants were able to adopt the appropriate FOA, participants completed a post manipulation questionnaire. Participants were asked to state the intensity of their focus on internal and external foci, revealing the extent to which they were able to adopt the appropriate FOA and also to what extent they adopted an inappropriate FOA (i.e., a focus that was different to the one instructed to adopt for the participant's experimental group) (see Table 1). During acquisition, the questionnaire was administered at the end of each day. It was decided that administering the manipulation check immediately following retention might act as a reminder of the focus instructions prior to transfer. Thus, a single (combined) manipulation check was carried out at the end of day three following both retention and transfer. Adherence to the focus instructions for each condition were assessed using three separate (one for each of the three focus questions, see Table 1) 4 group (internal relevant, internal irrelevant, external, control) x 3 time (day 1, day 2, day 3) mixed model ANOVAs with repeated measures on the second factor.

| **FOCUS OF ATTENTION** | No Focus | Weak | Moderate | Strong | Very Strong |
|---|---|---|---|---|---|
| How intense was your focus employed on exerting an even pressure on your feet, keeping your arms out straight, level with your shoulders? | 1 | 2 | 3 | 4 | 5 |
| How intense was the focus employed to your facial muscles and expressions? | 1 | 2 | 3 | 4 | 5 |
| How intense was the focus employed to your movement pathway and maintaining an even pressure on the support surface? | 1 | 2 | 3 | 4 | 5 |

**Table 1. Manipulation check questionnaire to assess the extent to which participants were able to adopt the appropriate focus of attention.**

*Dependent measures and analyses*

All trials were video recorded for purpose of analysis. Performance was assessed by two experienced independent gymnastics judges (British Gymnastic Association (BGA) area qualified (Welsh Gymnastics) with 20 yrs experience and BGA club qualified with 8yrs experience, respectively) who were blind to both the research hypotheses and focus conditions, and were not present during testing. Participants were judged according to the *Fédération Internationale de Gymnastique* Code of Points (2007) for Artistic Gymnastics (WAG/MAG). Judges were asked to view the video recordings and award points for each trial according to the criteria on the Code of Points, with marks deducted for poor execution and errors (see Table 2). A maximum score of 10 points could be awarded for the whole routine (this was a composite score for all five movements). Focus instructions in the internal relevant and the external groups were designed to provide performance benefits on these criteria in an equivalent nature. For example, the instructions in the internal relevant focus group were designed to impact on the single 'bent arms' execution faults item ("keeping your arms out straight….") and those criteria under the 'maintaining balance' subheading ("exerting an even pressure on your feet"). For the external focus group, instructions were designed to aid the single 'deviation from straight direction' item ("movement pathway") and similar to the internal relevant group those criteria under the 'maintaining balance' subheading ("exerting an even pressure on the support surface"). Since, these items carry equal weighting (faults and penalties) for the routine adopted the performance benefits of these instructions should have been equal (see Table 2). The mean of each block of five trials was calculated to obtain an overall block score.

| **Faults** | **Small** | **Medium** | **Large** | **Very Large** |
|---|---|---|---|---|
| | **0.10** | **0.30** | **0.50** | **0.80** |
| **Execution Faults** | | | | |
| – Bent arms or bent knees | | | | |
| – Leg or knee separations | | | | |
| – Legs crossed during elements with twist | | | | |
| – Insufficient height of elements | | | | |
| – Insufficient exactness of tuck, stretch or pike position | | | | |
| − Failure to maintain stretched body posture | | | | |
| – Insufficient split | | | | |
| – Body posture in dance elements | | | | |
| – Hesitation during jumps, press or swing to handstand | | | | |
| – Insufficient extension in the preparation for landing | | | | |
| – Precision *(Each movement has a clear start and finish position. Each phase of the movement has to demonstrate perfect control)* | | | | |
| **Throughout the entire exercise:** | | | | |
| • Relaxed or incorrect foot/body/trunk posture | | | | |
| • Insufficient flexibility | | | | |
| • Insufficient dynamics | | | | |
| • Insufficient amplitude of elements | | | | |
| **Landing Faults** ***(all elements including dismounts)*** | | | | |
| – Deviation from straight direction | | | | |
| – Legs apart on landing | | | | |
| **Movements to maintain balance:** | | | | |

| | | | | |
|---|---|---|---|---|
| • extra arm swings | | | | |
| • additional trunk movements to maintain balance | | | | |
| • extra steps, slight hop | | | | Max 0.70 |
| • very large step or jump *(guideline – 1 metre)* | | | | Max 0.70 |
| • body posture fault | | | | |
| • deep squat | | | | |
| • brushing apparatus with hands-arms, but not falling against the apparatus | | | | |
| • support on mat/apparatus with 1 or 2 hands | | | | 0.80 |
| • fall on mat to knees or hips | | | | 0.80 |
| • fall on or against apparatus | | | | 0.80 |

**Table 2. Table of general faults and penalties from the *Fédération Internationale de Gymnastique* Code of Points for artistic gymnastics (2007).**

In order to assess reliability of judging, mean inter-judge reliability scores were calculated and analysed across all trials for both acquisition and learning (retention and transfer). The results of this analysis revealed a significant correlation ($r$ = 0.912, $p$<.001), suggesting that participants' performance was rated similarly across both judges for each trial. In addition, the intra-judge reliability, as calculated by intra class correlation (ICC), was analysed using a random selection of five double marked trials. Here the judge was blind to the fact that they were marking the same selection of trials twice. ICC was significant for both judge 1 ($F_{4, 4}$ = 4171.80, $p$<.001) and judge 2 ($F_{4, 4}$ = 105.67, $p$<.001).

To ensure there were no significant differences between the performances of the groups prior to testing, the means of pre test performance data were submitted to a one way (group) ANOVA. A 4 group (internal relevant, internal irrelevant, external, control) x 8 block (block 1, 2, 3, 4, 5, 6, 7, & 8 of acquisition) mixed model ANOVA with repeated measures on the second factor was performed on the mean acquisition data. In order to assess the retention and transfer performance data mean scores were submitted to separate 4 group (internal relevant, internal irrelevant, external, control) x 2 block (pretest and retention or transfer, respectively) mixed model ANOVAs with repeated measures on the second factor. In addition, two similar 4 group (internal relevant, internal irrelevant, external, control) x 2 block (acquisition and retention or transfer, respectively) mixed model ANOVAs with repeated measures on the second factor were conducted to assess possible changes from the end of acquisition to retention and transfer (the last block of acquisition trials were used in this analysis). Significant between-subject effects were broken down using Tukeys HSD post hoc tests while significant within-subject effects were broken down into their simple main effects.

### 3.2. Results

*Manipulation check*

The descriptive data for the manipulation check are presented in Table 3. In order to maintain brevity, a summary of all three separate analyses of the responses to each Likert rated attentional focus question is reported. All revealed only a significant main effect of group (internal relevant question: $F_{2, 27} = 12.64$, $p<.001$, $\eta^2 =.48$; internal irrelevant question: $F_{2, 27} = 32.94$, $p<.001$, $\eta^2 =.71$; external question: $F_{2, 27} = 42.36$, $p<.001$, $\eta^2 =.76$). Breakdown of each revealed that all participants reported greater Likert scores on the question most closely related to their required focus. For example, participants in the internal relevant FOA condition scored significantly higher on the internal relevant focus question than participants in the external and internal irrelevant groups. Since there were also no main effects or interactions regarding time ($p>.05$), this pattern of results continued throughout the retention and transfer tests where the focus instructions were not presented. Finally, results also revealed that participants in the control group adopted both internal relevant and external attentional foci. Control group scores on the internal relevant item did not significantly differ from those reported by the internal relevant group and those on the external item did not differ from those reported by the external group.

| | External question | | | Internal Relevant question | | | Internal Irrelevant question | | |
|---|---|---|---|---|---|---|---|---|---|
| | Day 1 | Day 2 | Day 3 | Day 1 | Day 2 | Day 3 | Day 1 | Day 2 | Day 3 |
| External | 4.00 | 3.80 | 4.00 | 2.70 | 2.70 | 2.30 | 2.10 | 1.80 | 1.80 |
| | *0.47* | *0.63* | *0.47* | *0.48* | *0.67* | *0.82* | *1.10* | *0.92* | *0.79* |
| Internal Relevant | 2.80 | 2.50 | 2.30 | 3.80 | 4.00 | 3.70 | 1.70 | 2.00 | 1.60 |
| | *0.92* | *1.08* | *0.97* | *0.79* | *0.47* | *0.67* | *0.82* | *0.67* | *0.52* |
| Internal Irrelevant | 1.90 | 2.00 | 1.80 | 2.50 | 2.70 | 2.60 | 3.90 | 3.80 | 3.80 |
| | *0.74* | *0.67* | *0.63* | *0.97* | *1.16* | *0.70* | *0.99* | *0.63* | *0.63* |
| Control | 3.40 | 3.50 | 3.40 | 3.10 | 3.50 | 3.60 | 2.10 | 2.50 | 2.40 |
| | *0.70* | *0.97* | *0.84* | *0.74* | *0.97* | *0.84* | *0.74* | *1.08* | *0.97* |

**Table 3. The means and *SDs* for the manipulation check questions as a function of group (external, internal relevant, internal irrelevant, control) and focus orientation of the manipulation check question.**
Note: External question; how intense was the focus employed to your movement pathway and maintaining an even pressure on the support surface? Internal Relevant question; how intense was your focus employed on exerting an even pressure on your feet, keeping your arms out straight, level with your shoulders? Internal Irrelevant question; how intense was the focus employed to your facial muscles and expressions?), and testing phase (Day 1; at the end of block 4, Day 2 at the end of block 8, Day 3 at the end of transfer.

*Performance*

*Pre-test:* Analysis of the pre-test data revealed no significant differences between the performance of the groups ($F_{3,\,36}$ = 0.43, $p$= .73, $\eta^2$ =.36) (external = 7.65, *SD* = 0.37, internal relevant = 7.51, *SD* = 0.38 internal irrelevant = 7.60, *SD* = 0.34, control = 7.60, *SD* = 0.31). Thus, any performance effects during or following acquisition could not be attributable to differences prior to the experiment.

*Acquisition:* Results revealed a significant main effect for block ($F_{7, 252}$ = 3.84, $p$<.05, $\eta^2$ =.56), but not group ($F_{3, 36}$ = 0.76, $p$= .53, $\eta^2$ =.06). Overall, there was a decline in performance from block 1 to block 4 (i.e., day 1) and an increase in performance from block 5 to block 8 (i.e., day 2); see Figure 1. There was also a significant group x block interaction ($F_{21, 252}$ = 1.64, $p$<.05, $\eta^2$ =.25). Breakdown of this interaction revealed a significant decrease in performance from block 1 to 4 only for the external focus group. There was an increase in performance from block 2 to block 8 only for the internal irrelevant focus group.

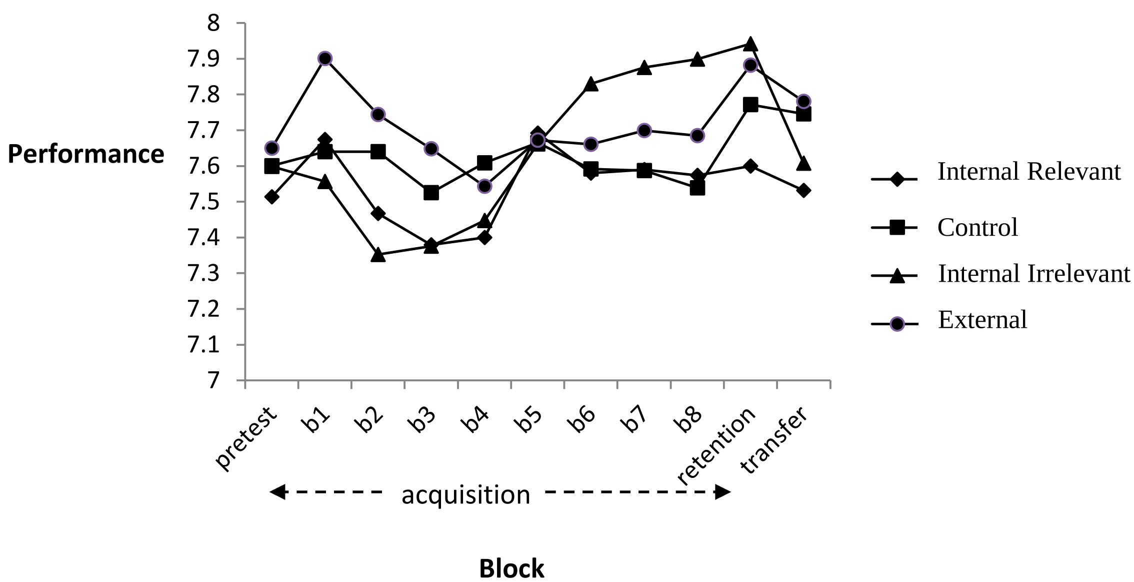



**Figure 1. Mean performance (judges scores) as a function of attentional focus (internal relevant, control, internal irrelevant, external) and block (pretest, b1 = trials 1-5; b2 = trials 6-10; b3 = trials 11-15; b4 trials 16-20; b5 trials 21-25; b6 = trials 26-30; b7 = trials 31-35; b8 = trials 36-40, retention = trials 41-45; transfer = trials 46-50).**

*Pretest versus Retention:* The analysis revealed only a significant main effect for block ($F_{1, 36}$ = 10.65, $p$<.05, $\eta^2$ =.23). Specifically, performance increased from pre-test to retention (external = 7.88, *SD* = 0.32, internal relevant = 7.60, *SD* = 0.24, internal irrelevant = 7.94, *SD* = 0.28, control = 7.77, *SD* = 0.30) demonstrating learning in all groups. No significant main effect for group ($F_{3, 36}$ = 1.99, $p$=.22, $\eta^2$ =.14) or significant group by block interaction ($F_{3, 36}$ = 0.36, $p$=.56, $\eta^2$ =.03) was observed.

*Pretest Versus Transfer:* The results of the analysis comparing the pretest and transfer data (external = 7.78, *SD* = 0.27, internal relevant = 7.53, *SD* = 0.24, internal irrelevant = 7.61, *SD* = 0.58, control = 7.80, *SD* = 0.31) revealed no significant main effects (block, $F_{1, 36}$ = 1.09, $p$=.30, $\eta^2$ =.30; group, $F_{3, 36}$ = .94, $p$=.43, $\eta^2$ =.07) or interactions (group x block, $F_{3, 36}$ = .25, $p$=.86, $\eta^2$ =.02).

