THE UNIVERSITY OF HULL

The effects of internally and externally directed attention during motor skill execution and learning

being a Thesis submitted for the Degree of Doctor of Philosophy

by

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July 2005

For my sister Nicola

Always in our thoughts, never forgotten.

"The only cure for grief is action."

George Henry Lewes

ABSTRACT

Focusing attention onto the intended outcome or goal of a movement (an *External* focus of attention) has been shown to be more beneficial to the learning and performance of movements than focusing onto the components of the movement being carried out (an *Internal* focus of attention). In this thesis, four studies assessed the effects of attentional focusing strategies on the learning and execution of motor skills during different situations. Study 1 demonstrated that an internal focus of attention during a supra-postural pointing task resulted in degraded postural control as well as larger movements of the hand and arm. In Study 2 novices using an external focus were more accurate in a dart throwing task than those using an internal focus, but no different from a control condition. In Study 3 two experiments investigated the effects of attentional focuses on postural control at rest and whilst fatigued. Postural control was no better using external focus when compared to an internal focus at rest, but was better than baseline. When fatigued (localised and generalised), balance was significantly deteriorated using an external focus, but not when an internal focus was used. In two experiments during Study 4 novices carrying out a dart throwing task used different attentional focusing instructions during practice and later performance. During practice sessions in Experiment 4.1 and 4.2 accuracy was not affected by attentional focusing instructions. Using an external focus during performance resulted in significantly better accuracy than using an internal focus. In Experiment 4.2, novices who preferred an internal focus but used an external focus during performance performed less accurately than participants who preferred the external focus. Findings demonstrate that the benefits of an external focus of attention is evident in performance situations, whereas an internal focus may be beneficial whilst fatigued and is not detrimental during practice.

ACKNOWLEDGEMENTS

My initial debt is to Dr Peter Clough for the opportunity to work towards a PhD. His advice, guidance and encouragement is greatly influential.

Thanks also to Dr Martin Crawshaw whose availability for even the smallest questions, his reading of drafts copies and the subsequent suggestions regarding content, presentation and unclear passages has been a great support.

Advice and ideas from Matt Greig, particularly regarding biomechanics and movement, have been invaluable.

I shared an office with James Jackson during the years that this work was carried out, and I am grateful of his humour during this time and being a great friend and colleague.

Finally, the most important people in my life. Many thanks to my parents Ann and Brian for the support they have given me. Their encouragement and optimism has been inspirational through setbacks and insecurities.

I am thankful for the support I have received from Lucy, whose patience is a virtue and her cheerful voice, which was often at the end of the phone, always a comfort.

PUBLICATIONS FROM THESIS (PRE-VIVA)

Published Abstracts

Marchant, D. Clough, P, & Crawshaw, (In Press) M. Influence of Attentional Focusing Strategies During Practice and Performance of a Motor Skill. *Journal of Sport Science.*

Marchant, D, & Clough, P (2005) Effects of Attentional Focusing Strategy on Darts Performance and Heart Rate. *Journal of Sport Science, 23, p.172.*

Marchant, D, Greig, M & Clough, P (2005) Attentional Focus as a Mediator of Fatigue in Balance. *Journal of Sport Science, 23, p.213.*

Conference Presentations

Marchant, D. Clough, P, & Crawshaw, (2005) M. Influence of Attentional Focusing Strategies During Practice and Performance of a Motor Skill. *BASES Annual Conference, Loughborough.*

Marchant, D. (2005) Participants' experiences of and the effects of attentional focusing instructions during practice and performance. *PSYPAG Conference, Exeter*

Marchant, D, Greig, M & Clough, P. (2005) Physical fatigue influences the effectiveness of attentional focusing strategies during dynamic balance. *BPS Quinquennial Conference, Manchester.*

Marchant, D & Clough, P (2004) Effects of Attentional Focusing Strategy on Darts Performance and Heart Rate. *BASES Annual Conference, Liverpool.* (Awarded Best Student Psychology Presentation)

Marchant, D, Greig, M & Clough, P (2004) Attentional Focus as a Mediator of Fatigue in Balance. *BASES Annual Conference, Liverpool.*

Marchant, D, Greig, M & Clough, P (2004) Effects of Attentional Focus & Fatigue During Balance: *PsyPAG Annual Conference, Manchester.*

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CHAPTER 1

ATTENTIONAL FOCUS AND HUMAN MOTOR SKILL PERFORMANCE

"The life of the mind is like that of the body. If it depended on conscious awareness or control, it would fail entirely" (Gray, 2003, p64).

Attention and Performance

There has been a long interest in the role of attention during performance, particularly its importance to athletic and motor performance. "The ability to selectively pay attention to the appropriate stimuli is critical in most athletic situations . . . Selective attention is perhaps the single most important cognitive characteristic of the successful athlete" (Cox, 1994, cited in Moran, 1996, p. 67). Similarly, Orlick (1990) and Näätänen (1992) proposed that the ability to maintain the mental focus and to shift it according to the changing mental environment is critical to success.

In the sports and exercise psychology literature, attentional focus is often defined along the dimensions of width (wide-narrow) and direction (internal-external). The width dimension refers to the number of concurrent stimuli that can be effectively attended to, and the direction dimension refers to the extent to which attention is directed externally to environmental stimuli or internally to cognitions, emotions and kinaesthetic information. These dimensions interact to produce four possible attentional focus styles; broad external, broad internal, narrow external, narrow internal. Nideffer was a key proponent of this conceptualisation of attentional focus within sports and exercise psychology (e.g., Nideffer, 1979) and suggested that you use a broad-external focus when you need to be environmentally aware and ready to react automatically and/or instinctively. A broad-internal focus helps you to analyse, strategise and plan. You would use a narrow-internal focus to systematically rehearse information or to assess and manipulate your own internal state. Finally, a narrow-external focus is useful during the performance of a task. The searchlight metaphor can be used to describe three main errors associated with attentional selectivity (Abernethy, 2001). For example, the searchlight could be too broad, pointed in the wrong direction, or not able to be adjusted with changing demands. Interest in this area within sport psychology has switched the focus from simply arousal per se to pre-performance emotional states and, more specifically, how attention is allocated during in-event mental activity (Collins, 2002).

This thesis draws mainly from the research and theoretical work of Wulf and colleagues (e.g., Wulf & Prinz, 2001; Wulf & McNevin, 2003) who have demonstrated that directing performers' attention to their movements through *internal focus* instructions interferes with the automated control processes normally used to regulate movement. An *external focus* of attention, manipulated by instructions which direct a performer's attention to desired outcomes or effects of their movements on the environment or implement, has been shown to be beneficial to motor skill execution and learning. This recently emerging and rapidly growing area is now beginning to attract further interest not only in sport skill learning and execution but also in areas such as physical therapy and rehabilitation. Although other researchers have conducted research in these areas, it is the aim of this thesis to work primarily around the theory and research of Wulf, with reference to other researchers, to advance this work. Before considering this research, an introduction to the theories of motor skill acquisition is necessary.

Constructing the Motor Skill

Traditional theory claims that motor learning progresses through distinct phases. Early in learning the person tries to make sense of instructions and make a great deal of use of verbal labels. This does not mean that instruction needs to be verbal, but simply that the individual uses verbalisation to aid memory. Depending on the nature of the task being learned, this period will vary in length. The motor components of skills at this stage are characterised by crude uncoordinated movement (McMorris, 2004), and are supported by a set of un-integrated control structures that are held in working memory and attended to one-by-one in a step-by-step fashion (Anderson, 1983, 1993; Fitts & Posner, 1967; Proctor & Dutta, 1995). This stage is attentionally demanding and characterised by conscious and effortful information processing (Wulf & McNevin, 2003).

It has been assumed that beginners should be taught skills by using instructions which direct their attention to the movements they are carrying out. By paying attention to details it is believed that learners will better understand what is needed to be controlled, and how to control it (Singer, Lidor, & Cauraugh, 1993). Specifically, learners should feel movements and muscle tone and think about the courses of action that change their position and move the body (Feldenkrais, 1972). Furthermore, investigators have stated or implied that there is a need to deliberately attend to proprioceptive feedback to generate appropriate skilled behaviours (e.g., Adams, 1971; Laszlo & Bairstow, 1983; Notterman & Page, 1962). That such instructions promote the use of conscious control is seen as a necessary phase that the learner must pass through in order to progress.