*Acquisition versus Retention:* A significant main effect for block ($F_{1, 36}$ = 6.95, $p$<.05, $\eta^2$= .16) revealed that performance at retention (mean = 7.80, *SD* = .30) was greater than during acquisition (mean = 7.67, *SD* = .43). There was no significant main effect for group ($F_{3, 36}$ = 2.37, $p$=.16, $\eta^2$= .17) and no significant interaction ($F_{3, 36}$ = 1.59, $p$=.27, $\eta^2$= .12).

*Acquisition versus Transfer:* The results of the analysis comparing the acquisition and transfer data revealed no significant main effects (block, $F_{1, 36}$ = .00, $p$=.98, $\eta^2$ =.01; group, $F_{3, 36}$ = .1.30, $p$=.29, $\eta^2$ =.07) or interactions (group x block, $F_{3, 36}$ = .19, $p$=.86, $\eta^2$ =.12).

### 3.3. Discussion

The objective of the current investigation was to further examine optimal FOA for novice performance and to examine whether the previous attentional focus findings could be extended to a form sport. Typically, adopting an external FOA enhances movement performance with this effect having being demonstrated in a variety of motor skills (e.g. basketball, golf, jumping, and leg cycling). However, the present investigation failed to replicate these findings using a novel gymnastic routine. Attention was manipulated towards movements made by the individuals (either relevant to the skill or irrelevant to the skill) or the movement effects (external). No significant differences were found between the learning of the groups with participants in all conditions increasing performance at retention and maintaining performance at transfer. Thus, in the present form based task, adopting either an external, an internal relevant or an internal irrelevant FOA neither benefited nor degraded learning comparative to a control group where no explicit FOA instructions were provided.

Since there was no benefit of adopting an external FOA during acquisition, retention and transfer, it appears that the findings of the current investigation are not supportive of either the action-effect principle (Prinz, 1997) or the CAH (Wulf et al., 2001). While only the CAH can specifically account for the different learning effects of an internal versus an external FOA, both hypotheses agree that adopting an external FOA improves the efficiency of motor programming, through enhancing the congruence between movement planning and movement outcome. Specifically, Prinz's action-effect principle suggests that actions are planned in terms of their movement effects, with Wulf et al. (2001) rationalising that when participants focus on movement effects the organisation of motor programming is enhanced and performance is augmented. Thus, it is fundamental to direct attention towards a clear movement effect that is directly related to the goal of the action in order to enhance performance regardless of which explanation one adopts. With this in mind, it is reasonable to suggest that if there is no obvious movement effect to attend to, such as the predicted trajectory of the club or ball in a golf putting task (Wulf & Su, 2007) or the stability of a balance platform in a stabilometer task (Wulf et al., 2001), then perhaps the benefit of adopting an external FOA is removed, a notion which appears to be supported by the present findings.

The gymnastics floor routine of the current investigation was multifaceted and did not contain an obvious movement effect in comparison to the tasks adopted in previous research. For example, the golf putting and chipping tasks adopted in previous research (Bell & Hardy, 2009; Wulf et al., 1999; Wulf & Su, 2007) require only one discrete movement with the desired outcome of placing the ball in or as close as possible to the target hole/marker. On the other hand, the gymnastics routine of the present investigation contained a number of linked but distinctly different movements (i.e., lunge to arabesque to full turn) with the desired outcome being to produce accurate form and look aesthetically pleasing (through the use of correct technique). As such, it is more challenging to direct attention to a clear movement effect that is both evident and suitable for the goal of each movement and the routine as a whole. Therefore, the tasks and corresponding verbal instructions utilised to manipulate an external focus of attention in previous research, for example, 'focus on the trajectory of the ball' (Bell & Hardy, 2009), may provide a more apparent focus toward the desired outcome of the movement when compared to those of the present investigation. Thus, focusing on the less apparent movement effects in the current task may have resulted in a reduction in the congruence between movement planning and movement outcome and hence, the benefits typically seen when adopting an external focus.

A null effect of FOA has been reported in previous research (Poolton, Maxwell, Masters, & Raab, 2006; Wulf, 2008). However, it is possible that participants did not adhere to the instructions requiring them to employ a particular focus. The current investigation controlled for this by adopting a manipulation check based on that recently used by Bell and Hardy (2009). Results revealed that all participants adhered to the verbally presented focus instructions resulting in the adoption of the intended foci of attention during acquisition. Interestingly, participants reported adopting the same foci of attention to that required during acquisition one week later during both the retention and transfer tasks (where participants were not required or reminded to adopt a particular FOA). While it is beyond the scope of the current investigation to determine if these effects are due to either the presentation of the verbal focus instructions, the focus reminder questions or a combination of the two, the findings do have some interesting implications from both a research and an applied perspective. Firstly, Maxwell and Masters (2002) reported that participants switch attention according to specific task demands, thus highlighting the difficulty researchers face when attempting to effectively manipulate attentional focus. Hence, from a research perspective, the present investigation's manipulation protocol appears to prevent or discourage this attentional switching and, importantly, enables participants to employ and maintain the required experimental focus. Secondly, if coaches require performers to maintain a particular attentional focus adopted during practice in subsequent situations, perhaps where the delivery of focus instructions is not possible (i.e., competitions), then it is suggested that a focus manipulation similar to that of the present investigation is utilised during practice.

The current investigation revealed that performance improved from pretest to retention and hence learning occurred for all groups. However, there were no significant interactions involving group. Although there were no differences in learning between the different foci of attention manipulations as measured on retention, there was a significant difference in performance between the groups during acquisition. In line with the CAH (Wulf et al., 2002), it was hypothesised that the external focus group would improve performance to a greater extent than either the internal relevant, internal irrelevant, or control groups. However, results revealed that the external focus group actually decreased performance during the first half of acquisition and then maintained performance while only the internal irrelevant focus group enhanced performance (acquisition scores in this group increased from trials 6-10 to trials 36-40). These findings are inconsistent with previous research that has manipulated attention to external and internal features that differ in relation to their relevance to the skill (Ford et al., 2005). Ford et al. (2005) found that novice performers adopting an internal relevant focus resulted in greater performance than adopting an internal irrelevant focus. We propose that the conflicting results between the current experiment and those of Ford et al. (2002) are due to the increased task complexity and the resulting intricacy of the FOA manipulations in the present investigation. The task adopted by Ford et al. (2005) required participants to use a single foot to dribble a standard sized football around a 9m slalom course with the primary dependent measure being the time taken to complete the course. In comparison, our gymnastics routine combined a series of five novel, full body, linked but distinctly different movements that were judged on whole body technique/form. As such, the ensuing focus instructions required the inclusion of a variety of items. For example, participants in the external focus group were asked to 'focus on their movement pathway as well as exerting an even pressure onto the support surface' and those in the internal relevant group were asked to 'focus on exerting an equal force on their feet, keeping their arms out straight, level with their shoulders'. It is possible that asking participants to focus on a number of features in conjunction with performing the complex attention demanding gymnastics routine resulted in participants exceeding their attentional capacity and as a consequence a reduction in performance was observed. In support of this suggestion, the results of the manipulation check revealed that participants in the control group adopted a combination of both an internal and external focus and did not improve performance as typically seen in previous research (Beilock et al., 2002; Ford et al., 2005). Furthermore, the focus instructions of the internal irrelevant group asked participants to focus on a single item; their facial muscles. Thus, these instructions could be argued to be less attention demanding compared to those adopted in the external, internal relevant and surprisingly the control groups, the result of which was an increase in performance only for the internal irrelevant focus group.

The results of the current investigation do not support the findings from previous research involving outcome based tasks and the authors suggest a possible reason is the reduced salience of movement effects when performing the current form based task. However, the present findings are consistent with the only previous study that has explicitly assessed movement form (Wulf et al., 2002). Here, the researchers examined the effect of directing attention through internal and external focus feedback on both the outcome and the form of a volleyball serve. In line with previous research, both novice and expert volleyball players demonstrated more accurate outcome scores when provided with the external focus feedback. Conversely, there were no significant differences between the two focus conditions in the participant's achievement of the correct movement form. When these results are combined with those of the present investigation, it appears that the benefits of adopting an external focus do not generalise to tasks that are assessed on the accurate production of a particular movement pattern/technique or form where an obvious movement effect on the environment may be absent. However, it should be noted that in both experiments, form was measured using experienced judges and a subjective judging criteria. This is not necessarily a limitation of the research per se, since this is often how the performance of form sports are measured in real sporting situations (e.g., gymnastics, high diving). Nevertheless, it is suggested that future studies consider utilizing 3D motion analysis techniques to give a more objective and detailed measure of form and technique when investigating the effects of adopting different foci of attention. For example, given the predictions of the CAH (Wulf et al., 2001), one would expect individuals performing a form task under an internal focus condition to constrain the body's degrees of freedom into various movement synergies (see Turvey, 1977) to a greater extent compared to those in an external focus condition. Indeed this may have actually been the case in both Wulf et al.'s (2002) and the current investigation, however, such patterns of results would likely only be observed through the use of more objective and detailed analysis techniques.

Conclusions drawn from the present investigation suggest that adopting either an internal or an external FOA when performing a novel form sport does not result in any performance benefits. These findings may be due to both the increased complexity and ensuing intricacy of the focus instructions of the current task and the less salient movement effects associated with form actions. The former may result in an increase in the attention demanding properties of two competing processes and produce a reduction in performance, while the latter may ultimately reduce the congruence between movement planning and movement outcome. If adopting an external FOA only benefits actions with a clear movement effect on the environment then it is imperative that coaches strive to determine these when directing both the learner's and potentially (although not explicitly investigated in the current experiment) expert's attention, particularly in form based tasks. It is also suggested that manipulation checks continue to be employed in future investigations if concrete conclusions are to be drawn surrounding the effectiveness of attentional foci. This is particularly important since both external and internal foci have been shown to occur in control conditions.

# CHAPTER 4

# THE EFFECTS OF LEARNING WITH DIFFERENT FOCI OF ATTENTION ON ANXIOUS PERFORMANCE AND MOVEMENT VARIABILITY

Previous research suggests that strategies adopted during learning which direct a performer's focus of attention (FOA) away from their movements can help alleviate performance decrements typically associated with the presence of pressure (Hardy, Mullen & Jones, 1996; Jackson, Ashford & Norsworthy, 2006; Masters, 1992). Performing under pressure is an integral part of any athlete's sporting experience, and an inability to deal with this pressure can often result in an athlete choking or "performing more poorly than expected, given one's level of skill" (Beilock & Carr, 2001, p.701). The current investigation endeavoured to inhibit the undesirable effects of choking during anxious performance, by manipulating FOA during the acquisition of a golf putt.

Atypical performance under pressure has been accounted for with both distraction and self-focus theories. Distraction theories (Eysenck, 1992) suggest that the detrimental effect of anxiety on performance is due to worry consuming the central executive component of working memory, which would normally be used in information processing. Alternatively, self-focus theories (Baumeister, 1984; Lewis & Linder, 1997) suggest that stress can cause performers to become self-conscious and focus on skill mechanics, which can impede performance by disrupting normally automatic response programming. Early research by Fitts and Posner (1969), supports this notion, ascertaining that conscious control is redundant once skills reach the autonomous phase of learning and according to Masters (1992) conscious processing hypothesis (CPH) can in fact be detrimental to performance.

CPH (Masters, 1992) accounts for the stress performance relationship by suggesting that stress can mediate the reinvestment of conscious control over movements and interfere with normally automatic response programming, thus disrupting performance. Masters reasons, that under pressure, self-consciousness initiates the breakdown of larger, integrated chunks of information into separate, smaller units, thus prolonging information processing. Furthermore, Masters proposes that if automatic processes are encouraged during learning, via the development of implicit knowledge, and acquisition of explicit knowledge minimised, then reinvestment of conscious explicit knowledge cannot occur and the breakdown of information units as associated with the presence of anxiety is less likely to transpire. Previous researchers have explored ways of preventing this breakdown in automatic processes in order to maintain performance under pressure. Masters (1992) advocates analogy learning as a successful method of reducing acquisition of explicit knowledge, whilst Hardy, Mullen and Jones (1996) suggest holistic imagery, holistic process goals and modelling as additional ways to encourage automatic processes, through conceptual representations of skills during learning.

Similarly, the Constrained Action Hypothesis (CAH) (Wulf et al., 2001) suggests another strategy to reduce the breakdown of automatic processes is adopting an external FOA. This involves directing attention to movement effects such as the swinging motion of the club in golf, as opposed to directing focus to body movements, such as the swinging motion of the arms (internal FOA). Wulf et al. suggest that focusing on movements themselves as opposed to movement effects can reduce the congruence between planning and action, disrupting usually automatic control processes, and thus constraining the movement outcome. The benefits of an external FOA have been demonstrated across a variety of domains and populations (for a review see Wulf, 2007a).

Current FOA literature (Wulf, 2007) would suggest that attaining explicit knowledge regarding movement production, i.e. internal information, would be more detrimental to performance comparative to explicit knowledge regarding movement effects i.e. external information. One aim of the current study was to investigate this further in an attempt to understand if it is the acquisition of explicit knowledge in general, which perturbs anxious performance or whether it is a specific *type* of explicit knowledge (i.e., explicit knowledge regarding ones movements or the effects of one's movements on the environment), which is responsible for disrupting performance when anxious. To achieve this participants learned a golf putting task under either internal, external or control FOA conditions and were then transferred to an anxiety condition. If the choking phenomenon is reduced in the external FOA condition then one can propose that reinvestment in explicit knowledge is only detrimental to performance if that knowledge is centered around movement mechanics.

In previous research Beilock and Carr (2001) analysed attention during skill execution by examining the quantity of episodic memories for both experts and novices, revealing that automaticity of expert performance results in fewer episodic memories. The current investigation examined this further in an attempt to understand if it is the amount explicit knowledge/rules obtained during acquisition which perturbs anxious performance or whether it is a specific type of explicit knowledge, which is responsible for disrupting anxious performance (i.e., explicit knowledge centered around internal FOA or those centered around external FOA). Poolton et al., (2006) suggested that participants who adopt an internal FOA tend to acquire more internal rules regarding their movements. With this in mind it is expected that those who learn under external

FOA conditions will develop fewer explicit rules regarding the movement itself (internal rules) compared to those who adopt an internal FOA and will thus be less likely to choke under pressure as breakdowns in automatic programming will not occur in the absence of these rules.

If we consider the underlying theoretical foundations which underpin both the CAH and CPH, it is surprising that researchers have not previously considered the two lines of research in conjunction to a greater extent prior to this investigation. A principle study by Bell and Hardy (2009), which did examine the FOA literature in line with anxiety literature revealed that expert performance of golf chipping was enhanced by an external FOA under both low and high anxiety conditions. The current research elected to adopt a learning paradigm to investigate the effects of anxiety on golf putting performance when participants have *learnt* under different attentional foci conditions. This should lead to more permanent (learnt) behaviours, promoting action production and execution without movement centered knowledge, which will result in consistent performance between low and high anxious situations (i.e., eliminate the choking phenomenon). The current research should reveal more insight into the efficaciousness of adopting either an internal or external FOA on anxious performance.

Previous researchers have generally adopted outcome measures of performance such as speed and accuracy, neglecting to determine what is happening to the movements themselves to create these robust performance differences (Wulf, 2007; Lawrence, Gottwald, Hardy & Khan, *In Press*). The current investigation addressed this issue by utilising Vicon motion analysis together with a novel variability methodology previously used to investigate limb trajectories in upper body target directed aiming movements (for a review see Khan et al., 2006). This method allows us to examine the variability in both distance travelled and velocity at various percentiles of overall movement time. Specifically, this involved calculating both distance travelled and velocity every 10th percentile of each trial's movement time. The within-subject *SD* of this data was then calculated and the means of this data provided a measure of variability throughout movement trajectory. This process was completed for both the back-swing and forward-swing of the golf putt. It was hypothesised that participants who adopt an external FOA during learning will exhibit more consistent movements than those learning under internal FOA conditions. The rationale here being that focusing on one's movements will disrupt automatic processes (e.g., Wulf et al., 1998; Wulf et al., 2001) and may lead to maladaptive corrections whereby participants alter movements from trial to trial on the basis of over analysing the mechanics of movement (Lai & Shea, 1999).

The aim of the current investigation was to examine if explicit learning (regarding movements) can be minimised through learning with an external FOA and thus prevent performance breakdown under subsequent anxious conditions. Additionally, a novel variability methodology was utilised in order to investigate the effects of different foci of attention on the control of movement trajectories. As such, the current investigation has endeavoured to fill some of the more pertinent gaps in the FOA and anxiety literature. To achieve this, performance (as measured by both movement production and movement outcome) was investigated whilst participants learnt a golf putting task under either an external FOA, an internal FOA or as a control FOA (no focus), and were subsequently transferred to both a low-anxiety (LA) and high-anxiety (HA) transfer test.

## 4.1. Methods

*Participants*

Participants (mean age 22.1 years (*SD* = 4.3); mean mass 69.3kg (*SD* = 13.0); mean height 171.2cm (*SD* = 8.6) with no previous experience in golf, volunteered to participate in this experiment (N = 29; 20 females, 9 males). All were naïve to the research hypotheses being tested and gave their informed consent prior to taking part in the investigation. The experiment was conducted in accordance with the ethical guidelines laid down by the ethics committee of the School of Sport, Health and Exercise Sciences, Bangor University for research involving human participants.

*Task and Apparatus*

The task was a 2.5m golf putt performed on a Huxley Premier Pro turf putting green (8” x 12”). The green was set up with a standard ‘Huxley incliner’ placed under the surface of the green 1m from the start and positioned just left of the line of the putt, creating a convex half-sphere with an incline rising to 4.5cm and resulting in a left to right breaking putt (see Figure 2d). Participants putted into a 10.5cm hole, consistent with standardised PGA requirements, with a standard KT25 Prosimmon golf putter and Slazenger Raw Distance 432 dimple pattern golf ball provided. A 12 camera Vicon system (see Figure 2a and 2b) sampling at 100 Hz was used to track co-ordinates of 3 retro-reflective markers (14mm diameter), with two markers placed on the head of the golf club and the final marker placed at the lower end of the shaft (see Figure 2c). The Vicon Nexus system utilised marker movements in the XYZ plane in order to calculate and plot movements in 3D space. A heart rate (HR) monitor was used as an indicator of physiological stress.

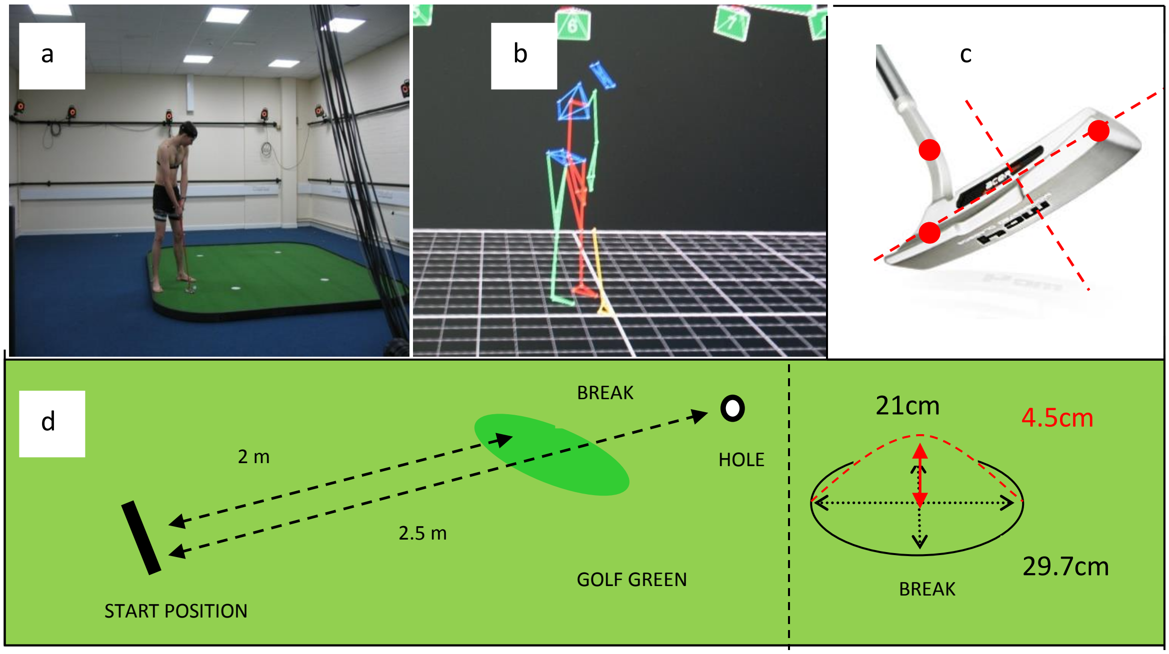



**Figure 2a, 2b, 2c, 2d. 12-camera Vicon system and Nexus software, retro-reflective marker placement on club-head and lab set-up.**

*Procedure*

At the start of testing, participants were informed that the purpose of the investigation was to examine the accuracy of golf putting over a period of practice trials. It was explained that the goal of the task was to putt the ball as accurately as possible and that putting performance would be assessed by the number of successful putts and the distance from the hole on unsuccessful putts. Participants completed a 25-trial pre-test before being randomised into either, an internal FOA group, an external FOA group or a control group. Those in the internal focus group were instructed to putt whilst simultaneously focusing on the ‘swinging motion of their arms’, those in the external focus group were instructed to focus on the ‘swinging motion of the golf club’ and those in the control group were given no FOA instructions. Focus instructions were adopted from Wulf and Su (2007) and directed participants on ‘what’ to attend to but not ‘where’ to look. Participants performed 400 acquisition trials[4], which were split into four blocks of 50 trials and performed over two consecutive days (blocks 1 and 2 on day 1 and blocks 3 and 4 on day 2). FOA reminders were posted on a wall and also given verbally at the start of every block and subsequently every 25 trials. A simple focus question, devised according to each group, (see Lawrence et al., *In Press*) was asked following every trial, and served to reinforce focus reminders. Participants in the internal and external focus groups were asked a question regarding the swinging motion of their arms or club respectively.

At the end of the acquisition trials participants were given a short break, where they were asked to leave the room. Following this, participants then completed 25 trials under LA before finally completing 25 trials under HA. Participants were not given any FOA instructions or reminders during the transfer tests. Following the HA test participants reported their episodic memories. Specifically, participants were asked to describe the last putt they had taken in enough detail so that a friend would be able to replicate it (adopted from Beilock & Carr, 2001).

A single (combined) post manipulation questionnaire was carried out at the end of day two following both transfer conditions. It was decided that administering this manipulation check immediately following the LA transfer condition might act as a reminder of the focus instructions prior to the HA transfer condition. Participants were

[4] Master’s (1992) study revealed that 400 trials were sufficient for learning to occur.

asked to state the intensity of their focus on internal and external foci, revealing the extent to which they were able to adopt the appropriate FOA and also to what extent they adopted an inappropriate FOA.

*Anxiety Manipulation*

Anxiety was manipulated by a combination of ego threat and social evaluation, which has previously been utilised successfully (Masters, 1992; Beilock, Carr McMahon & Starkes, 2002). Specifically, participants were asked to leave the room for a short duration, and informed that during this time their performance would be discussed by the two researchers present during testing. Upon their return participants were informed that they had been paired randomly with another participant and that if they both improved their putting performance by 20% then they would both receive £10. They were then informed that their partner had already improved their performance by the required 20% and thus they would need to do the same in order for both them and their partner to receive the money. In addition, they were told ‘if you fail to improve your performance by the required 20% , your partner would be informed of your identity and told that you had been unsuccessful and thus neither of you can now receive the prize money’. Finally, participants were informed that this final block of trials would be video recorded and then sent off to an expert golfer for analysis and that if they missed 75% or more of their putts their name would be added to a loser-board, posted around the sports science department.

*Dependent Measures and Analyses*

*Performance Data*

The primary measure of performance was the number of successful putts (NSP). To ensure there were no significant differences between the performance of groups prior to testing, the means of pre-test performance data were submitted to a one way (group) ANOVA. In order to assess performance from pre-test to transfer a 3 group (control [Con], internal [Int], external [Ext]) x 3 block (pre-test (Pre), LA, HA) mixed model ANOVA was performed on the mean NSP data. Significant between-subject effects were broken down using Tukeys HSD post hoc tests while significant within-subject effects were broken down into their simple main effects.

A secondary, but less crude measure of putting performance was Mean Radial Error (MRE). This was calculated as the distance from the ball to the hole, using Pythagoras theorem $(x^2+y^2)^{0.5}$. Again, means of pre-test data were submitted to a one way (condition) ANOVA to ensure there were no significant differences between the performance of groups prior to testing. Performance from pre-test to transfer was assessed using a 3 group (Con, Int, Ext) x 3 block (Pre, LA, HA) mixed model ANOVA.

*Episodic Memory*

Measurements of episodic memory were taken to determine both the quantity of explicit knowledge acquired, as well as the qualitative content of this knowledge. A one-way ANOVA was performed on the total number of episodic memories for each group. To analyse the qualitative content memories were subjectively categorised as being either internal (e.g., swinging of the arms; kept arms straight) or external (e.g., lining the club up with the ball and hole; swinging of the club). This was done by two independent researchers (not involved in the current study), to ensure validity. A 3 group (Con, Int, Ext) x 2 type (internal/external) ANOVA was then performed on this data.

*Motion Analysis and Variability*

Vicon motion analysis was used to calculate co-ordinates of markers in the x, y and z planes of movement. Researchers then calculated both velocity and distance travelled every 10$^{th}$ percentile of each trial's movement time. The within-subject *SD* of this data was then calculated and the means of this data provided a measure of variability throughout movement trajectory. This process was completed for both the back-swing and forward-swing of the golf putt up until ball contact. Thus, we calculated separate measures of variability in both velocity and distance travelled every 10% of the movement time. To analyse the back-swing data, separate 3 group (Con, Int, Ext) x 3 time (Pre, LA, HA) x 10 position (10%, 20% ... 100%) mixed model ANOVAs were performed on resultant XYZ data for both velocity and distance travelled. The same analyses were then performed on forward-swing data post ball-contact to analyse variability in that portion of the movement trajectory.

*Anxiety Data*

The Mental Readiness Form-3 (Krane, 1994) was used to determine competitive anxiety and was administered prior to both LA transfer and HA transfer conditions. Additionally, HR gave a physiological indicator of anxiety and was recorded throughout LA and HA transfer conditions. This data was submitted to a 3 group (Con, Int, Ext) x 2 time (LA, HA) ANOVA.

## 4.2. Results

*Anxiety (MRF-3 and HR)*

Results revealed a significant main effect for block ($F_{1, 26}$=19.35, $p$<.01, $\eta^2$=.43) with an increase in anxiety Scores from LA to HA transfer (LA=10.03, SD=4.14, HA=13.76, SD=6.63). The results of the self-reported anxiety scores were supported by the HR data, which revealed a significant main effect for block ($F_{1, 26}$=9.68, $p$<.01, $\eta^2$=.27) with a significant increase in HR from LA to HA transfer (LA=83.95, *SD*=9.57, HA=86.66, *SD*= 10.76).

*Performance (NSP)*

*Pre-test:* Results at pre-test revealed no significant difference between the NSP of participants in different conditions ($F_{2, 26}$=3.24, $p$>.05) (internal=3.67, *SD*=0.83, external=2.70, *SD*=1.34, control=4.70, *SD*=1.25). Thus, any performance differences cannot be attributed to differences prior to the investigation.

*Pre-test, LA and HA:* Results revealed a significant main effect for block ($F_{2,52}$=16.45, $p$<.01, $\eta^2$=.39) with performance improving as a function of time as well as a significant group x time interaction ($F_{4, 52}$=2.80, $p$<.05, $\eta^2$=.18). A breakdown of this revealed a decrease in NSP from LA to HA for those in the control group, an increase in NSP from LA to HA for those in the external FOA group and no change in NSP from LA to HA for those in the internal FOA group (see figure 3).