With patience and practice, procedural knowledge specific to the task develops. Procedural knowledge does not require constant control and operates largely outside working memory (Beilock, Carr, MacMahon, & Starkes, 2002). The skill can be automatically performed, fast, effortlessly, and without the need for attention (Logan, 1988), leaving attentional resources free to process extraneous stimuli (Beilock et al.). Shiffrin & Schneider (1977) were instrumental in describing the nature of controlled processes (effortful and deliberate) of information processing associated with beginners versus the automatic (effortless and rapid) processing displayed by experts. Skills at the automatic stage are believed to be difficult to alter (McMorris, 2004), and Reber (1993) notes they are 'classic examples of implicit systems'.

These differences in cognitive processes of novices and experts have been described as 'software differences'. For instance, both Abernethy (1992) and Moran (1996) maintain that the majority of empirical evidence supports the idea that it is 'software differences' (e.g., the fact experts use early cue and/or have more efficient ways of organizing and identifying task-relevant cues) which are attributable to learning, and not 'hardware' (e.g., genetic factors) differences that separate experts from novices.

Garfield and Bennett (1985) suggest that highly skilled athletes lose all conscious thought when they perform at their best. Athletes often describe optimal performance states as "thoughtless" and "selfless" (Williams & Krane, 1993), and describe themselves as "letting go" (Singer et al., 1993). Klatzky (1984) stated that 'awareness of performance decreases with practice', and that 'becoming aware impairs execution of a skilled act' (p. 62). This lack of awareness of limb positioning has been observed, both anecdotally and experimentally, in expert athletes. For example, Lee, Lishman, and Thomson (1984) observed that expert long jumpers were using information specifying time-to-contact to adjust the final footfalls in their run up, without actually being aware of this adjustment strategy.

Attempting to facilitate automated skills by isolating and consciously focusing on specific components of the skill would often result in a decrement in performance (e.g., Baumeister, 1984;Gallwey, 1982;Schneider & Fisk, 1983; Masters, 1992). In light of this, researchers have attempted to address the different attentional focuses during motor performance and learning in a hope to ascertain the optimal mental states required. This research direction is summed up by Singer, Lidor, and Cauraugh (1994) with the simple question: "what should a person think about while attempting to perform a movement skill?" (p. 335). In this review, a consideration will be given to the research assessing the role attentional focus plays during the acquisition of motor skills, which will be followed by the research assessing the effects of attentional focus on the execution of well-learned skills.

Attentional Focus and Motor Learning

"Instructions are a central part of basically any situation in which motor skills are taught" (Wulf, McNevin, Fuchs, Ritter, & Toole, 2000).

With the discovery that novices and experts differ in their attentional state during learning and performing, interest increased in the notion that novices could use more expert-like strategies to achieve faster, more efficient learning. Singer (2000) suggests there is an increasing acceptance of the doctrine of mind over matter, that a trained and disciplined mind can control biological functions and, in turn, performance. Evidence of this would move the approach to motor skill learning away from the countless trial and error experience (not to mention the amount of practice time needed) advocated by the traditional approach. Although research highlighting the benefits of an external focus during performance of well learned skills is valuable, by far the most innovative and challenging research comes from the motor learning research.

One of the major motivations of the research conducted by Wulf and colleagues has been the neglect of the influence of instructions given to learners. This point was further highlighted by Lavallee, Kremer, Moran, and Williams (2004) who stated that further research is necessary to determine the specific role of verbal cues and narration during the instruction process: specifically, how different instructions can direct a performer's attention towards specific information and away from other information. In the case of motor learning, a large number of variables have been assessed, such as the organisation of practice (for reviews, see Magill & Hall, 1990; Shapario & Schmidt, 1982), the frequency of feedback given to the learner (for reviews, see Salmoni, Schmidt, & Walter, 1984; Schmidt, 1991), the presentation of a model (for a review, see

McCullagh, 1993; McCullagh, Weiss, & Ross, 1989) or the provision of physical guidance (e.g., Winstein, Pohl, & Lewthwaite, 1994; Wulf, Shea, & Whitacre, 1998). The lack of research assessing the influences of verbal instruction is interesting, as Wulf, Hoss, & Prinz (1998) point out, because instructions are given both before and during practice, and include information on how to perform the skill. Also, it is important to focus an individual's attention on the relevant aspects of the task because those are not necessarily picked up from the observation of a model.

During motor skill learning Wulf Hoss, and Prinz (1998) suggest that to achieve an appropriate focus, researchers often confront the learner with information regarding the correct placement of body parts, the timing of submovements, or the overall dynamics of the movement in line with traditional approaches to learning. For example, in learning a tennis forehand the learner is told where a place his or her feet; how to perform the backswing, forward swing, and follow-through; where (in relation to the body) to hit the ball; and how to time the whole action with the arrival of the ball. Wulf et al. stress that these body-related instructions are very common in the teaching of motor skills. However, little is known about how much or what kind of information should actually be provided to learners and at what point in the learning process, because those questions have hardly been addressed in the research literature. Yet, if a researcher's goal is to optimize learning, providing the learner with the right information could be critical (Wulf, Hoss, & Prinz, 1998).

In light of the findings regarding the detrimental nature of an internal focus, researchers such as Masters, (1992), Wulf, McNevin, and Shea, (2001) and Singer et al., (1993) have criticised the traditional theory of motor learning. Masters indicates that although there are those who have suggested, in a more cognitive than motor sense, that a skill may initially develop without explicit, declarative encoding of knowledge (Brooks, 1978; Hayes & Broadbent, 1988; Reber, 1976), most investigators of skill learning rely on this fundamental belief that skill acquisition begins with declarative, explicit encoding of knowledge in which the demands on 'cognitive' processing are high and ends with procedural, implicit encoding in which demands are low. Some researchers have gone as far as suggesting that instructions given to performers attempting to learn a new skill should be kept to a minimum (Masters, 1992; Masters, Polman, & Hammond, 1993). Masters proposes that, when given too many instructions, learners are more likely to adopt a controlled mode of information processing and tend to become preoccupied with thoughts about how they are executing the skill. Therefore, making learners more aware of their movements (or inducing an explicit mode of learning) should be avoided as much as possible.

Masters (1992) used a golf-putting task to examine the effectiveness of "implicit" (i.e. knowledge that is abstract, unavailable to consciousness and non-verbalizable; Reber, 1993) versus "explicit" (i.e. knowledge that is rule-based, available to consciousness and verbalizable; Reber, 1993) modes of learning. In order to prevent participants from processing (too much) explicit knowledge, one group performed a secondary random-word generating task whilst performing the golf-putting task. This loading of the articulatory loop was believed to limit learners' development of explicit knowledge compared to another group who were given explicit instructions regarding their technique. After learning, when participants were placed in a stressful performance situation, learners who learned with the secondary task showed a further performance improvement relative to the end of practice, whilst explicit learners showed performance decrements. Masters interpreted these results as providing support for the explicit knowledge explanation of anxiety effects on performance. Hardy, Mullen, and Jones (1996) demonstrated similar findings, but acknowledged limitations of both their own and Masters' studies, particularly the ecological validity of the approach.

Wulf and colleagues have been the major proponents of a new approach to motor learning, indicated in the direction of their research. Wulf, Lauterbach, and Toole (1999) found performance and learning advantages for participants learning golf "pitch shots" when directing their attention to the motion of the club head, rather than to the motion of their arms. Instructions to focus on the movement of the club head (external) demonstrated greater accuracy in pitching to a target compared to participants instructed to focus on their arm movements (internal). Importantly, the benefits of an external focus were apparent during the early stages of practice and remained significantly higher throughout the course of practice and during retention testing. Similarly, learners who were instructed to focus on the movement of the wheels of a ski-simulator demonstrated learning benefits when compared to participants instructed to direct their attention to their feet (Wulf, Hoss, & Prinz, 1998, Experiment 1).

In their review of the research carried out on attentional focus and motor learning, the majority conducted by Wulf and colleagues (e.g., Shea & Wulf, 1999; Wulf, Hoss, & Prinz 1998; Wulf et al., 1999; Wulf, Shea, & Park, 2001), Wulf and Prinz (2001) concluded that providing instructions and feedback phrased in a way to direct attention to the effects of the learners' movements (an external focus) generally seems to be more beneficial than directing learners' attention to their own movements (an internal focus). The research shows that focusing on external movement effects enhances performance by allowing performance to be mediated by autonomic control processes.