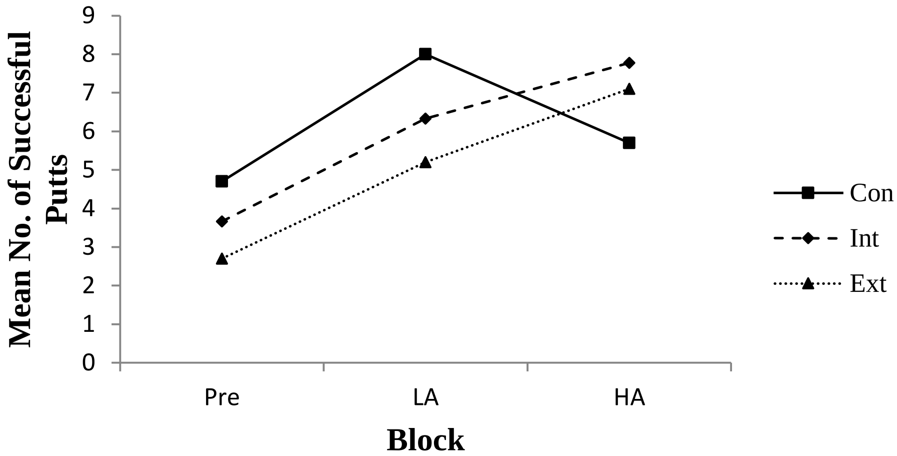



**Figure 3. Performance (NSP) as a function of attentional focus (Con, Int, Ext) and block (Pre, LA, HA).**

*Performance (MRE)*

*Pre-test:* Results at pre-test revealed no significant difference between the NSP of participants in different conditions ($F_{2,26}$=.05, $p$>.05) (internal=601.67, *SD*=169.98, external=575.33, *SD*=130.13, control=586.11, *SD*=203.20). Thus, any performance differences cannot be attributed to differences prior to the investigation.

*Pre-test, LA and HA:* Results revealed a significant main effect for time (($F_{1.65, 42.81}$=33.34, $p$<.01, $\eta^2$=.56) and a main effect for group ($F_{2, 26}$=3.38, $p$<.05, $\eta^2$=.21) but no significant time x group interaction ($F_{4, 52}$=.97, $p$=.43, $\eta^2$=.07). Breakdowns revealed that MRE decreased as a function of time and that the control group exhibited more error comparative to the external group.

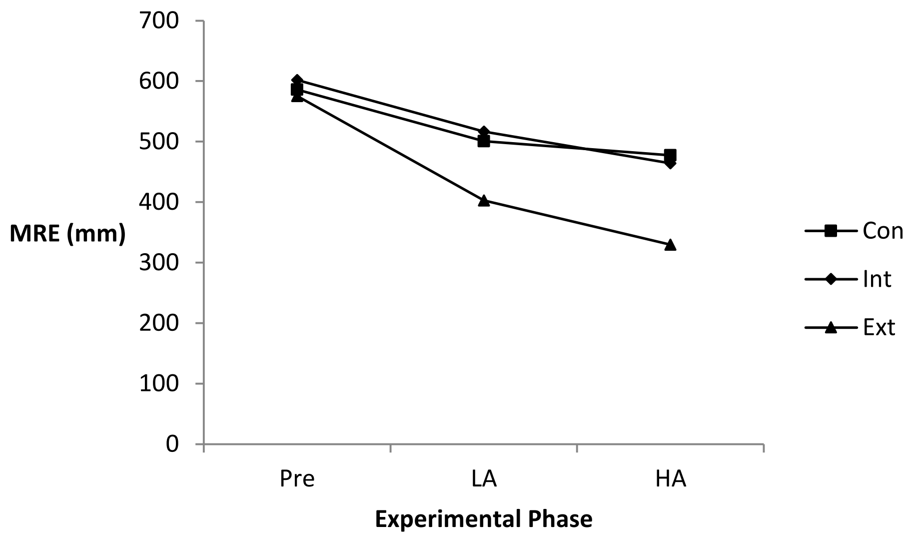



**Figure 4. Performance (MRE) as a function of attentional focus (Con, Int, Ext) and block (Pre, LA, HA).**

*Episodic Memory*

*Total number of memories/rules reported and type of memories/rules reported (details of the both the number and type of memories reported can be seen in Table 1):*

Results for the analysis of number of memories reported revealed no significant group differences ($F_{2,28}$=.40, $p$>.05) (mean rules; Con = 4.1, *SD* = 3.21, Int = 5.2, *SD* = 2.10, Ext = 4.3 *SD* = 2.87).

Results of the analysis on the type of memories revealed a significant group x type interaction ($F_{2,27}$=5.01, $p$<.05, $\eta^2$=.27), breakdowns of which confirmed that participants in the internal FOA group acquired a higher number of internal memories than participants in the control and external FOA groups. Similarly participants in the external FOA group acquired a higher number of external memories than participants in the control and internal FOA groups. There was no difference between the amount of internal and external memories reported by the control group.

| **Internal** | **External** |
|---|---|
| Feet shoulder width apart | Looked at the ball |
| Bent knees | Looked at the hole |
| Leant forward | Lined up putter with target |
| Right hand below left | Putter head square to target |
| Wrist action | Slowly pulled putter back |
| Straight arms | Swing of the club |
| Pendulum motion of arms | Followed through the ball |

**Table 4. Examples of episodic memories reported; categorised as internal or external.**

*Variability pre ball contact*

*Distance Travelled XYZ*

*Back-swing:* Results revealed a significant main effect for time ($F_{2,52}$=22.70, $p$<.01, $\eta^2$=.47) with variability decreasing from pre-test to LA and from pre-test to HA, a main effect for position (%) ($F_{9,234}$=269.81, $p$<.01, ŋ=.91) with variability increasing at 30% of the back-swing onwards and a main effect for group ($F_{2,26}$=4.05, $p$<.05, $\eta^2$=.24), with the internal group being more variable than the control group. Additionally, results revealed time x position ($F_{18,468}$=5.32, $p$<.01, $\eta^2$=.17), position x group ($F_{18,234}$=3.72, $p$<.01, $\eta^2$=.22) and time x position x group interactions ($F_{36,468}$=1.64, $p$<.05, $\eta^2$=.11). Specifically, breakdowns confirmed that variability was greater during the pre-test, and more so during the second half of the back-swing. This increase in variability throughout the back-swing was greater for the internal group compared to the external and control group with this effect being greater in LA and HA compared to the pre-test (see figure 5).

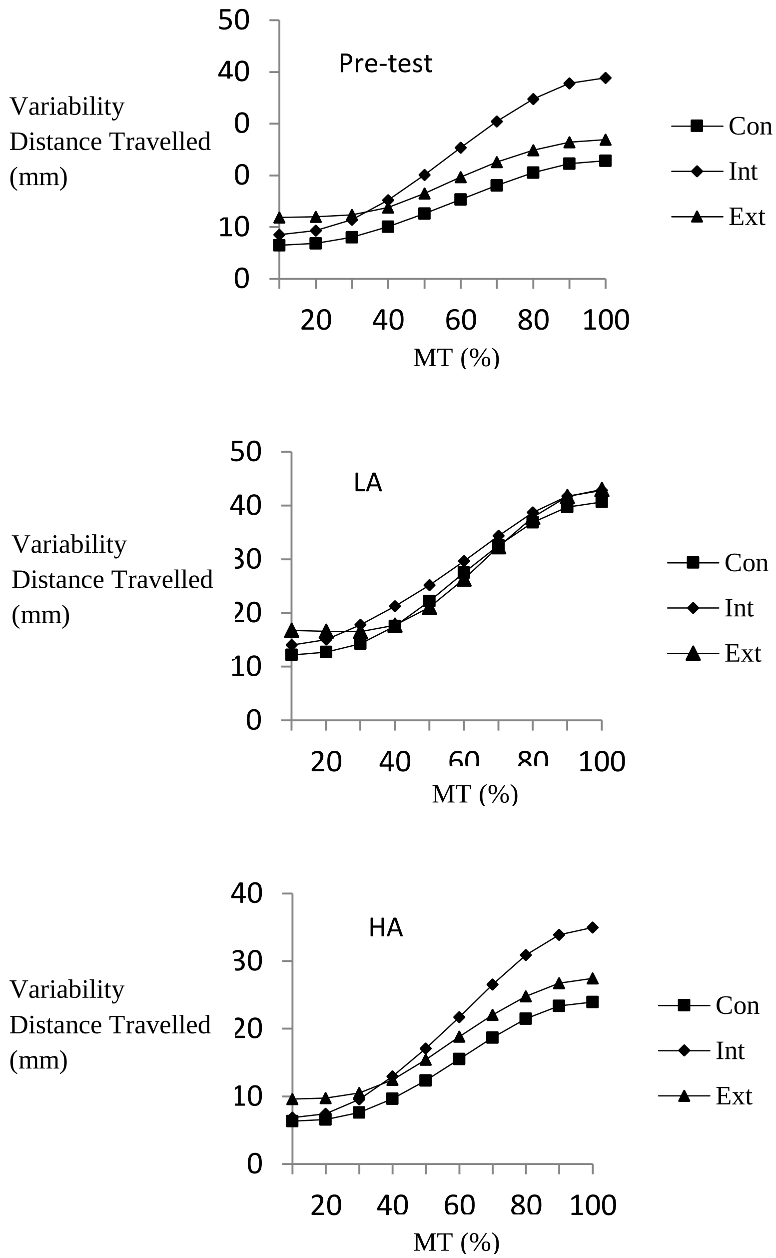



**Figure 5. Graphs showing variability in distance travelled at every 10% of MT for the back-swing as a function of group (Con, Int, Ext) and experimental phase (Pre, LA, HA).**

*Forward-swing:* Results revealed a significant main effect for time ($F_{2,52}$=19.65, $p$<.01, $\eta^2$=.43), with variability decreasing from pre-test to LA and from pre-test to HA, a main effect for position ($F_{9,234}$=518.37, $p$<.01, $\eta^2$=.95), with variability decreasing as a function of MT percentage and a main effect for group ($F_{2,26}$=4.89, $p$<.05, $\eta^2$=.27), with the internal group being more variable than the control group. Additionally there was a significant time x position ($F_{18,468}$=13.69, $p$<.01, $\eta^2$=.35) and a position x group interaction ($F_{18,234}$=4.38, $p$<.01, $\eta^2$=.25). Breakdowns confirmed that pre-test variability was greatest at the start of the forward-swing. This increased variability at the start of the forward-swing was greatest for the internal group compared to the external and control group.

*Velocity XYZ*

*Back-swing:* Variability for the velocity data can be seen in Figure 6. Results revealed a significant main effect for time ($F_{2,52}$=31.53, $p$<.01, $\eta^2$=.56) with variability decreasing from pre-test to LA and again from LA to HA and a main effect for position ($F_{9,234}$=191.47, $p$<.01, $\eta^2$=.88) with variability increasing during the first 50% of the back-swing before decreasing during the second 50% of the back-swing. Additionally there were significant time x position ($F_{18,468}$=18.43, $p$<.01, $\eta^2$=.42) and time x position x group interactions ($F_{36,468}$=2.06, $p$<.01, $\eta^2$=.14). Breakdowns revealed that variability was greater at the mid-point of the back-swing during the pre-test and that this effect was greater for the internal and external groups.

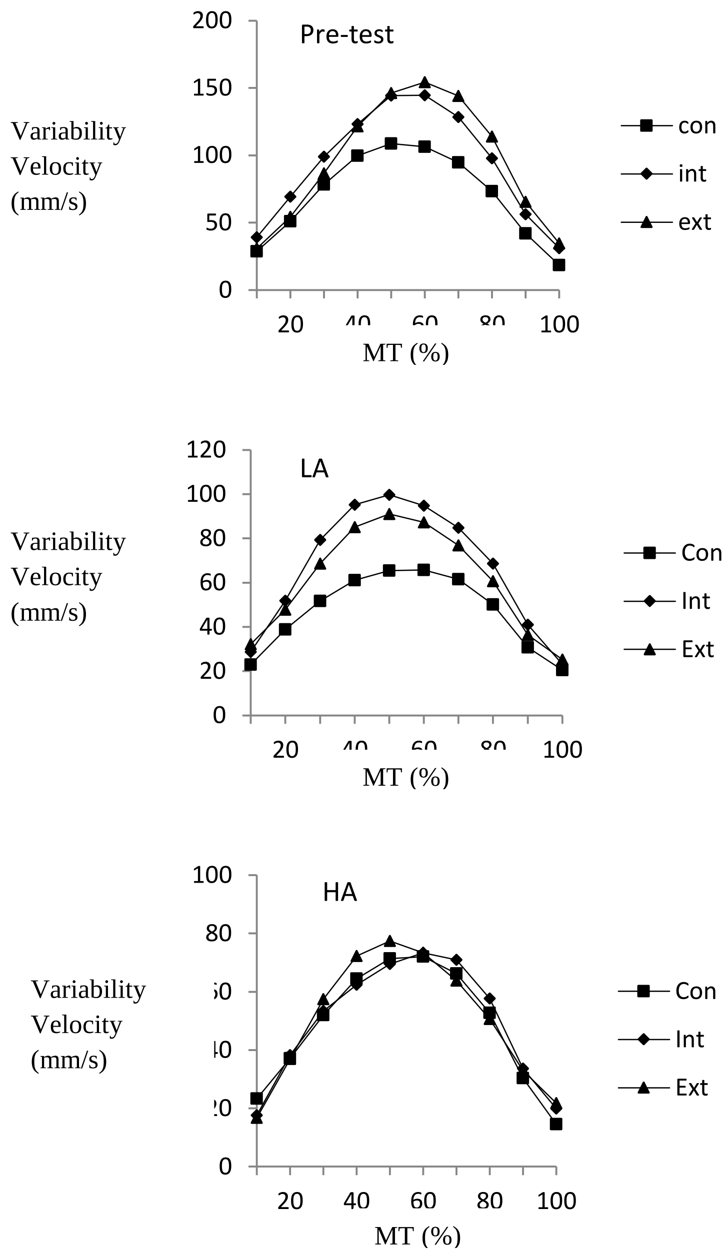



**Figure 6. Graphs showing variability in velocity at every 10% of MT for the back-swing as a function of group (Con, Int, Ext) and experimental phase (Pre, LA, HA).**

*Forward-swing:* Results revealed a significant main effect for time ($F_{2,52}$=60.36, $p$<.01, $\eta^2$=.70) with variability decreasing from pre-test to LA and from pre-test to HA and a main effect for position ($F_{9,234}$=250.81, $p$<.01, $\eta^2$=.91) with variability increasing during the first 60% of the forward-swing. Results also revealed a time x position interaction ($F_{18,468}$=26.31, $p$<.01, $\eta^2$=.50) together with a time x group interaction ($F_{4,52}$=3.00, $p$<.05, $\eta^2$=.19). Breakdowns confirmed that variability was greatest during pre-test for the second half of the forward-swing and that the external group was more variable at pre-test.

*Variability post ball contact*

*MT XYZ*

Results revealed a significant main effect for position ($F_{9,243}$=109.39, $p$<.01, $\eta^2$=.80). There were also significant time x position ($F_{18,486}$=5.00, $p$<.01, $\eta^2$=.16) and position x group interactions ($F_{18,243}$=3.21, $p$<.01, $\eta^2$=.19). Specifically, variability increased throughout the forward-swing with this effect being more pronounced during the pre-test compared to either transfer test and for the internal group compared to both the external and control groups.

*Velocity XYZ*

Results revealed significant main effects for time ($F_{2,54}$=17.62, $p$<.01, $\eta^2$=.40) and position ($F_{9,243}$=81.78, $p$<.01, $\eta^2$=.75). There were also significant time x group ($F_{4,54}$=3.87, $p$<.01, $\eta^2$=.22), time x position ($F_{18,486}$=15.97, $p$<.01, $\eta^2$=.37) and time x position x group interactions ($F_{36,486}$=2.50, $p$<.01, $\eta^2$=.16). Breakdowns revealed a decreasing variability throughout the forward-swing and over time. Variability of the control group was more pronounced at pre-test during the first half of the forward-swing.

### 4.3. Discussion

The purpose of the current study was three fold; primarily to investigate the effects of learning under different FOA conditions on subsequent anxious performance; in relation to this, we also aimed to determine if any positive effects of learning with an external FOA on anxious performance could be explained by the nature of the explicit rules generated during learning; thirdly, whilst conducting the above, we adopted dependent measures that allowed investigation into the effects of the different FOA on movement kinematics (a previously neglected performance variable within the FOA literature). Findings revealed that participants who adopted an external FOA throughout acquisition continued to improve performance (NSP) when subjected to pressure. However, participants devoid of focus instructions displayed classic choking behaviours. The results surrounding the explicit rules generated during learning suggested that the protective effect of practicing under an external FOA can be explained, in part, by the development of explicit skill rather than movement centered rules. Finally, the above effects were not represented clearly within the movement kinematics of the learned action, since results of the variability profiles for both velocity and distance travelled during all components of the golf putt (back-swing, forward-swing to ball contact and forward-swing post ball contact) did not reveal performance differences between groups at either the LA or HA transfer tests.

There is a considerable body of evidence to suggest that adopting differential attentional foci, results in performance differences at retention (Wulf et al., 1999; Wulf, et al., 2002; McNevin et al., 2003). However, results of the current investigation revealed no performance differences following acquisition trials. Nevertheless it is plausible that there may have been discrepancies in performance earlier on in acquisition. Previous studies revealing acquisition differences have been conducted with notably fewer acquisition trials (e.g. Wulf & Su, 2007 incorporated just 60 acquisition trials in a novice golf putting task) and it is reasonable to suggest that these differences may have been extinguished after 400 learning trials. Indeed, Poolton et al. (2006) incorporated a substantial 300 acquisition trial protocol similar to that of the current investigation and also found no performance differences at retention. In Poolton et al.'s research differences were only revealed under secondary task loading where an internal FOA hindered performance and was accounted for using the CAH (Wulf et al., 2001).

Despite the null findings in retention, differences in performance were certainly evident once pressure was induced. Although relatively low compared to genuine competition anxiety, the anxiety manipulation was successful in raising both self-reported anxiety scores (MRF-3) and HR, between LA and HA transfer. Consistent with CPH (Masters, 1992) the control group's performance deteriorated as a consequence of elevated performance pressure. CPH accounts for this by proposing that anxiety instigates the reinvestment of conscious control over actions, which inhibits normally automatic response programming and thus impedes performance. Hence, performance of the control group deteriorated to a level similar to early in learning.

However, when adopting an external FOA this negative effect of anxiety on performance was negated. Whilst these findings are consistent with research by Bell and Hardy (2009), who illustrated the benefits of an external FOA on expert golf chipping performance under pressure, the theoretical explanations offered for the current findings are different. The rationale for this is twofold, firstly, the skill levels of participants and consequential performance or learning paradigms adopted by both investigations are very different: Bell and Hardy utilised expert performers and a performance paradigm whereas the current investigation utilised novice participants and a learning paradigm. Secondly, only the current investigation included a measure to investigate explicit rule generation during skill execution. The exclusion of this in Bell and Hardy's research meant that the CPH and the theory of reinvestment (Masters, 1992) could not be fully investigated as a possible explanation for their findings. Consequently, Bell and Hardy account for their findings with the distraction hypothesis (Wine, 1971). They suggested that since skill execution consumes less attentional capacity under an external FOA comparative to an internal FOA (Wulf et al., 2001), the attentional threshold is less likely to be exceeded when anxiety is present and thus performance is maintained or even enhanced. If one looks at performance data alone, distraction is a plausible explanation for the findings of the current investigation. However, if one looks at these in conjunction with the results surrounding the amount and type of explicit rules utilised during transfer, it is more likely that benefits of learning with an external FOA on subsequent anxious performance are due to the learning strategy which preventing reinvestment. Poolton et al., (2006) previously revealed that participants adopting an external FOA accumulate significantly fewer rules regarding their movements comparative to those adopting an internal FOA. The results of the current investigation supported these findings, revealing a significant difference in the nature, but not the number of explicit rules developed during learning under either the internal or external FOA groups. Specifically, the external FOA group reported less explicit knowledge regarding movements of their body than both the internal FOA and control groups. As such, when placed into the HA transfer test the golf putting skill of these participants were less likely to breakdown as explicit knowledge regarding skill movement was reduced (Masters, 1992). It should be noted here that whilst the external FOA group reported less explicit knowledge surrounding the mechanics of their movements compared to the internal FOA or control group, they did not actually report generating fewer explicit rules during learning. These results are in line with our second hypothesis suggesting that it is the *type* and not the *number* of explicit rules performers generate that govern reinvestment under anxious conditions. Consequently, reinvestment theory should be extended to clarify that tasks are more likely to break down under anxiety if performers have accumulated accessible and conscious task-relevant knowledge that is centered around body movements (i.e., the swing of the arms) and not necessarily around skill movements (i.e., the swing of the club).

Contrary to expectations, participants adopting internal focus instructions during learning were able to maintain performance under pressure. According to the CPH (Masters, 1992) the internal FOA group should have invested explicit movement knowledge under pressure, resulting in performance decrements. However, previous research by Beilock and Carr (2001) determined that self-consciousness training can protect against the debilitative effects of choking under pressure. Beilock and Carr had participants practice golf putting under self-focus conditions and revealed that when these participants were subjected to an anxiety test they were able to maintain performance, suggesting that training under conditions of self consciousness can lead to a reduction in the choking phenomenon. Similarly, in the current study, participants adopted an internal FOA during learning and so became familiarised with consciously controlling movements and thus it is possible that the self-focus induced by the presence of anxiety did not disrupt performance since participants were accustomed to performing under these conditions. This notion is consistent with Henry's (1968) specificity of learning principle, whereby practice conditions that most closely approximate the movements of the target skill and the environmental conditions of the target context result in the best learning experiences. Thus, if anxiety induces a self-focus then learning conditions that also prompt a self-focus or internal focus should facilitate optimal performance in anxiety inducing situations.

In order to further investigate the effects of different foci of attention on both LA and HA performance, we examined the variability of both the velocity and the distance travelled throughout the movement trajectory. This allowed for insights into how external and internal FOA affect the kinematics of movements, something that until the current investigation has received little or no research attention. It was expected that movements in the external FOA group would be less variable and result in greater outcome accuracy (i.e., participants would be producing consistent and accurate trajectories), than those in the internal FOA group. The rationale was that adopting an internal FOA would constrain normally automatic movement control leading to trial to trial differences and inconsistent actions, hence greater variability. Furthermore, in line with the CAH (Wulf et al., 2001) and the CPH (Masters, 1992) it was expected that both the internal FOA and control groups would suffer a similar constraining of the action when participants were subjected to the anxiety transfer test. That is, through the adoption of either a self-focus or through the reinvestment of explicit movement centered knowledge, normally automatic or procedualised skills would be constrained and/or broken down into step by step processes. This over-analysis and breakdown of automatic movement would manifest itself in inconsistent actions and result in increases in trial to trial variability.

The analysis of the variability profiles for both the velocity and the distance travelled data only revealed significant group differences at the LA and HA transfer tests in the distance travelled during the back-swing of the golf putt. Specifically, variability was greater in the internal FOA group compared to both the external and control groups at the LA and HA tests. At first glance, these findings appear partially supportive of the above hypothesis, in that adopting an internal FOA resulted in a disruption in the automatic process involved in movement control and consequently reduced the consistency of actions. However, the number of successful putts (NSP) data does not suggest that this increase in variability during the back-swing of the movement trajectory was sufficient to disrupt overall performance. Indeed there were no group differences in NSP at retention (LA test) and only the control group experienced a decrease in putting performance during the HA test despite not demonstrating any increases in the variability of the movement trajectory. Although the internal FOA group increased variability it is possible that the null effect of this on putting performance was as a result of the previous discussed specificity of learning principle. That is, training under the self-focus condition resulted in a development of a variable action that at the end of 400 acquisition trials was able to effectively meet the requirements of the task goal. When, conditions then changed to include anxiety the effect this emotional state had on the control of movement was similar to that of training (i.e., movements were performed under self-focus conditions in both acquisition and anxiety transfer). Thus, both the movement trajectory and movement outcome performance was comparable between the acquisition and the HA transfer conditions.

One possibility to account for the non significant change in the variability of the control group between the LA and HA transfer, despite the decrement in NSP, may be that trajectories were consistently inaccurate in terms of the line of the putt when under pressure. This proposal would account for why the variability profiles between the control and external FOA groups did not differ at the HA transfer test. That is, whilst the external FOA group produced consistent putts of an accurate nature, the control group produced consistent putting actions with an inaccurate outcome. This would result in variability remaining relatively low regardless of a decline in performance between LA and HA retention.

In conclusion, the present investigation demonstrated that adopting an external FOA during learning is beneficial for maintaining performance under subsequent anxiety conditions. We propose that the protective effect of acquiring skills under external FOA is due to the nature of the explicit knowledge developed under these conditions not being centered around the mechanics of body movements. In addition and contrary to expectations, it appears that learning under internal FOA also prevents decrements in performance typically associated with the presence of anxiety. We suggest that these effects are due to the specificity of learning principle, in that acquiring skills under an internal focus prepares individuals for the self-focus conditions that are induced as a result of the presence of anxiety. Finally, results demonstrated that if learners are given no explicit FOA instructions during learning they are susceptible to choking under anxious conditions. As such, coaches should endeavour to either minimise the acquisition of explicit movement knowledge during the learning process by encouraging an external FOA, or apply the principles of specificity to prevent choking by instructing participants to adopt a self-focus during long periods of learning.

# CHAPTER 5

# ENHANCING IMAGERY EFFECTIVENESS THROUGH THE CONSIDERATION OF ATTENTIONAL FOCUS

Visual imagery is a psychological tool, which allows performers to mentally rehearse their performance for a variety of intentions (Hardy, Jones & Gould, 1996). Past research has been robust in exhibiting the use of imagery to enhance performance through different functions, for example increasing confidence, emotional regulation, improving concentration, skill acquisition, injury management and strategy development (Hall, Mack, Paivio & Hausenblas, 1998). Bio-informational theory (Lang, 1977, 1979) has been used to justify these extensive benefits of imagery. This concept suggests that images are stored in the brain and coded by two types of information; stimulus and response propositions. The highly inter-related nature of these propositions means that retrieval of one can prompt the retrieval of the other, which explains how producing a mental representation of a skill through visual imagery can actually stimulate muscle activation. Athletes often utilise imagery scripts as a method of directing this mental rehearsal and it is therefore imperative that the images created as a result of the content of each script, facilitate optimal performance.

The practice of mental rehearsal shares similarities to directing attentional focus in that both techniques allow athletes to target concentration pertinently with the ultimate goal of enhancing performance. Despite these similar purposes, there are two major distinctions between mental rehearsal and FOA, namely modality and timing relative to skill execution. The modality of each differs in so much that visual imagery entails the activation of distinct visual images whereas FOA is solely a matter of directing focus to aspects of skill execution (normally through verbal instructions), without the need to generate visual images. The timing distinction occurs since visual imagery is performed prior to movement execution, whereas attentional focus is directed simultaneous to movement execution.

Deliberation of previous literature would suggest that when directing attentional focus, concentration should be targeted to movement effects in order to optimise performance. The CAH (Wulf et al., 2001) accounts for this with the notion that adopting an external FOA encourages automaticity in response programming, resulting in more efficient skill execution. The current study investigated whether the benefits of focusing on movement effects enhances the efficacy of other psychological skills. Specifically, we integrated FOA into imagery scripts and compared performance between scripts designed to induce either an internal or external FOA.

Research into the effects of imagery use on performance is vast and over the last three decades this research has shown considerable benefits (e.g. Feltz & Landers, 1983; Orlick & Partington, 1988; White & Hardy, 1995; Hardy & Callow, 1999). When competing at a high level the margins between success and failure are often minimal and as a result even marginal increases in performance can be of great significance to the athlete. Advances in training methods and technology have meant that athletes are often limited physiologically by their peak fitness and thus the effective use of psychological skills, such as imagery, may distinguish between winners and losers.

When using imagery athletes have reported using different visual perspectives, which Mahoney and Avener (1977) have classified as being either internal (i.e., imaging from a 1$^{st}$ person perspective) or external (i.e., imaging from a 3$^{rd}$ person perspective). The performance benefits of adopting each visual perspective are dependent on task characteristics with White and Hardy (1995) suggesting that an internal perspective is optimal for tasks where perception and line are important (e.g., slalom skiing) whereas an external perspective is optimal for tasks in which form is important (e.g., gymnastics). By assuming the appropriate perspective, the athlete is provided with information more pertinent for success. Through an external perspective (third person) a gymnast will be able to view precise movement kinematics required to accomplish the task effectively. On the other hand a slalom skier will be provided with salient information regarding the environment as well as the precise timings of approaching gates if an internal (first person) perspective is adopted. Golf putting could arguably be classified as being a task where form is critical to success but simultaneously a task where line is important. With this in my mind the current researchers have implemented imagery perspective according to individual aptitude. This was measured using the Vividness of Movement Imagery Questionnaire–2 (VMIQ-2) (Roberts et al., 2008) which also ensured that participants were able to create vivid and controllable images to the researcher's satisfaction prior to the start of the study.

Due to researcher's avid interest in the effect of task type on optimal imagery perspective (Paivio, 1985; White & Hardy, 1995), previous imagery studies have utilised a combination of outcome based tasks (e.g., athletics, Ungerleider & Golding, 1991) as well as form based tasks (e.g., karate kata, gymnastics and rock climbing, Hardy & Callow, 1999) in order to shed light on the issue. However in form tasks, such as those used in Hardy and Callow's research, it is important to highlight that performance has been measured using a subjective judging criteria which is not necessarily a limitation of the research per se, since this is often how the performance of form sports are measured in real sporting situations (e.g., gymnastics, high diving).