McNevin, Shea, and Wulf (2003) stress that findings which indicate an external focus of attention is beneficial to learners is worrying in that traditionally learners are often given instructions that refer to the coordination of bodily movements. That is, performers are provided information related to the correct positioning of their limbs during various phases of the movements, as well as the overall movement dynamics (McNevin et al., 2003). This has led Wulf and colleagues to suggest a change to the way motor skills are taught. They advocate an approach where novices are given instructions aimed to direct their attention externally from the start, with the rationale that it will produce better and more effective learning.

Singer et al. (1994) was also a proponent of this view. They suggested that when novices are traditionally instructed, they are told to pay attention to what they are doing, and to think about the act during execution. They are guided to be aware of movement cues and what the body parts are doing while performing (p.335). It is concerning that both Singer and Wulf make these claims based on anecdotal evidence. What does not exist at present however, is actual research that states what instructions novices are actually given during learning in the real world rather than in the laboratory. Research addressing what types of instructions are given to novices and whether these change under certain conditions would be a valuable starting point to any proposed widespread changes to current teaching.

In light of the above findings, the lack of research addressing the nature of verbal instruction in other fields is worrying. For example, verbal instruction and encouragement is standard protocol during isometric, isotonic, and isokinetic muscle testing and training, particularly when the goal is to increase muscular output (Campenella, Mattacola, & Kimura, 2000). However, little research has addressed the specific nature of different types of instructions as suggested by Wulf and colleagues. Chantal, Guay, Dobreva-Martinova, and Vallerand (1996) found verbal encouragement consisting of loud commands increased isometric peak torque values and McNair, Depledge, Brettkelly, and Stanley (1996) reported isometric mean peak torque values significantly increasing following verbal encouragement. Bickers (1993) found verbal encouragement improved motor endurance. The lack of consideration given to the subtleties of the emphasis of verbal instructions is made more problematic in light of the findings showing beneficial effects of an external attentional focus during motor learning.

Research into physical rehabilitation has addressed the re-learning of skills after injury. Wulf and Prinz (2001) point to the notion of Purposeful Activity in Occupational Therapy as being linked to the notion of the external focus, which researchers have found to be beneficial (e.g., Hsieh, Nelson, Smith, & Peterson, 1996). Purposeful activities have added purpose to the movement (reaching for objects) which takes conscious attention away from movement mechanics. Similarly, Fasoli, Trombly, Tickle-Degnen, and Verfaellie (2002) have found beneficial effects using instructions that emphasize an external focus in adults with and without Cerebrovascular Accident learning to develop functional reach. The role attentional focusing instructions may play in the rehabilitation of injuries is an area of potentially fruitful application and will be discussed more thoroughly later in this chapter.

Attentional Focus and Motor Skill Execution

A growing body of research suggests that there are differences in the type of attentional focus that can be used during motor skills execution. Some of the first researchers to highlight the importance of different attentional focus types during performance were Singer and colleagues in a series of studies addressing self-paced skills such as dart throwing (e.g., Singer, Lidor, & Cauraugh, 1994). Their concern was that, when analysing experts' behaviour during performance, automaticity and lack of awareness is frequently associated with good performance.

There is now an agreement that expert performance can break down if 'reinvested' with explicit knowledge (Masters, 1992), through an internally based awareness focus of attention. Masters brought together much of the research in this area and pointed to the work of Baddeley & Woodhead, (1982) and Klatzy (1984). Baddeley and Woodhead state that attempting to facilitate automated skills by isolating and focusing on specific components of the skill would often result in a decrement in performance, and Klatzy expounded on 'the common notions that awareness of performance decreases with practice, and that becoming aware impairs execution of a skilled act'. As part of the 'reinvestment' theory, Masters (1992) suggested that, under stress, the process of progression through the stages might reverse, with performers regressing to cognitive strategies associated with earlier stages of learning resulting in performance decrements. Indeed, this approach was proposed by Baumeister (1984) who suggested that stress engenders the desire to perform well, which causes the actor to focus on his or her own performance processing in order to control the execution of the task. Ironically, this conscious control of execution disrupts the automatic nature of the performance. "Choking" involves 'the failure of normally expert skill under pressure' (Masters, 1992) or 'the occurrence of sub-optimal performance under pressure conditions' (Baumeister & Showers, 1986).

One prediction of the hypothesis that stress results in an increased likelihood of using an internal focus is that training under such high degree of self-consciousness and skill focus (e.g., being video-taped) should lead to a large amount of explicit, declarative knowledge that will increase the likelihood that performance will fail under pressure. Liao and Masters (2002) demonstrated that self-focused training of basketball free-throw shooting led to a greater amount of explicit knowledge (e.g., rules) and worse performance under pressure relative to a control group. Liao and Masters conclude that sensorimotor skills should be acquired with as little explicit knowledge as possible to avoid such choking under pressure.

Lee and Swinnen (1993) suggested that the progression-regression hypothesis (Fuchs, 1962), originally proposed to explain movement tracking behaviour, might be useful in describing the acquisition and breakdown of complex motor skills. As Mullen and Hardy (2000) state, according to the progression-regression hypothesis, experts use higher order derivatives of time-position information to guide performance. The regression phase of the progression-regression hypothesis predicts that, under pressure, the functioning of motor skills, as described by higher order derivatives, becomes destabilised as performers focus internally onto control strategies associated with earlier stages of learning.

Bringing a more everyday example to the discussion, Eysenck (1982) suggested that deautomatization can occur in everyday skills: "for example, if you think too deeply about the leg movements involved in walking down a flight of stairs, you may well finish up in a heap at the bottom of the stairs" (p.13). Similarly Schmidt (1988) suggested that asking a pianist to describe what the hands are doing whilst playing will focus attention on the specific hand and finger movements, causing degraded performance. It has even been suggested that performers could use such effects to their advantage by directing their opponent's attention internally through skill focused comments.

The body of research conducted and developed by Gabrielle Wulf and colleagues continues to grow, and is becoming more influential. Although motivated by the growing interest in the detrimental effects of an internal focus on motor skill performance, Wulf et al. were not satisfied with the explanation that attention directed internally would disrupt skill execution and that attention should be directed away from the movements that were being produced. This was seen as too simplistic, and an appropriate external focus of attention should be attained. Specifically, what information should be focused upon whilst performing a motor skill?

Wulf and colleagues' research has focused upon how instructions can be optimized so that the performer is attending to the appropriate information. Wulf et al. have operationalised their research along the dimension of attentional focus being either internally directed or externally directed. Specifically, Wulf and Prinz (2001) define an external attentional focus of attention as being towards the desired effects or outcome of a particular movement in the environment, and away from the mechanics of the movement, for instance, the movements of an implement such as a golf club or tennis racquet, whereas an internal focus is onto the actual movements being produced.

Parallels can be drawn with these definitions and the previous theories, in particular, the influential James' discussion of close effects and remote effects in the control of action. The term 'close effects' refers to those consequences that are directly related to the action (e.g., kinaesthetic feedback), whereas the term 'remote effects' refers to the more or less distant results of the action (e.g., a nail in the wall after hammering it in). James proposed that the remote effects are often more important than the action itself or its close effects. This was summed up in James' quote "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" (James, 1890, p.520). In the description of his pre-performance routines, a world class rugby kicker stated that "I just try to focus on a spot between the posts" before a kick (Jackson & Baker, 2001, p. 59). Comments such as these advocate Wulf's suggestions that the external focus should be onto relevant goal directed information, rather than just a distraction away from movement awareness.

Henry and Rogers' (1960) memory drum theory of motor control suggests that conscious attempts to control movements, especially well-learned, complex movements, should interfere with performance. This interference results in increased reaction time under conditions of enforced motor set, that is, when the performer is asked to concentrate on the to-be-performed movement, as opposed to an enforced sensory set, namely, when the performer is to concentrate on the stimulus that evokes the response. Wulf et al. (1998) suggest that the supportive findings of Henry (1960) and Christina

(1973) demonstrate that concentrating on something that is related to, but external, to the movement can be more effective than concentrating on the movement itself.

Wulf and Colleagues' Attentional Focus Research

In the first study that demonstrated the comparative advantages of external over internal focus, Wulf et al. (1998, Experiment 1) used a ski-simulator task and found that instructing performers when to exert force on the wheels of the platform on which they were standing (which were located directly under the performers' feet) was more beneficial for learning (i.e., retention) than was instructing the performers to focus on when to exert force with their feet or providing no instructions at all. Previous to this Wulf and Weigelt (1997) examined the effects of instructions on the performance of slalom-type movements on a ski-simulator. They found that giving participants instructions about the optimal "timing of forcing", i.e., when to exert force within the movement cycle – instructions that presumably directed the performer's attention to his or her own bodily movements – produced significant performance decrements after extended practice on the ski-simulator task.