However, the current researchers endeavoured to utilise more quantitative measures when examining form and so adopted Vicon motion analysis together with a novel variability methodology previously used to investigate limb trajectories in upper body target directed aiming movements (for a review see Khan et al., 2006). This method allows us to examine the variability in both distance travelled and velocity at various percentiles of overall movement time. Specifically, this involved calculating both distance travelled and velocity every 10$^{th}$ percentile of each trial's movement time. The within-subject *SD* of this data was then calculated and the means of this data provided a measure of variability throughout movement trajectory. This process was completed for both the back-swing and forward-swing of the golf putt. It was hypothesised that participants using an imagery script designed to induce an internal FOA will exhibit more consistent movements than those using an imagery script designed to induce an internal FOA. The rationale here, being that focusing on one's movements will disrupt automaticity of response programming as a result of the CAH (Wulf et al., 2001).

The current thesis is novel in the fact that preceding studies have not yet considered visual imagery integrated with attentional focus. However, an innovative study which investigated the effects of visual search strategies on basketball free throw shooting could be used to draw some conclusions regarding the potential effects of FOA and imagery when used in conjunction (Al-Abood, Bennett, Hernandez, Ashford & Davids, 2002). Participants were required to view videos of successful free throws with attention directed to either the movement form (internal focus) or the movement effects (external focus). Findings revealed that participants who focused on the movement effects as opposed to the movement form on the video demonstrated performance improvements from pre-test to post-test, whereas those directing attention to movement form exhibited no improvements. These findings corroborate the CAH (Wulf et al., 2001), advocating the benefits of visual search strategies which direct attention to movement effects prior to performance. Watching another athlete successfully perform a skill on a video is not too different from imaging oneself perform a skill but the current study will hopefully shed light on whether FOA can be effectively integrated into an imagery script.

The present research has endeavoured to determine whether performance differences occur as a result of using imagery scripts which induce either an internal or external FOA. This knowledge would provide further information to suggest whether an imagery script created to encourage an external FOA would be favourable to an imagery script that encourages an internal FOA. Participants were required to practice a golf putting task in a Vicon motion analysis laboratory. Participants regularly listened to an imagery script which was designed to induce either an internal or external FOA, with visual perspective determined by imagery ability on internal and external constructs. It was hypothesised that participants employing imagery which induced an external FOA would demonstrate superior performance in terms of both movement production (indicated by reduced trajectory variability; representative of more consistent actions) and outcome at retention due to principles of the CAH (Wulf, et al., 2001).

## 5.1 Methods

*Participants*

Participants (N=27; 14 male, 13 female) with no previous experience of golf, volunteered to participate in the study (mean age = 19.7 yrs, *SD*=0.8). All were naïve to the research hypotheses being tested and gave their informed consent prior to taking part in the investigation. The experiment was conducted in accordance with the ethical guidelines laid down by the ethics committee of the School of Sport, Health and Exercise Sciences, Bangor University for research involving human participants.

*Task and Apparatus*

The task was a 2.5m golf putt performed on a Huxley Premier Pro turf putting green (8” x 12”). A standard KT25 Prosimmon golf putter and Slazenger Raw Distance 432 dimple pattern golf ball were provided and participants putted into a 10.5cm hole, consistent with standardised PGA regulations. A 12 camera Vicon system sampling at 250 Hz was used to track co-ordinates of 10 retro-reflective markers (14mm diameter). There were two markers placed on the medial and lateral condyles of each wrist as well as one marker on each hand above the second metacarpal. Two markers were placed on the head of the golf club at the heel and toe and the final markers were placed at the lower and higher end of the shaft. Anthropometric measurements including height, body mass, wrist width and hand thickness were used in conjunction with marker movements in the XYZ planes so that the Vicon motion analysis system could calculate and plot movements in *3D* space.

In order to measure imagery ability and preference, participants filled out the VMIQ-2 (Roberts et al., 2008). The VMIQ-2 requires athletes to form images of a variety of movements and then rate the vividness of each image. Specifically, the measure contains 12 items and participants are asked to image each item from a specific imagery perspective and rate the image on a 5 point Likert scale according to the degree of clearness and vividness (the scale ranges from 1; perfectly clear to 5; no image at all). The 12 items are then added together to give a score for that imagery perspective. A lower score indicates greater imagery ability. This process is completed separately for external visual imagery and internal visual imagery perspectives. Finally, participants are given an image of a person and required to indicate from which area/angle of body they have imaged (see Appendix G).

*Procedure*

Participants were given a verbal overview of the study and told that their objective would be to putt the ball as accurately as possible, with performance measured according to both number of successful putts and the distance the ball finished from the hole on unsuccessful putts. Once the motion analysis markers had been positioned appropriately, participants completed a 30 trial pre-test. Following this, the VMIQ-2 (Roberts et al., 2008) was used to determine each individual's optimal imagery perspective and establish whether or not their imagery ability was sufficient to continue with the study. Consistent with previous research (Hardy & Callow, 1999) three participants were removed from the study as a consequence of scoring 36 or above in the VMIQ-2; a score of this nature represents poor imagery ability.

Following the pre-test and VMIQ-2 completion, participants were randomised into either, an internal FOA group, an external FOA group or a control (no imagery script) group. An imagery script was then allocated (perspective was dependent on VMIQ-2 internal and external perspective construct scores), which participants were asked to read through in their own time. For the internal FOA group the imagery script asked participants to image movements of the body (e.g., imagine yourself looking at your feet, which are shoulder width apart…imagine yourself locking your wrist and elbow joints…) whereas the external FOA script required imagery of the effects of one's movements on the environment (e.g., imagine the club being swung in a backward motion…) (see appendices B, C, D and E).

The experiment consisted of three phases; pre-test, acquisition and retention. The pre-test was 30 trials in duration, whilst the acquisition phase consisted of 120 trials divided into eight blocks of 15 trials with time provided at the start of each block to listen to the imagery script. This was done whilst the participant was standing at the start position, holding the golf club, ready to putt, with a choice of having eyes open or closed. Participants were encouraged to perform the imagery prior to every trial even when the script was not provided. Following acquisition, a manipulation check was administered to determine whether participants had adhered to the allocated imagery script. Specifically, participants answered 7 questions on a 7-point Likert scale e.g., "I was able to image myself perform the golf putt perfectly" (the scale ranged from 1; rarely to 7; often) with a higher score reflecting that a higher level of imagery had been achieved (see Appendix F). Participants then received a short break before completing the retention test. This phase consisted of 30 trials, identical in nature to those of the pre-test. Finally, participants completed the manipulation check for a second time following the end of the retention test.

*Dependent measures and analysis*

The primary measure of performance was the number of successful putts (NSP). To ensure there were no significant differences between the performance of groups prior to testing, the means of pre-test performance data were submitted to a one way (group) ANOVA. In order to assess performance from pre-test to retention a 3 group; (internal (Int), external, (Ext) and control (Con)) x 2 block; (pre-test (Pre), retention (Rtn)) mixed model ANOVA was performed on the mean data. Significant between-subject effects were broken down using Tukeys HSD post hoc tests while significant within-subject effects were broken down into their simple main effects. The same analysis was then performed on MRE data, which provided a less dichotomous measure of performance. Specifically, MRE was measured as the absolute distance from the ball to the center of the hole (cf. Mullen, Hardy, & Tattersall, 2005).

*Motion Analysis and Variability*

Vicon motion analysis was used to calculate co-ordinates of markers in the x, y and z planes of movement. Researchers then calculated both velocity and distance travelled every $10^{th}$ percentile of each trial's movement time. The within-subject *SD* of this data was then calculated and the means of this data provided a measure of variability throughout movement trajectory. This process was completed for both the back-swing and forward-swing of the golf putt up until ball contact. Thus, we calculated separate measures of variability in both velocity and distance travelled every 10% of the movement time. To analyse the back-swing data, separate 3 group (Con, Int, Ext) x 2 time (Pre, Rtn) x 10 position (10%, 20% ... 100%) mixed model ANOVAs were performed on resultant XYZ data for both velocity and distance travelled. The same analyses were then performed on forward-swing data post ball-contact to analyse variability in that portion of the movement trajectory.

## 5.2 Results

*Performance*

*Pre-test*

Analyses for both the NSP and MRE data revealed no significant group differences ($F_{2, 24}$=.002, $p$>.05; $F_{2, 24}$=.05, $p$>.05) (NSP and MRE values respectively). Thus, any performance differences cannot be attributable to differences prior to the investigation.

*Pre-test versus Retention:*

NSP: Analyses revealed a significant main effect for block ($F_{1, 24}$=9.53, $p$<.01, $\eta^2$=.28) with performance improving as a function of time. There was no significant main effect for group ($F_{2, 24}$=.49, $p$>.05, $\eta^2$=.04) and no significant block x group interaction ($F_{2, 24}$=.48, $p$>.05, $\eta^2$=.04) (see figure 7).

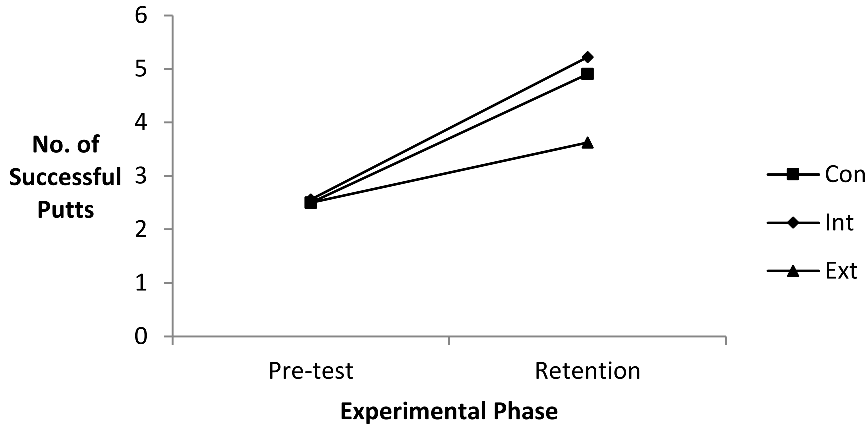



**Figure 7. A graph showing the relationship between NSP as a function of group (Con, Int, Ext) and experimental phase; Pre-test (Pre) and Retention (Rtn).**

MRE: *Pre-test versus Retention:* Results revealed a significant main effect for block ($F_{1, 24}$=22.91, $p$<.01, $\eta^2$=.49) with a decrease in MRE as a function of time, but no significant main effect for group ($F_{2, 24}$=.44, $p$>.05, $\eta^2$=.04) and no significant block x group interaction ($F_{2, 24}$=1.40, $p$>.05, $\eta^2$=.11).

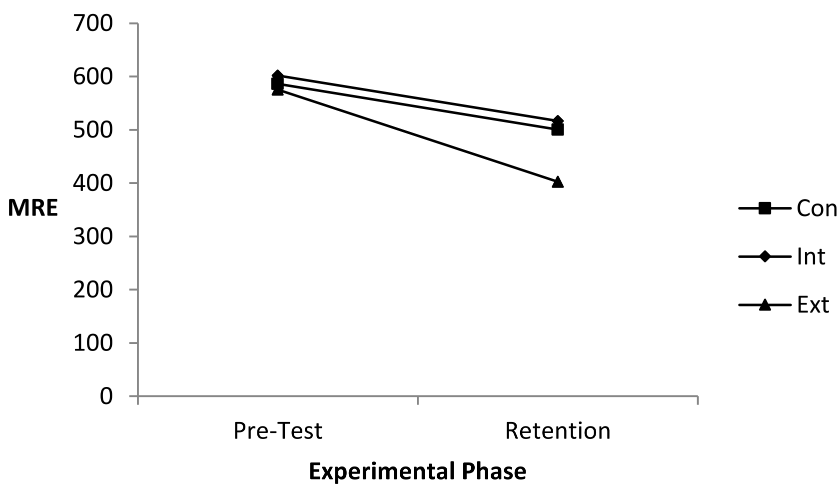
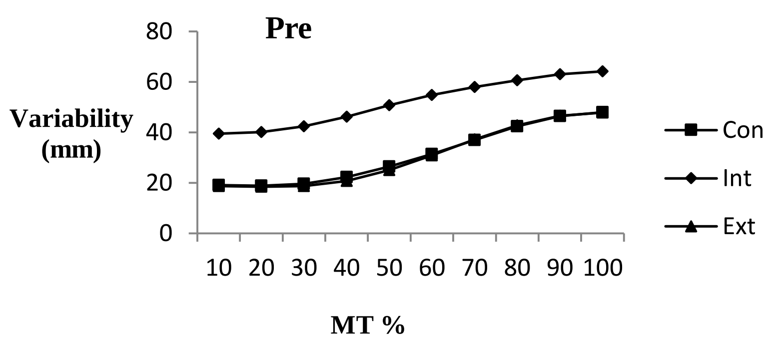



**Figure 8. A graph showing the relationship between MRE as a function of group (Con, Int, Ext) and experimental phase (Pre, Rtn).**

*Variability pre ball-contact*

*Distance Travelled XYZ*

*Back-swing:* Results revealed a significant main effect for time ($F_{1, 24}$=13.94, $p$<.01, $\eta^2$=.37) with variability decreasing from Pre to Rtn, a main effect for position (%) ($F_{9, 216}$=55.37, $p$<.01, $\eta^2$=.70) with variability increasing from 10% of the back-swing to 70% and onwards. There was no significant main effect for group ($F_{2,24}$=1.70, $p$>.05, $\eta^2$=.12), however there was a significant time x position interaction ($F_{9, 216}$=2.62, $p$<.01, $\eta^2$=.10), which revealed that participants were more variable at Pre than Rtn and to a larger extent in the second half of the back-swing (see figure 9).



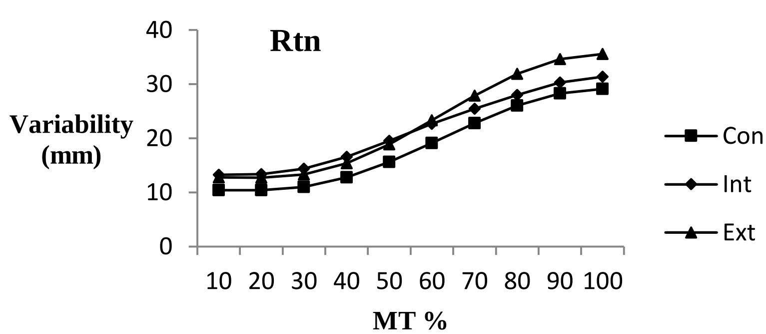
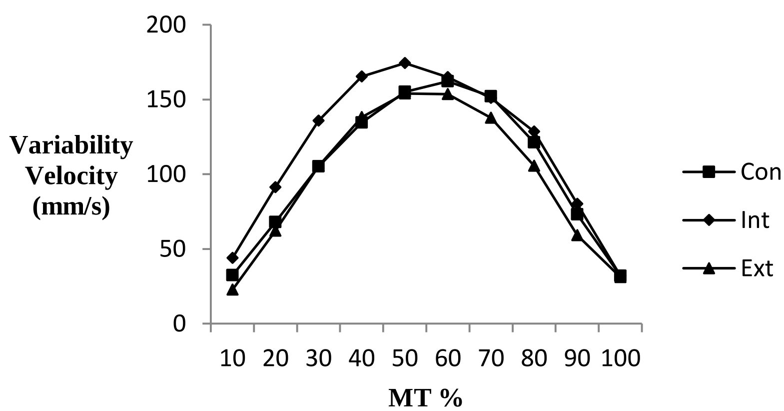




**Figure 9. Graphs showing variability in distance travelled at every 10% of MT for the back-swing as a function of group (Con, Int, Ext) and experimental phase (Pre, Rtn).**

*Forward-swing:* Results revealed a significant main effect for time ($F_{1,24}$=11.67, $p$<.01, $\eta^2$=.33) with variability decreasing from Pre to Rtn and a main effect for position (%) ($F_{9,216}$=74.39, $p$<.01, $\eta^2$=.76) with variability increasing from 10% to 70% onwards of the movement. Whilst there was no significant main effect for group ($F_{2,24}$=.98, $p$>.05, $\eta^2$=.08) there was a significant time x position interaction ($F_{9,216}$=6.44, $p$<.01, $\eta^2$=.21), breakdown of this revealed that participants were more variable at Pre and to a larger extent during the first half of the forward-swing.

*Variability Velocity XYZ*

*Back-swing:* Results revealed no significant main effect for group ($F_{2,24}$=.39, $p$>.05, $\eta^2$=.03). However, there was a significant main effect for time ($F_{1,24}$=9.96, $p$<.01, $\eta^2$=.29) with variability decreasing from Pre to Rtn, a main effect for position (%) ($F_{9,216}$=89.67, $p$<.01, $\eta^2$=.79) with variability increasing from 10% to 50% before decreasing again between 50% and the end of the movement. Analyses also revealed a significant time x position interaction ($F_{9,216}$=17.27, $p$<.01, $\eta^2$=.42), breakdown of which suggested that participants were less variable at pre-test during the mid-point (50%) of the back-swing (see figure 10).



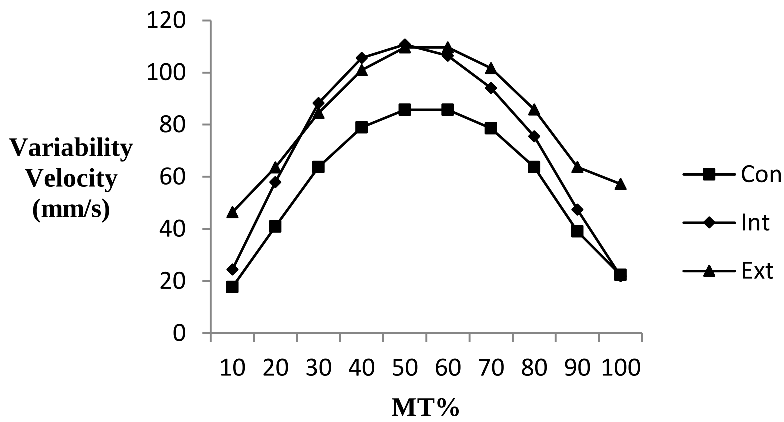



**Figure 10. Graphs showing variability in velocity at every 10% of MT for the back-swing as a function of group (Con, Int, Ext) and experimental phase (Pre, Rtn).**

*Forward-swing:* Results revealed a significant main effect for time ($F_{1,24}$=12.53, $p$<.01, η²=.34) with variability decreasing from Pre to Rtn, a main effect for position (%) ($F_{9,216}$=75.41, $p$<.01, η²=.76) with variability increasing between 10% and 40% of the movement onwards. There was however, no significant main effect for group ($F_{2,24}$=.23, $p$>.05, η²=.02) but a significant time x position interaction ($F_{9,216}$=14.98, $p$<.01, η²=.38), which revealed that participants were more variable at pre-test and this effect was exaggerated during the second half of the forward-swing.

*Variability post ball-contact*

*Distance Travelled XYZ*

Results revealed no significant main effect for time ($F_{1,24}$=2.90, $p$>.05, η²=.11) but a significant main effect for position (%) ($F_{9,216}$=126.85, $p$<.01, η²=.84) and group ($F_{2,24}$=3.58, $p$<.05, η²=.23) with variability increasing throughout the movement as well as being greater for the internal focus group. Additionally, there was a significant group x position interaction ($F_{18,216}$=3.09, $p$<.01, $\eta^2$=.21) with the internal group being more variable during the second half of the forward-swing.

*Variability Velocity XYZ*

Results revealed a significant main effect for time ($F_{1,24}$=12.25, $p$<.01, $\eta^2$=.34) with variability decreasing from Pre to Rtn, a main effect for position (%) ($F_{9,216}$=44.24, $p$<.01, $\eta^2$=.65) with variability decreasing between 40% the end of the movement. There was however, no main effect for group ($F_{2,24}$=1.18, $p$>.05, $\eta^2$=.09) but a significant time x position interaction ($F_{9,216}$=18.99, $p$<.01, $\eta^2$=.44), which revealed that participants were more variable at pre-test at the beginning of the forward-swing.

## 5.3 Discussion

Previous research has demonstrated robust findings regarding the benefits of imagery (Orlick & Partington, 1988; Hall et al., 1998, Hardy & Callow, 1999). Furthermore, researchers have also advocated the application of an external FOA for optimal skill execution (for a review see Wulf, 2007a). Thus, the purpose of the current experiment was to determine whether it is important to consider FOA when writing imagery scripts; specifically, whether those scripts that induce an external FOA are more efficacious than those that induce an internal FOA. It was hypothesised that the use of imagery would result in greater performance than learning with the absence of imagery. Furthermore, in line with the CAH (Wulf et al., 2001), it was hypothesised that performance would be greatest when participants used imagery scripts that induced an external rather than an FOA. However, results revealed no significant benefits of imagery, or differences between scripts that induced either an internal or external FOA. The analysis of both number of putts and MRE revealed a significant main effect of time with all participants improving from pre-test to retention. However, analyses failed to reveal a main effect for group or a group x block interaction. Since these findings are inconsistent with expectations, we propose a number of possible reasons to account for these null effects; the mechanisms behind bio-informational theory (Lang, 1977, 1979), the timing differences behind when imagery and FOA are typically used and the relatively small amount of acquisition trials adopted in the current experiment.

Bio-informational theory rationalises that imagery works by stimulating muscle activation; a result of highly inter-related stimulus and response propositions. With this in mind, an internal FOA integrated into an imagery script is likely to enhance this muscular activation to greater extent than a script that induces an external FOA. The rationale here being that the focus of the internal FOA imagery script encourages attention to movement execution (i.e., swinging of the arms), whereas the external FOA script would encourage the production of images associated with the effects of the movement outcome (i.e., club movement). We propose that the differences between the movement and outcome centred images resulted in differences in actual muscle activation and the subsequent benefits of imagery use. That is, a clear and vivid image representing movements of the body may have increased activation of the muscles associated with those movements to a greater extent than images representing the outcome of the action. Thus, the hypothesised benefits of adopting imagery scripts that induce an external FOA were negated due to images of this nature leading to a reduction in muscle activation. Similarly, despite the possible increased muscle activation in the internal FOA imagery group, we propose that the benefits associated with this were reduced due to the nature of images produced and resultant muscle activation leading to the constraining of automatic processes (Wulf et al., 2001).

Consequently, the bio-informational benefits of adopting internal FOA imagery were negated by the principles of the CAH (i.e., internal focus disrupts automatic processes, reducing performance), whereas the hypothesised benefits of adopting external FOA imagery were negated by the resultant images reducing the muscle activation proposed to be responsible for the benefits of imagery. These interactions resulted in the null differences between the performance of the internal and external FOA imagery groups.

An alternative and/or additional explanation for the null findings of the current investigation relate to timing differences between the typical use of imagery and FOA. For example, to ensure optimal performance, visual imagery should be performed prior to movement production (Hardy & Callow 1999; White & Hardy, 1995), whereas directing attentional focus should occur simultaneously to movement execution (Wulf et al., 1998; Wulf et al., 2001). However, in the current experiment only the imagery adhered to these principles. That is, whilst imagery was assumed to be performed prior to every putt, the FOA component of the investigation was also produced at this time point. Thus, contrary to directing FOA during movement execution, as is normal in the FOA literature, the current investigation directed attentional focus prior to movement production. It is possible that directing attention to movement effects only results in performance benefits when the focus occurs concurrently with task execution. Future research should investigate this possibility further.

Finally, it is possible that the absence of performance differences between the internal and external FOA imagery groups was due to an inadequate number of acquisition trials. Masters (1992) suggested that 400 or greater acquisition trials of a golf putting action are necessary for learning to occur. However, despite participants in the current investigation significantly improving performance over learning, the experimental protocol only incorporated 120 acquisition trials. This amount of practice was perhaps not adequate for incontrovertible learning to have occurred and thus reduced the effects hypothesised between the different acquisition groups. The inclusion of additional learning trials in future research may result in performance differences at retention.

In conclusion, findings revealed that there are no performance differences between utilising imagery scripts that induce either an external or internal FOA only. The present researchers propose that these effects are due to a number of possible reasons. Firstly, that the principles of bio-informational theory (Lang, 1977, 1979) interact with the principles of the CAH (Wulf et al., 2001) to both negate the benefits of adopting an external FOA on enhancing movement automaticity and the benefits of increased muscle activation associated with producing images surrounding body movements. Secondly, that imagery was performed prior to skill execution and thus attentional focus was not directed during task execution. Consequently, it appears that FOA is important to consider in so much that an imagery script that adopts a single focus actually serves to disrupt the typical benefits associated with imagery.

# CHAPTER 6

# GENERAL DISCUSSION

Directing attention in a manner to facilitate optimal performance has been investigated as early as the 19th century (James, 1890). This research explored the advantages of focusing on the target versus focusing on the hand during reaching and grasping actions. Despite this early research, it is only over the past decade that the purpose and results of the investigation have become more prominent in the field of motor control and learning. Nevertheless, understanding the practical implications of how adopting different foci of attention can impact on movement performance and learning is extremely important. For example, teachers and coaches often instruct athletes where to focus their attention during movement execution, however, recent findings within the FOA literature indicate that these instructions are not always advantageous to performance and unfortunately the aspiration for fast improvements often negate the consideration of long-term learning and performance benefits.

Wulf has been instrumental in directing this research to examine the differential effects on performance between adopting an internal FOA (where attention is directed to movements) or an external FOA (where attention is directed to movement effects) (for a review see Wulf, 2007a). In particular, Wulf et al.'s (2001) CAH has been pivotal to this body of research, suggesting that focusing on movements can actually impede automaticity in response programming, whereas consistent with Prinz's (1997) work, directing attention to movement effects improves performance by enhancing the congruence between motor planning and action. The benefits of an external FOA have been extended to a variety of different sports, (see Wulf 2007a for a review) ability groups (e.g. Wulf & Su, 2007) and population domains (e.g. Landers et al., 2005).

The current thesis endeavoured to supplement this research in an attempt to further understand when and why adopting an external FOA is beneficial and to see if manipulating FOA within other psychological skills can serve to further enhance the benefits of those skills. The first experimental chapter explored the consequences of adopting an external FOA in a skill where movement effects are not immediately salient to performance (a form task). The following chapter examined the FOA literature in conjunction with anxiety literature, exposing the similarities between the CAH (Wulf et al., 2001) and CPH (Masters, 1992), in an attempt to explore the possibility that learning under an external FOA reduces the choking phenomenon. The third experimental chapter investigated whether it is possible to further enhance the effects of imagery by creating imagery scripts that encourage an external FOA. Finally, since previous literature has primarily focused on movement outcome and not movement production when measuring performance, the second and third experimental chapters aimed to fill this research void by investigating the effects of foci of attention on both movement outcomes and movement kinematics.

## 6.1. Internal and External FOA

Wulf et al.'s (2001) CAH suggests that focusing on one's movements can interfere with normally automatic response programming and disrupt performance. Wulf therefore advocates the use of an external focus when performing or learning movement skills. The benefits of adopting an external FOA have been explained using Prinz's (1997) action-effect principle, which indicates that movements are planned in terms of their effects. Hence, focusing on a movement outcome enhances the congruence between movement production and movement outcome, improving movement planning and ultimately performance. Previous research has identified the advantages of an external FOA in a variety of sports where performance outcomes determine success and failure (e.g. basketball, Al-Abood et al., 2002; golf, Wulf et al., 1999; and tennis, Wulf & Su, 2007). However, the current thesis endeavoured to establish whether adopting an external FOA in a form sport with no salient movement effects will offer the same benefits. Novice participants learnt a short gymnastics routine (adapted from Hardy & Callow, 1999) with either an internal or external FOA before being subjected to both retention and transfer tests the following week. Inconsistent with the CAH (Wulf et al., 2001), findings revealed no performance differences between those adopting either an internal, an external or no explicit FOA.

The theoretical underpinning behind the CAH (Wulf et al., 2001) is that directing attention to movement effects encourages automaticity in motor programming as it enhances the congruence between movement planning and movement outcome. However, the results of the present thesis suggest that if the to-be-performed task does not contain obvious movement effects then the benefits of adopting an external FOA are removed. In the gymnastics floor routine employed the most obvious movement effect was identified as the pressure exerted on the support surface, which is clearly not as pertinent to success as the path of the ball in a golf putt or the motion of the racket in a tennis serve. As a consequence the current researchers have concluded that an external FOA does not serve to enhance performance in tasks where movement effects are not immediately salient (i.e., form tasks). As such, it may not be beneficial to encourage the use of an external FOA in tasks such as dance, martial arts patterns/kata, high diving, synchronised swimming and that utilised in chapter 3 of this thesis (floor gymnastics).