Due to the automatic nature of balance and postural control, Wulf and colleagues have regularly used balancing tasks to assess the influence of the direction of attentional focus during well-learned tasks. Wulf and colleagues (e.g., Wulf et al., 1998, Experiment 2; Wulf, McNevin & Shea, 2001) performed a series of studies where participants carried out a standing dynamic balance task on a stabilometer platform with the aim of minimising deviations of the platform from the horizontal. To induce attentional focus, instructions were given to direct attention to specific information. For an internal focus, participants were instructed to focus upon the movements of their feet, trying to keep them level during the task. An external focus was induced by directing performers to focus upon the movements of markers attached to the platform upon which they were standing, with the aim to keep these markers level throughout the balancing trial. Results show consistently that participants who focused on keeping a set of markers attached to the platform horizontal (external focus) produced more effective postural control than participants who focused on keeping their feet horizontal (internal focus).

Such findings demonstrate and support the theory that an internal focus upon the movements being carried out degrades performance by allowing methods of control to revert back to those early in learning. Where Wulf and colleagues' research add to this area is that an appropriate external focus has been identified. By directing performers to focus their attention onto an intended outcome, they are less likely to focus upon their movements and more likely to produce movements necessary for the desired outcome.

Focus Externally, but where?

Although research had demonstrated advantages of an external focus, research needed to establish whether there may be differences in the types of external focuses available that might offer further advantages. Focusing externally on an effect of movement suggests a concept of distance, and this "distance of focus" metaphor provides a conceptualisation of different types of external focuses which has been investigated further by Wulf and colleagues. Assessing the previous research conducted using externally focused instructions McNevin et al. (2003) found that as the distance of the external focus emphasised differed, so did the observed effects. Specifically, that this was related to the distance participants were required to focus away from the actions they were carrying out. Although they did accept the inherent limitations associated with comparing data across experiments and the obvious differences between movements involved in performing each task.

McNevin et al. (2003) indicated that in the Wulf et al. (1999) study, the advantage of the external focus was found almost immediately during acquisition for the golf task, where the distance between the arms and the club head was large. On the ski-simulator task (Wulf et al., 1998, Experiment 1), where the external cues (wheels) were located under the feet, the external focus benefits were only seen at the end of the first day of practice and remained present throughout the second day of practice, as well as during the retention test on Day 3. Finally, for the balance task (Wulf et al., 1998, Experiment 2), where the distance between the feet and markers on the platform was very small (the feet touched the markers), the advantage of the external focus only became apparent during the retention test after two days of practice. Therefore, McNevin et al. postulated that by increasing the distance of the movement effects from the body, the advantages of an external (relative to an internal) focus may become more pronounced. McNevin et al. speculated that effects that occur in close proximity to the body are less easily distinguishable from the body than more remote effects and therefore may increase attention towards the movements being produced.

Park, Shea, McNevin, and Wulf (2000) attempted to assess the claim that distance of external focus benefits performance and learning by having participants balance on a stabilometer moving in the medial-lateral plane. Park et al. adjusted the distance of the attentional focus by having participants focus on markers located at the end of two sticks that were attached to the stabilomter platform in front of their feet. This group demonstrated even better balance learning than those who either focused on markers either directly in front of their feet (near), or markers placed further away from the body (far-outside markers) and far-inside markers (markers placed away from the feet but between the legs). This research gave one of the first indications that distance was a key factor in the effectiveness of the external attentional focus.

Using similar methodology McNevin et al. (2003) found that all three external focus groups (near, far-outside, far-inside) showed generally more effective balance than an internal focus group in a retention test. Additionally, the far-outside and far-inside groups demonstrated similar performances and both were more effective than the near group. From their results they propose that the internal and near conditions resulted in participants attempting to exert more active postural control resulting in degraded balance. They concluded that one critical factor underlying the advantage of an external focus is the distance between the action and its effect, and that by increasing the distance of the effect from the movement producing it seems to allow performance to be mediated by automatic control processes that result in enhanced learning and performance. By directing a performer's attention to the body or towards proximal effects, the regulation of control processes involved in motor execution are constrained, resulting in performance and learning decrements.

This notion that the effectiveness of an external focus can be improved by increasing its distance from the movements producing it is attractive. However, there may be a limit to the effective distance of an external focus. Wulf et al. (2000, Experiment 2) suggests that focusing on more remote effects may not always be more beneficial. In their study participants were required to hit golf balls to a target. Participants were instructed to focus either on the swing of the club or on the anticipated trajectory of the ball or on the target. The trajectory and target focus group were presumed to be focusing on more distant effects. Results showed that, as compared with instructing participants to focus on the ball trajectory and target, instructing them to focus on the club motion actually resulted in a greater accuracy of their shots, not only in practice, but also in a retention test.

In light of this research Wulf and Prinz (2001) suggest that it is possible that not only very small distances, but also very large distances of the effects that the performer focuses on are not optimal for learning and performance. Rather, focusing on an effect at an "intermediate" distance might be most beneficial. They conclude that there may be an optimal distance of the effect, at which it is easily distinguishable from the body movement but at which it is still possible for the performer to relate this effect to the movement technique. They suggest that one reason why focusing on the (less distant) club movement resulted in better learning than focusing on the (more distant) ball trajectory might be that it provided more salient information about the movement technique. However, whether or not this is also true for expert performers requires further research.

To confirm what relevant sources of information should be used as an effective external focus, a study by Wulf, Mercer, McNevin, and Guadagnoli (2004) recently assessed the effects of focusing externally upon a supra-postural task have on both balance and the performance of the supra-postural task. Participants balancing on an inflated rubber disk whilst holding a pole horizontally performed under 4 attentional focus conditions: focusing externally upon the balance disk or internally on the feet, and focusing externally upon the pole or internally upon their hands holding the pole. Wulf et al's findings indicate that performance on a specific task (postural or suprapostural) is enhanced if attention is directed to that task. Specifically, their results demonstrated that performance on the postural task was most effective if attention was directed to the postural task and if the focus used was external. Similarly, performance on the suprapostural task was best if an external focus was adopted on to the pole. Therefore, despite suprapostural goal influences on postural control, the task that was attended to (postural or suprapostural) was performed best. These results, Wulf et al. add, confirm the view of a 'smart' motor system that optimises the control processes based on the environmental outcome, or movement effect, that the performer wants to achieve.

Feedback and Attentional Focus

In the first study to assess the effects of different types of attentional focusing feedback Shea and Wulf (1999) required participants to learn to balance on a stabilometer which gave concurrent visual feedback (lines representing the movements of the platform) to two groups of participants, whilst two other groups were given internal and external performance instructions. One feedback group were informed that the visual feedback represented their own movements (internal focus), whereas the other group were told that the feedback represented lines attached to the platform in front of each foot (external focus). Results showed that learning was more effective not only when performers were given external focus instructions, but also when they were provided with external- rather than internal-focus feedback. Specifically, even though the visual feedback was identical for both feedback groups, the group interpreting the feedback as external performed better than the group interpreting it as internal.

The online nature of the feedback in Shea and Wulf's (1999) study led the authors to argue that this could have induced an external focus of attention, independent of the (internal – external) attentional focusing instructions given for the learner's interpretation. That is, Wulf and Prinz (2001) suggest, the visual feedback display might have induced a more remote focus of attention (a concept discussed earlier), and the display might have provided a constant and more powerful reminder to maintain an external focus throughout the task.

Wulf, McConnel, Gartner, and Schwarz's (2002) first experiment examined the generalisability of the external-focus feedback benefits to the learning of a sports skill, volleyball "tennis" serving under more ecologically valid conditions. Different feedback statements were selected that are often used in volleyball training and that refer to the performer's bodily movements (internal-focus feedback). These instructions were then translated into instructions that directed the learner's attention more to the movement effects (external-focus feedback). Learners were provided with a feedback statement after every fifth trial depending on what was deemed appropriate based on their previous performance. Results indicated that serve accuracy was enhanced by the external-focus, relative to the internal-focus, feedback not only during practice but also after a 1-week retention interval in a retention test without feedback. In their second experiment, Wulf et al. demonstrated similar findings with soccer lofted pass accuracy, but provided feedback in either 100% or 30% of the trials. Furthermore, more effective performance was observed during both practice and retention when the frequency of feedback directed at the performer's movements (internal focus) was reduced. Even though no significant difference was observed between groups receiving external focus feedback in practice or retention, feedback on 100% of the trials tended to be more effective than receiving feedback on 33% of the trials, the reverse of what was observed in the internal feedback groups. The benefits of the external focus was overriding, but the general benefits of receiving external focus feedback more regularly may be because this serves as a constant reminder of the appropriate focus and allows for no opportunity to focus internally (see also, Shea & Wulf, 1999). Unfortunately, no control group was included in this study, limiting full discussion of the relationship observed. Wulf et al. state that the results demonstrate the effectiveness of effect-related, as opposed to movement-related, feedback and also suggest that there is a need to revise current views regarding the role of feedback for motor learning.