## 6.2. Attentional Focus under Pressure

The CAH (Wulf et al., 2001) shares a similar theoretical basis to CPH (Masters, 1992) in that both hypotheses suggest that attending to movement execution too closely can disrupt performance. Both an internal FOA, generally induced through verbal instructions and a self-focus, often induced by stress, instigate a switch from automatic programming to step-by-step processing of declarative knowledge typically resulting in performance decrements. In line with reinvestment theory (Masters, 1992), the current researchers rationalised that if the conscious processing of explicit knowledge can be minimised during acquisition then breakdowns in automatic processes as a result of increased pressure should be prevented, thus reducing choking. We investigated whether an external FOA could lead to such learning strategies by preventing a build-up of explicit movement centred information during learning and by encouraging automatic processes. To test this notion, novice golfers learnt a putting task under either an internal FOA, an external FOA or under a control (no focus) condition. Participants were then subjected to a LA retention and a HA stress test with both outcome performance and movement variability measured through Vicon motion analysis.

Consistent with CPH (Masters, 1992), findings revealed the choking phenomenon only for participants who learnt under conditions devoid of focus instructions. The episodic memory data suggested that participants developed some explicit movement centred rules during learning, and the performance data revealed that skills had likely reached the procedualisation/autonomous stages of learning at the end of acquisition. Thus, when anxiety was introduced in the transfer test performers reinvested in the explicit step by step movement knowledge resulting in a disruption in automatic processes and a subsequent decrement in performance. Whilst there was evidence of choking in the control group, no such pattern of results was observed for either the external or internal FOA groups.

The benefits of an external FOA on anxious performance were consistent with research by Bell and Hardy (2009). Bell and Hardy offer a distraction hypothesis to account for the results in that adopting an external FOA utilises less attentional resources (Wulf et al., 2001) and thus the primary task performance is not negatively affected by the resources thought to be consumed by the presence of anxiety. However, the theoretical explanations offered to account for the findings of the current research take a conscious processing approach. The rationale for the adoption of different approaches to explain findings is twofold; firstly, performance levels differed between the two experiments with Bell and Hardy using expert performers whereas the current investigation utilised novice participants and could thus employ a learning paradigm. Secondly, only the current investigation included a measure to investigate explicit rule generation during skill execution. The exclusion of this in Bell and Hardy's research meant that the CPH and the theory of reinvestment (Masters, 1992) could not be fully investigated as a possible explanation for their findings. We propose that the benefits of learning under an external FOA are due to participants not developing explicit movement centered knowledge that is then reinvested when anxiety is introduced to the performance setting.

The unanticipated finding that learning under an internal FOA maintains anxious performance was initially very surprising, but when considered alongside past research can actually be explained comprehensibly. Self-consciousness training previously implemented by Beilock and Carr (2001) resulted in similar performance between LA and HA conditions, thus learning under self-conscious conditions prevented choking. In the same respect, it appears that learning under an internal FOA (self-focus) can protect against choking. Thus, in line with the specificity of learning and practice principles (Henry 1968, Proteau, 1992, Mackrous & Proteau, 2007) participants may become familiar with the self-focus conditions that both a self-consciousness and an internal FOA induce and consequently develop performance strategies and movement plans during learning that are effective under subsequent self-focus (anxiety) inducing situations.

Unfortunately the movement variability findings were unable to corroborate outcome performance differences. This was explained with the notion that control participants choked as a result of a maladjustment in the line of their putt under pressure, which would not have been reflected in movement variability. That is, participants produced consistent but inaccurate movements. This proposal would account for why the variability profiles between the control and external FOA groups did not differ at the HA transfer test. That is, whilst the external FOA group produced consistent putts of an accurate nature, the control group produced consistent putting actions with an inaccurate outcome. This would result in variability remaining relatively low regardless of a decline in performance between LA and HA retention.

MRE findings were also unable to substantiate outcome performance data. This was accounted for with a methodological limitation meaning that putts overshooting the hole longitudinally, shortly came into direct contact with the putting green wall and as a result were given a maximum MRE score lower than what would have been given had the ball come to a standstill naturally without obstruction. Consequently, MRE scores were not reflective of true error and should be regarded accordingly.

### 6.3. Integrating Imagery with FOA

The extensive benefits of visual imagery on performance have been proven robust in numerous research articles (e.g. Feltz & Landers, 1983; Hall et al., 1998; White & Hardy, 1995) and explained comprehensibly by Lang's bio-informational theory (Lang, 1977, 1979). This theory suggests that mental rehearsal can trigger muscle stimulation due to highly inter-related stimulus and response propositions. This proposal is supported by brain imaging techniques which have provided evidence for functional equivalence in brain activity between actual and imagined skill execution (Grézes & Decety, 2001; Filimon, 2007; Sakamoto et al., 2009). Despite the fact that the skill is not physically executed during imagery the muscle activation induced as a result can develop an array of factors such as confidence, skill acquisition and strategy development (Hall et al., 1998). Equally empirically sound are the performance benefits of adopting an external FOA during movement execution (for a review see Wulf, 2007a), which can be explained by the CAH (Wulf et al., 2001). However, these two concepts have yet to be examined in conjunction.

This thesis attempted to implement FOA into an imagery script, to investigate whether performance differences occur as a consequence of inducing differential attentional foci through imagery. Novice golfers practiced a golf putting task using either an imagery script designed to induce an internal FOA, an imagery script designed to induce an external FOA or without an imagery script (control). Participants were then subjected to a retention test measuring both performance outcome and movement variability.

Findings revealed no performance differences between utilising imagery scripts that induce either an external or internal FOA only. The present researchers propose that these effects are due to a number of possible reasons. Firstly, the principles of bio-informational theory (Lang, 1977, 1979) interact with the principles of the CAH (Wulf et al., 2001) and consequently negate the benefits of both imagery and an external FOA. For participants utilising an imagery script which induced an internal FOA, any benefits that might usually be gained from visual imagery are negated as a result of the CAH (Wulf et al., 2001) (i.e., internal focus disrupts automatic processes, reducing performance). Similarly, for participants utilising an imagery script that induced an external FOA, any benefits normally revealed from an external FOA were negated by the resultant outcome images (i.e., images of the movement effects not movements themselves) reducing the muscle activation proposed to be responsible for the benefits of imagery (i.e., imagery is no longer effective). These interactions resulted in the null differences between the performance of the internal and external FOA imagery groups.

In addition, the lack of performance differences between utilising imagery scripts which induce either an internal or external FOA can be explained with timing differences between the typical use of imagery and FOA. For example, to ensure optimal performance, visual imagery should be performed prior to movement production (Hardy & Callow 1999; White & Hardy, 1995), whereas directing attentional focus should occur simultaneously to movement execution (Wulf et al., 1998; Wulf et al., 2001). However, in the current experiment only the imagery adhered to these principles. That is, whilst imagery was assumed to be performed prior to every putt, the FOA component of the investigation was also produced at this time point. Thus, contrary to directing FOA during movement execution, as is normal in the FOA literature, the current investigation directed attentional focus prior to movement production. It is possible that directing attention to movement effects only results in performance benefits when the focus occurs concurrently with task execution. Future research should investigate this possibility further.

Finally, it is possible that the absence of performance differences between the internal and external FOA imagery groups was due to an inadequate number of acquisition trials. Master's (1992) suggested that 400 or greater acquisition trials of a golf putting action are necessary for learning to occur. However, despite participants in the current investigation significantly improving performance over learning, the experimental protocol only incorporated 120 acquisition trials. This amount of practice was perhaps not adequate for incontrovertible learning to have occurred and thus reduced the effects hypothesised between the different acquisition groups. The inclusion of additional learning trials in future research may result in performance differences at retention.

In conclusion, findings revealed that there are no performance differences between utilising imagery scripts that induce either an external or internal FOA only. The researchers have accounted for these null findings using the principles of bio-informational theory and the CAH, the timing of attentional focus application and the quantity of acquisition trials. Consequently, it appears that FOA is important to consider in so much that an imagery script that adopts a single focus actually serves to disrupt the typical benefits associated with imagery.

### 6.4. General Conclusions

In summary, targeting attentional focus appropriately is a powerful tool in enhancing the acquisition and retention of motor skills, through the activation of augmented efficiency in motor programming (CAH, Wulf et al., 2001). This thesis has highlighted the extensive benefits from adopting an external FOA but has also revealed that this type of attentional focus is not always advantageous, especially in skills where movement effects are not immediately obvious such as form sports or skills where object interaction does not occur (i.e., floor gymnastics, martial arts patterns or kata and high diving). Additionally, current researchers have examined the effects of learning with different attentional foci on anxious performance and movement variability. Previous studies have often selected outcome variables, neglecting to consider what happens during movements to create these robust performance differences (Lawrence et al., *In Press*). This thesis has ascertained that adopting an external FOA at the onset of the cognitive phase of learning, can ultimately inhibit choking under pressure once in the autonomous phase of learning. However, it is unclear from the analysis of movement kinematics (specifically the variability of movements) as to why this effect occurs. Finally, the current researchers attempted to create imagery scripts which induced different attentional foci, but were unsuccessful in further supplementing the benefits of imagery through the application of an external FOA. In explaining these results we have identified some critical proposals worthy of consideration in future research.

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## APPENDIX A

## Mental Readiness Form-3

**1. My thoughts are:**

**1 2 3 4 5 6 7 8 9 10 11**

**CALM** **NOT CALM**

**2. My body feels:**

**1 2 3 4 5 6 7 8 9 10 11**

**TENSE** **NOT TENSE**

**3. I am feeling:**

**1 2 3 4 5 6 7 8 9 10 11**

**CONFIDENT** **NOT CONFIDENT**

## APPENDIX B

### Imagery Script A: External Imagery Perspective with an External FOA

In a minute you will be asked to listen to an imagery script. You can choose to have your eyes open or closed.

You will be taken through the task you are going to perform, imagining yourself from outside of your body as if you are watching yourself performing the task…that is from an external visual imagery perspective….

You will imagine looking at your trainers which are slightly apart ……..your trainers are evenly distributed onto the floor………. you will imagine focusing on the intended line of the club………. and imagine a light grip close together on the handle of the club…….you will imagine the club being swung in a backward motion the same distance as you plan to swing the club forward………as you do so you will imagine your trainers are still firmly planted in the same position………you will then imagine the golf club being swung forward and making contact with the ball.

# APPENDIX C

## Imagery Script B: External Imagery Perspective with an Internal FOA

In a minute you will be asked to listen to an imagery script. You can choose to have your eyes open or closed.

You will be taken through the task you are going to perform, imagining yourself from outside of your body as if you are watching yourself performing the task…that is from an external visual imagery perspective….

You will imagine yourself looking at your feet which are shoulder width apart ……..your weight is evenly distributed onto both feet……….you will imagine your eyes focusing on the intended movement of your arms……….and imagine your hands close together with a light grip…….your standing with your knees slightly bent and locked……..you will imagine yourself locking all joints except your shoulders, this includes your wrists and elbows……imagining yourself swinging your shoulders backwards the same distance as you plan to swing your shoulders forwards………as you do so imagine minimal body movement and weight transfer………you will then imagine your shoulders making the final swing forwards.

# APPENDIX D

**Imagery Script C: Internal Imagery Perspective with an External FOA**

In a minute you will be asked to listen to an imagery script. You can choose to have your eyes open or closed.

You will be taken through the task you are going to perform, imagining yourself from outside of your body as if you are watching yourself performing the task…that is from an internal visual imagery perspective….

You will imagine looking at your trainers which are slightly apart ……..your trainers are evenly distributed onto the floor……….you will imagine focusing on the intended line of the club………and imagine a light grip close together on the handle of the club…….you will imagine the club being swung in a backward motion the same distance as you plan to swing the club forward………as you do so you will imagine your trainers are still firmly planted in the same position………you will then imagine the golf club being swung forward and making contact with the ball.

# APPENDIX E

## Imagery Script D: Internal Imagery Perspective with an Internal FOA

In a minute you will be asked to listen to an imagery script. You can choose to have your eyes open or closed.

You will be taken through the task you are going to perform, imagining yourself from outside of your body as if you are watching yourself performing the task…that is from an internal visual imagery perspective….

You will imagine yourself looking at your feet which are shoulder width apart ……..your weight is evenly distributed onto both feet……….you will imagine your eyes focusing on the intended movement of your arms………and imagine your hands close together with a light grip…….your standing with your knees slightly bent and locked……..you will imagine yourself locking all joints except your shoulders, this includes your wrists and elbows……you will imagine yourself swinging your shoulders backwards the same distance as you plan to swing your shoulders forwards………as you do so you will imagine minimal body movement and weight transfer………you will then imagine your shoulders making the final swing forwards.

## Appendix F

## Imagery Manipulation Questionnaire

| 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|
| **Rarely** | | | | | | **Often** |

1. Before attempting the golf putt I imagined myself performing it perfectly. ____
2. I was able to consistently control the image of the golf putt. ____
3. When imaging the golf putt I consistently performed it perfectly in my mind. ____
4. I imaged myself perform the golf putt perfectly. ____
5. When learning the skill, I imaged myself performing it perfectly. ____
6. I can easily change the image of the golf putt. ____
7. I imaged each step of the golf putt. ____

To what extent did you adhere to the imagery script?

What did you image?

# APPENDIX G

## Vividness of Movement Imagery Questionnaire-2

**Name:** **Age:**

**Gender:** **Sport:**

**Level at which sport is played at (e.g., Recreational, Club, University, National, International, Professional)**

**Years spent participating in this sport competitively:**

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.

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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:

| | | |
|---|---|---|
| Perfectly clear and as vivid (as normal vision or feel of movement) | …………… | RATING 1 |
| Clear and reasonably vivid | …………… | RATING 2 |
| Moderately clear and vivid | …………… | RATING 3 |
| Vague and dim | …………… | RATING 4 |
| No image at all, you only “know” that you are thinking of the skill | …………… | 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 | Perfectly clear and vivid as normal vision | Clear and reasonably vivid | Moderately clear and vivid | Vague and dim | No image at all, you only know that you are thinking of the skill | | Perfectly clear and vivid as normal vision | Clear and reasonably vivid | Moderately clear and vivid | Vague and dim | No image at all, you only know that you are thinking of the skill | | Perfectly clear and vivid as normal feel of movement | Clear and reasonably vivid | Moderately clear and vivid | Vague and dim | No image at all, you only know that you are thinking of the skill |
| 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 |