Taken together, Wulf, McConnel, Gartner and Schwart's (2002) and Shea and Wulf's (1999) findings suggest that attentional focus is an important qualifying variable for the effectiveness of feedback given during motor learning and performance. However, this is not in line with current views on feedback. According to traditional views, the effectiveness of feedback is enhanced to the extent that it encourages learners, or at least gives learners a chance, to attend to their own movements (e.g., Salmoni et al., 1984; Schmidt, 1991). From their findings, Wulf et al. (2002) suggested that, under natural conditions where other sources of information are available and the development of a dependency on augmented feedback might be less likely, the focus of attention induced by the augmented feedback might have a greater impact. Furthermore, Wulf et al.

(2002) suggest that attentional focus effects may also account for previous findings showing reduced benefits of feedback (e.g., Lai & Shea, 1998; Weeks & Kordus, 1998). They propose that reduced-feedback effects could result from the relief that reduction offers from constant internal focus induced by every-trial feedback. Wulf et al. emphasise that their results - in particular the general benefits of external- over internal-focus feedback (Experiments 1 & 2), the interactive effects of feedback frequency and attentional focus (Experiment 2), and the failure of frequent internal-focus feedback to produce a benefit during practice (Experiment 2) - seem to provide some support for this view.

Todorov, Shadmehr, and Bizzi, (1997) found that learning table tennis strokes was enhanced by providing performers with concurrent feedback about the trajectory of their paddle (in relation to the paddle trajectory of an expert). Those participants receiving this type of feedback demonstrated more accuracy when hitting a target than participants who were given verbal feedback relating to gross errors, and who had hit 50% more balls. Todorov et al. suggested that the highest level of motor planning and control seems to be in terms of the kinematics of the end effector and that, therefore, the feedback given to the learner should be most effective if it represents the movements of the end-effector, rather than body movements. This is a key principle proposed in Prinz's Common Coding Theory discussed later. Wulf and Prinz (2001) suggest it is conceivable that at least part of the reason for the effectiveness of feedback about the paddle motion was that it induced an external focus of attention, whereas the control participants (without feedback) paid more attention to their own movements.

Individual Differences in the Effects of Attentional Focus

The possibility that there may be individual differences in the preference for specific cognitive strategies during motor performance is not well researched, and the implications of any such effect could call into question many presumptions made about the effectiveness of attentional focusing strategies. Currently the attentional focus effects are believed to be a general phenomenon by researchers such as Wulf et al. However, if it turned out that there were individual differences in the preference of attentional focus, then it may also imply that there may be individual differences in the effectiveness of the attentional focus.

Wulf, Shea, and Park (2001) stressed that research addressing preference is critical as it is possible that while external focus instructions are more effective for most learners, some individuals might have a preference for an internal focus and show similar benefits if allowed to adopt an internal focus. If this is the case, Wulf et al. state, there should be no difference between the performance of individuals performing in their preferred attentional state. Wulf et al. were also interested in the possibility that learners can detect the effectiveness of different attentional strategies if given the chance to compare them directly. If participants are not able to detect differential effects of focus strategies on their performance, than an equal number of participants should choose an external or internal attentional focus. Furthermore, even if learners are not able to detect differential effects on their performance, they might choose to rely upon the method that "feels best" or "feels more natural". Wulf et al. conducted 2 experiments to attempt to address these issues.

In Experiment 1, participants practiced balancing on the stabilometer and were asked to switch their focus of attention between internal (focusing on their feet) and external (focusing on markers on the platform) from trial to trial on Day 1. At the end of the practice session on Day 1 participants were asked to choose the attentional focus that was best for them, and asked to use only their preferred attentional focus on the second day of practice. No instructions were given during retention on day three. In Experiment 2, additional practice was given such that participants were free to switch their attentional focus on the first two days. However, in the retention test on day three, they were asked to use only their preferred focus.

Wulf, Shea, and Park's (2001) results showed that the two experiments supported the notion that the benefits of an external attentional focus are a general phenomenon. In both experiments, participants who adopted an external focus of attention showed a better balance performance in retention than those with an internal focus. They also found that participants seem to be sensitive to the effectiveness of different attentional focuses. In each experiment more participants chose the external strategy as their preferred style.

Wulf, Shea, and Park (2001) suggest that their research shows that regardless of whether participants are allocated to attentional focus groups or allowed to choose their focus condition, an external strategy is always beneficial. Furthermore, they suggest that the notion of individual differences playing a significant role in the effectiveness of attentional focus should be discounted. These are grand statements, which would go against research in other areas of attentional focus research. However, in line with Wulf et al's findings they are correct. More current research discussed later will shed light onto possible flexibility in the use of attentional focus.

In both of Wulf, Shea, and Park (2001) experiments, small sample sizes limit the analysis of preference differences (Of the 17 participants in Experiment 1, 10 participants chose an internal focus while 7 chose an external focus. Of the 20 participants in Experiment 2, 16 chose an external focus and only 4 chose an internal focus). Furthermore, in Wulf et al. participants were encouraged to switch their attentional focus several times at will during practice trials. But if, as Wulf et al. go on to conclude, time is a critical factor in the ability of participants to choose an external focus over an internal focus, then the amount of time a participant spends using a specific strategy should be controlled. A further issue that Wulf, Shea, and Park (2001) research highlights but does not address is the effects of using a combined practice programme of internal and external instructions. In the practice sessions of Wulf et al's study participants used both strategies then used their preferred style. However, if a combined practice session where time using each strategy was controlled were top be employed, how would this affect preference and performance? In addition what affects would practising with one attentional focusing strategy have on performing using another? The concept of preference requires further research to establish whether the effects of attentional focusing instructions are general phenomena or are limited to certain individuals.

Attentional Focus Predispositions

As with possible individual differences in preferences for attentional focusing instructions, it has been suggested that some individuals may be predisposed to certain types of focus. If one attentional focus is more advantageous than another, it would be logical to presume that individuals would automatically adopt this optimal focus. It may be that instruction disturbs this natural allocation of attention. However, research would suggest that this is not the case. When no-instruction or control conditions have been included in experimental designs (e.g., Wulf & McNevin, 2003; Wulf et al., 1998, Experiment 1; Wulf & McNevin, 2003; Wulf, Weigelt, Poulter, & McNevin, 2003) participants' performance is typically similar to that seen under internal focus conditions and less effective than external focus conditions. This would suggest that when participants are not given any specific attentional direction, they are likely to choose a lower level of control. Wulf et al. (2004) suggest that reasons for this might be that people are inclined to be relatively cautious when confronted with novel and complex motor tasks, especially those involving balance. This predisposition towards an internal focus of attention is problematic, it will lead to poorer motor control and possibly a further reliance on an internal focus as the task progresses.

Wulf, Watcher, and Wortmann (2003) addressed possible gender differences in the effectiveness of attentional focusing instructions. The authors proposed that males might have a more "natural" tendency to focus more on the outcome of their movements (i.e. adopt an external focus) than on actual movements, whereas females might be more concerned with performing the movement correctly (i.e. adopt an internal focus). This possible difference was suggested to be due to differences in socialisation and/or skill-specific experience. The hypothesis therefore was that females might benefit from external-focus instructions to a greater extent than males would.

Using a soccer instep kick task, male and female participants received instructions which either directed their attention internally or externally. Results indicated that females who received internal instructions during practice showed greater performance decrements from retention to transfer than all other groups. Wulf et al. (2003) conclude that type of attentional instructions might affect females more than males. What their research does not show however, is that females naturally adopt an internal focus of attention in the first place. It may well be that the internal focus was more detrimental to females as it was *less*, rather than more, natural. Wulf et al. acknowledge the fact that future research needs to address directly the experience and preferences of individuals towards different attentional foci.

One such direct attempt at addressing individuals' predisposition towards an internal focus of attention was conducted by Masters et al. (1993). Masters et al. hypothesised that individuals may have a predisposition for the 'reinvestment' of controlled processing, which will lead to skill failure under stress as a result of disruption of the automatic functioning of the skill. Such was the strength of such predispositions, Masters et al. proposed, that it may be a dimension of personality, with some individuals having a greater or lesser predisposition than others to reinvest actions and percepts with attention. To explore this concept the Reinvestment Scale was constructed to assess personality factors linked to an individual's predisposition to focus attention inwards on the mechanics of the movements. The Reinvestment Scale consisted of twenty items borrowed from the Cognitive Failures Questionnaire (CFQ) (Broadbent, Cooper, FitzGerald, & Parkes, 1982), the 'Rehersal' factor of the Emotional Control Questionnaire (Roger & Nesshoever, 1987) and the Self-Consciousness Scale (Fenigstein, Scheier, & Buss, 1975). In Masters' (1992) study it was found that the CFQ tended to predict failure of a putting skill under pressure. The CFQ assesses the tendency to have 'slips of action' - occasions on which one's actions "do not proceed in accordance with intention" (Broadbent et al., 1982, p.1).

Other research has suggested that individuals may not be predisposed towards an internal focus of attention. For instance, when assessing the effectiveness of their non-awareness strategy in the acquisition of a sport task (a tennis serve), Bouchard and Singer (1998) suggested that participants in the control condition adopted similar strategies to that emphasised in their strategy. They concluded that leaving participants to their own devices may be as beneficial to learning as providing some sort of explicit instruction (beyond making the task requirements clear) to a person. Clearly, research needs to address what predispositions are present and in which situations they are apparent.

Changes in self-focused attention over time

Liao and Masters (2002) followed 21 university students from both male and female hockey teams up to and after important matches (both teams had reached the semi-final stages of the British Universities Sports Association National Competition) and measured levels of stress and self-focused attention using questionnaires to assess natural fluctuations in stress and self-focused attention. The competitive state anxiety inventory (CSAI-2, Martens, Vealey, & Burton, 1990) and The Private Self-Consciousness (PSC) subscale of the Self-Consciousness scale (Fenigstein et al., 1975) were used to measure state anxiety and self-focused attention 2 days before, 1 hour before, and 2 days after the match. Anxiety and self-focused attention increased prior to the match and decreased dramatically afterwards, suggesting a significant effect of psychological stress on self-focused attention. After further examination of their data, Liao and Masters suggest that Somatic anxiety, which represents perceived physiological activation, appears to have a straightforward relationship with self-focused attention. Their findings are consistent with those of Wegner and Guiliano, (1980, 1983), which demonstrated that a higher level of physical arousal, evoked by physical activities, led to a higher level of self-focused attention.

Liao and Masters (2002) suggest that cognitive anxiety, on the other hand, has a more complicated relationship with self-focused attention. Using McGrath's (1970) process model of stress and Carver and Scheier (1981)'s self-regulation model of self-focused attention, they suggested that an impending stressful event induces a process in which the demand of the event is compared to one's own response capabilities, which requires a high level of self-focused attention. However, when the stress is perceived as too demanding (cognitive anxiety is getting too high), they suggested the self-regulation process will be avoided and the self-focused attention will consequently abate.

Singer's Five Step Approach

Singer and colleagues have conducted research attempting to address the effects of attentional focus on motor learning and performance. Once again this was by attempting to focus attention away from movement mechanics (internal focus) through externally focused instructions. For example, Singer et al. (1993) had participants practice a ball-throwing task under different learning strategies. They found that "nonawareness" strategies that learners used in performing that task without consciously attending to its movement pattern produced more effective performance during acquisition and in a dual-task transfer situation than an "awareness" strategy that required learners to consciously attend to their movements. Recently Radlo, Steinberg, Singer, Barba, and Melnikov (2002) instructed participants to focus their attention towards their movements (internal focus) or onto the target (external focus) during a dart throwing task. They found that participants using the external strategy performed better than the internal group. Based on findings like these, Singer developed an effective strategy for the performance and learning of motor skills. Where Singer's research differs from Wulf et al. is by using a more flexible approach to the role of attentional focus during performance. Indeed, Singer's main concern was that awareness should not be avoided fully, and that a combination strategy might be effective.

Singer's research advocates, similarly to Wulf et al., a "just do it" approach (a sports shoe commercial slogan with probably unintended relevance). Singer suggests that students will be more likely to perform and learn successfully if they keep their mind clearly focused on the desired outcome, and developed the Five-Step Approach to motor learning (Singer, Flora, & Abourezk, 1989; Singer & Suwanthada, 1986). Principally, the Five-Step Approach was developed to balance both awareness and non-awareness strategies to enhance the acquisition and performance of complex skills. Where the five-step approach differs from Wulf et al's approach is that Singer's Five-Step approach aims to "balance" awareness and non-awareness strategies to enhance the acquisition and performance of complex skills. Because attempting to perform a movement skill as if it were automatic did not appear to be tenable for beginners, Singer developed his Five-Step Approach as a compromise between 'awareness' and 'nonawareness' strategies. Singer's Five-Step approach is summarized in Table 1.1.

Table 1.1: Singer's Five-Step Approach

1. Readying	(mental and physical)
2. Imaging	(mental pictures of successful performance)
3. Focusing	(attending to one cue in the skill – e.g., the target, or the seams on a baseball – and blocking out all other thoughts)
4. Executing	(performing the movement as if it were automatic, i.e., without thinking about it or thinking about the outcome)
5. Evaluating	(analysing the outcome and planning for any needed changes on subsequent trials)

Singer's Five-Step Approach emphasised awareness of the movement and desired outcome before execution (Steps 1 and 2). In agreement with Wulf et al., attention is focused onto external cues for movement execution to prevent the performer from focusing on what he or she is doing (Step 3) to keep performers from attending to their own movements during skill execution (Step 4). The process is complete with Step 5 (evaluation), which allows for conscious error correction before the student's next movement attempt, a type of self-regulating stage. Here we can see that an awareness strategy is advocated, but that this is prior to and after movement initiation rather than during it. For movement execution a clear and focused mind is emphasised, similar but not identical to Wulf et al.'s suggestions for an external focus during performance.

Singer and colleagues have examined the effectiveness of the Five-Step Approach compared to more traditional 'awareness' strategies (where the participant is instructed to think about their performance and be aware of their movements), 'nonawareness' strategies (where participants were instructed to focus on a relevant cue), and control conditions that received no additional attentional focus direction. In a simple motor study Singer et al. (1994) demonstrated the superiority of the five-step strategy to these conditions in dual-task transfer for a sequential key-pressing task. Singer et al. (1993)

using a ball-throwing task, found similar performance and learning benefits for participants using a non-awareness strategy or the Five-Step strategy, while both groups were more effective than the awareness and control groups. Similarly, using ball-throwing and dart-throwing tasks, Lidor, Tennant, and Singer (1996) found more effective transfer to the task that was not practised (dart-throwing or ball-throwing respectively), when participants were instructed to use the Five-Step Approach relative to one of the other strategies or to no strategy. However, a study by Bouchard and Singer (1998) looking at the acquisition of a tennis serve failed to show advantages of the 5-step strategy over a control condition.

Along with the proposals of Wulf et al., these findings suggest that instructing participants to focus on the details of their movements can be detrimental to both performance and learning whereas an external focus is beneficial. Singer has concluded that when learners are taught with the Five-Step Approach, they exhibited faster skill development with fewer errors than the control-group students, who used traditional awareness strategies during execution.

The Five-Step Approach has been documented as an effective means to learn self-paced tasks (e.g., Singer, Flora, & Abourezk, 1989) and to transfer to related tasks (Singer, Defrancesco, & Randall, 1989; Singer & Suwanthada, 1986). However there are drawbacks. As noted by Singer, Lidor and Cauraugh (1993), the Five-Step Approach appears to be more elaborate, more time consuming to teach, and more difficult to comprehend completely as compared to separate awareness and non-awareness strategies. Consequently, there are disadvantages and advantages to the different approaches to using expert-like strategies during learning.

A limitation of Singer's Five-Step Approach has been indicated by Wulf et al. (2000) They state that due to its specific step-by-step nature its use is limited to closed, self-paced skills. Alternatively, Wulf's external strategy of focusing attention onto the effects of one's movement is not restricted to a certain type of skill, as it requires focusing upon factors that are immediately within the performance at hand. That is, it can be used for closed or open skills and for self-paced skills a well as those for which the timing is determined by environmental factors (Wulf et al.).

Combining Approaches to Attentional Focus and Movement Research

Singer's more flexible approach to the role of attention during skill execution and learning is attractive, and less restrictive than Wulf et al's one-focus-fits-all approach. However, Singer's non-awareness during performance (Step 4) seems limited when compared to the more complex consideration of attentional focus during performance by Wulf et al. Singer emphasises to simply focus on simple external cues, where the main aim is to stop the performer focusing on movement mechanics. However, Wulf et al. advocate the focusing upon desired movement outcomes, an approach which has both a theoretical basis (e.g., Prinz, 1997) and research evidence (e.g., Wulf et al, 2000). Recognising this, Byers (2000) suggested a (as yet untested) combination of the two schools of research to create a modified five-step approach.

Byers (2000) suggests that if Singer's step 3 (concentrating on a relevant cue) is replaced with Wulf's external focus (concentrating on desired movement outcome), and if Singer's non-awareness strategy (Step 4) is re-thought as a "just do it" mentality, a modified Five-Step Approach is developed (see Table 1.2). This approach still allows for an evaluative internal focus during step 5 where an analysis of the outcome and planning for any needed changes in movements can be carried out. The advantage of the Five-Step Approach over non-awareness strategies may simply be that it advocates a more complete mental approach to movement execution, with not only the appropriate mental states during performance being emphasised, but also those before and after.

Combining Singer's and Wulf's conceptualisations of attentional focus during performance may produce a useful area of research as both seem to offer benefits to the performer and learner and both seem easily compatible.

Table 1.2: Byers (2000) Modified Five-Step Approach

1. Readying	(mental and physical)
2. Imaging	(mental pictures of successful performance)
3. Focusing	*(maintain an external focus of attention – e.g., on the intended outcome of the shot)*
4. Executing	("Just Do It!" Have complete trust in your ability and allow unconscious control to take over)
5. Evaluating	(analysing the outcome and planning for any needed changes on subsequent trials)

One study has attempted to address the discrepancies between Wulf et al. and Singer et al's advocated focus during motor execution. Wulf et al. (2000) were interested in whether it is critical and more advantageous to focus on the movement effects, as suggested by Wulf et al., or whether it is sufficient not to focus on one's movements (and on some other cue instead), as implied by Singer and colleagues. Using novice tennis players, Wulf et al. (2000 Experiment 1) found that participants instructed to focus on the arc of a return ball that they hit (the effects of their movement) demonstrated better retention performance than a group instructed to focus on the approaching ball that they were to hit (antecedent). From these findings Wulf et al. concluded that the difference in learning between participants who focused on events preceding the action or events following from it suggests the critical issue was not the external focus per se, but that attention was directed to the effect of the action. Confounding this conclusion however, is a simple difference in instructional focus. Whereas Singer directs attention to external target stimuli rather than events, rarely is attention directed to external stimuli that precede the action, as is the case in Wulf et al. So the comparison may not be totally effective. Wulf et al. suggest that all participants were aware of the fact that the goal was to hit the target and that their performance would be evaluated on the basis of ball placement accuracy. However, it seems possible that the instructions are still confounded as those who were focusing upon the intended trajectory would be pre-planning this movement, whereas those focusing upon the incoming trajectory would have fewer resources to pre-plan their movement.

In Wulf et al's (2000) Experiment 2, novice golf players hit golf balls towards a target. Here participants who focused on the motion of the club were clearly more effective in hitting the target than those who focused on hitting the target. Wulf et al. suggested that focusing upon the club motion might develop a better technique, which in turn resulted in more accurate performance. Furthermore, at least for novices, effect-related instructions might induce improvements in the technique through diminished cognitive intervention or facilitated self-organisation of different movement systems and might, therefore, be a more effective training strategy (Wulf et al.). This experiment does provide a more valuable comparison between Wulf et al's and Singer et al's use of external focus. It seems that Wulf's more complex definition of the external focus is more effective, but more research needs to address this issue.

Recent research by Wulf and McNevin (2003) was concerned with the relative effectiveness of preventing learners from focusing on their movements by having them perform an attention demanding task (e.g., Masters, 1993) versus instructing them to focus on the movement effects (an external focus). Participants were instructed to balance on a stabilometer by keeping the platform (which limited movement to the sagittal plane) horizontal for as long as possible during a 90s trial. To prevent learners from focusing upon their actions, one group continuously shadowed (repeated out loud) a story presented to them while engaged in the primary task of balancing. The external focus group were instructed to focus on keeping markers attached to the stabilometer platform horizontal, whereas the internal focus group were instructed to focus on keeping their feet horizontal. The internal and external focus instructions were based upon those used successfully in previous research by Wulf and colleagues in balance studies (e.g., Shea & Wulf, 1999; Wulf, Hoss, & Prinz, 1998; Wulf, Shea, & Park, 2001). Results showed that the external group was more effective than the shadowing group during both practice and retention. Wulf and McNevin state that this suggests there were no "hidden" learning benefits of having to learn whilst distracted. There is, however, an advantage of focusing attention towards movement effects. The external focus was also beneficial when compared to the internal and control groups. The results were further at odds with the predictions of Masters (1993) in that the shadowing group was not more effective than the internal strategy or the control group. These findings demonstrate that the advantage of an external focus of attention is simply due to attention being directed away from bodily movements. Focusing on the movement outcome seems to have the advantage over simple distraction techniques as it directs a performer's attention to the primary task while allowing automatic control processes to regulate, effectively and efficiently, the movement required to achieve the outcome (Wulf & McNevin, p. 11).

Theoretical Explanations for Attentional Focus Effects on Performance and Learning

Wulf and colleagues' growing body of research has demonstrated consistently that instructions or feedback that direct the performer's attention to the effects that her or his movements have on the environment (an external focus) leads to more effective performance and learning than directing attention to the movements themselves (an internal focus). Critically, external focus benefits have not only been found relative to internal focus conditions, but also relative to control conditions (although studies with control conditions are few, and more are needed to develop the discussion in this area). Initially, Shea and Wulf (1999) suggested that the exact reasons and underlying mechanisms for the beneficial effects of an external, relative to an internal, focus of attention were unclear. However, research has attempted to address the possible mechanisms associated with the observed effects.

Wulf and colleagues (e.g., Wulf et al., 2003; Wulf, McNevin & Shea, 2001; Wulf & Prinz, 2001) suggest that the advantage of focusing attention on the movement effect might be that it allows unconscious or automatic processes to control the movement required to achieve this effect. Whereas, Wulf, McNevin and Shea (2001) argue, when performers utilize an internal focus of attention they tend to interfere with these automatic control processes that would normally regulate movement. Indeed, McNevin et al. (2003) acknowledge that it has long been known that when individuals attempt to consciously control their movements, the result is often a more awkward movement pattern than when one does not attempt to intervene (e.g., Bliss, 1892-1893; Boder, 1935; Gallwey, 1982; Schneider & Fisk, 1983).

This "constrained action" hypothesis has been used to explain the detrimental effects of an internal focus upon motor execution, and research and the kinematic characteristics of movement have supported it. In their review, Wulf and Prinz (2001) highlight research showing that different attentional foci seem to be associated with different motor control processes, which presumably are responsible for the observed performance and learning differences. They propose that participants using an internal focus are inadvertently disrupting relatively automatic processes that normally control movement. In discussing their findings, McNevin et al. (2003) suggest that the increases in small amplitude, high frequency postural adjustments superimposed on large amplitude, slow frequency adjustments might, at first, seem to merely reflect an increase in random noise in the motor system, but in fact offer a valuable clue to the effects of different attentional focuses. A number of researchers, (e.g., Newell & Slifkin, 1996) have characterised increases in response frequency as an increase in the number of active degrees of freedom. Research looking at the Fast Fourier Transformation (FFT) analysis of finger or hand tremor of motor systems that are compromised by disease or aging (e.g., Gantert, Honerkamp, & Timmer, 1992; Newell, Gao, & Sprague, 1995) or for balance when inputs (e.g., vision) into the vestibular-occular system have been perturbed (e.g., Gurfinkel, Ivanenko, Levik, & Babakova, 1995), shows that the frequency of hand and finger tremor decreases while the amplitude increases. When the system is not compromised, hand and finger tremor is almost imperceptible because driving frequency is relatively high.

Supporting this, further analysis of McNevin et al.'s (2003) results determined that the FFT characteristics of platform movements during a balance task demonstrated higher frequency adjustments for external versus internal focus participants. McNevin, et al. state that higher frequency components seem to represent deterministic processes characterizing the incorporation and coordination of additional available degrees of freedom - a characteristic associated with higher skilled performance. Compromised systems on the other hand exhibit lower frequency components. Therefore, the superior performance under external focus instructions may reflect a system in which the coupling between agonist and antagonist muscles is assumed to be more effective due to coherence between sensory input (originating from the cerebellar system) (e.g., McAuley & Marsden, 2000).

In McNevin et al's (2003) study assessing different distances of external focus of attention, results show that both near and far externally focus groups made more and smaller corrections in maintaining their balance on the platform than the group focusing internally (markers close to their feet). More specifically, the external groups exhibited higher frequency and lower amplitude movements than did the internal group.

Therefore, this is taken as evidence that active intervention in control processes constrains or compromises the neurological degrees of freedom associated with maintaining balance. Such frequency components are similar to those identified in constrained or compromised perceptual-motor systems.

Lee, Chamberlin, and Hodges (2001) highlight one theoretical account that is in line with the attentional focus research findings is that of Latash (1993, 1996). Latash proposed that the control focus of a performer in a movement task is directed towards the end-point of the action, what has been referred to as the *working end-point*. This has been defined as the most important point for executing a task and may include such working end-points as the fingertips in grasping or the trajectory of a basketball free throw (see Latash, 1993). In comparison to other points that are involved in the movement, the working point demonstrates the greatest invariance across trials. This proposal leads to the suggestion that control strategies are somehow related to the working point, not with the details of the rest of the motor system (e.g., attending to limb positions or the actual movement).

The theory and research associated with the detrimental effects of an internal focus are well established, indeed it is now well known that conscious control of movement results in more awkward movement patterns. However, why an external focus of attention should offer benefits over and above simply not thinking about your movements has presented researchers with a theoretical void to fill. "Common Coding" theory proposed by Prinz (1990, 1997) has been used to provide a theoretical explanation for the advantages of focusing on the effects of one's movements, rather than on the movements themselves. Prinz argued that perception and action require a common representational medium, efferent and afferent codes are stored in the form of distal events. In summary, action planning and perception typically involved "distal events", as this is the only format that allows for commensurate coding and thus for efficient planning of action. Therefore, actions should be more effective if they are planned in terms of their intended outcomes, rather than in terms of the specific movement patterns. Furthermore, focusing on the intended effects (distal event) of one's movements promotes the use of automatic control processes and allows the motor system to self-organise more naturally (Totsika & Wulf, 2003).

Prinz's work represents a combining of previous research by Lotze (1852) and James (1890). James classically illustrates the effectiveness of movements being planned in respect to their remote effects rather then the close effects associated with it (e.g., kinaesthetic feedback) in the following quote: "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). Lotze's work preceded this, suggesting that the execution of body movements are always tightly coupled to representations of their effects. James summed up these ideas in the ideomotor principle of human action: "Every representation of a movement awakens in some degree the actual movement which is its object; and awakens it in a maximum degree whenever it is not kept from doing so by an antagonistic representation present simultaniously in the mind" (p. 526). Similarly, Requin has stated that what is most conscious is the stored representation or online perception of the changes that a movement introduces in the outside world and, perhaps what it feels like during its execution (Requin, 1992).

The regular links between motor acts and perceivable bodily and environmental events can be used and exploited in two ways. The first leads from actions to effects (e.g., in predicting or expecting an ongoing actions consequences). The second leads in reverse from effects to actions (e.g., in selecting and initiating a certain act on the basis of an intention to achieve certain effects) (Wulf & Prinz., 2001). The reverse relationship linking the intended effect to its action is the functional basis of the *ideomotor principle*. Any representation of an event of which we know from previous learning that it either accompanies or follows from a particular action will hereafter have the power to call forth the action that produces the event (Wulf & Prinz).

Prinz's common coding theory of perception and action (Prinz, 1990, 1997) is in contrast to traditional views, which assume that there are different and incommensurate coding systems for afferent and efferent information (e.g., Massaro, 1990; Sanders, 1980; Welford, 1968). Prinz argues for a common representational medium for perception and action. In their proposal Wulf and Prinz (2001) indicate that perception and action planning both refer to distal events, since this is the only format that allows for commensurate coding and, thus, for planning of actions in a format shared with perception. Therefore, in relation to an internal or external focus, actions should be more effective if they are planned in terms of their intended outcome, rather than in terms of the specific movement patterns. However, as common coding theory is relatively abstract, Wulf and Prinz suggest that it does not specifically predict the differential learning effects of external versus internal attentional foci. Therefore, two principles that may account for the influence that this factor has on the effectiveness of the attentional focus were suggested.

The first principle is that the effect that the performer focuses on should be as remote as possible, but still allowing the performer to relate the effect to the associated movements. This first principle is based on the findings of McNevin et al. (2003) discussed earlier, which showed that learning is enhanced if the distance of the external attentional focus is increased away from the movements that are producing it. It is suggested that increased remoteness of the external cue on which attention is directed facilitates the discriminability of the effect from the bodily movements being produced. This suggestion is supported by McNevin et al.'s (2003) conclusions that one critical factor underlying the advantages of an external focus is the distance between the action and its effect. Their findings demonstrated that when instructed to focus on proximal effects (close to the body), the regulation of control processes involved in maintaining balance are constrained, resulting in performance and learning detriment. Increasing the distance of the effects from the movement producing it allows performance to be mediated by automatic control processes.

The second principle appears to be in direct conflict with the achievement of the first principle, suggests that focusing on the less remote effect (e.g., motion of the golf club) can be more effective than focusing on a more remote effect (trajectory of the golf ball). This is based on the findings relating to limits of the distance of attentional focus discussed earlier. For example, Wulf et al. (2000, Experiment 2) demonstrated that focusing on the less remote effect of the motion of a golf club produced more effective performance in golf than focusing upon the more remote effect of the trajectory of the ball which was hit. The more remote effects, such as the trajectory of the golf ball, cannot be directly related to the body movements that produced it. The focus is too distant as there is no direct relationship between a given trajectory and a particular movement pattern. Specifically, the further the external focus is directed, the larger the possible movements that could potentially produce the effect. This undoubtedly causes problems if a specific motor execution pattern is needed. When attention is directed to a less remote effect, such as the movement of the golf club, the effect can be associated more easily with the motor commands that caused the club motion (Wulf & Prinz, 2001) and the focus is at a more appropriate point. Wulf and Prinz conclude that the most effective attentional focus appears to be one that represents a compromise between the two principles outlined above, with an optimal focus being directed to an effect that is as remote as possible but can still be related to the movements that caused it.

Further Advantages of an External Focus of Attention

Wulf and colleagues suggest that an external focus of attention reduces cognitive load by taking advantage of self-organising capabilities of the neuromotor system. Research by Wulf, McNevin and Shea (2001) supports this view by demonstrating that an external focus promotes the utilisation of more automatic control processes. In their study, participants balanced on a stabilometer whilst using either external or internal focus instructions. During the balancing task, probe reaction times (RTs) were taken as a measure of the attentional demands required. Participants using an external focus demonstrated shorter probe RTs than internal focus participants, indicating reduced attentional demands associated with an external focus and providing additional support for the constrained-action hypothesis.

Psychophysiology of Attentional Focus

The collection of psychophysiological measures during real-time performance and relating them to underlying nervous system processes, which can be related in turn to mental states (Lawton, Hung, Saarela, & Hatfield, 1998) has provided some valuable insight into attentional mechanisms during movement. Hatfield and Hillman (2001) suggest that the power of psychophysiological methods lies not only in that they are unobtrusive, but that they provide an unbiased, objective index of psychological processes. In line with this McNevin and Wulf (2002) suggested that future studies should examine more directly – e.g., by using electromyographic, kinematic, or kinetic analysis – how the focus of attention affects the control of body parts attended to, as well as those of other parts of the body. Indeed, Lawton et al. state that research must explain performance processes and outcomes and relate these to the psychophysiological processes observed. Such research would address the concerns of Collins (2002) who indicates that studies in "mainstream" psychophysiology, whilst addressing topics relevant to sport, can seem to esoteric and scholarly for those more interested in application.

Electrocortical activity

Electrocortical activity measured by electroencephalogram (EEG) has provided useful research regarding mental states and performance, with much of it centring around hemispheric differences. Abernethy (2001) suggests that the key abilities of *shifting*, *disengaging* and *engaging* of attention are associated with specific brain areas. Disengagement of attention from a stimulus appears to involve the parietal lobe primarily, shifting attention appears to involve the midbrain, and the pulvinar nucleus appears to be centrally involved in the pick-up information from a particular location. Abernethy states that the evidence to date is certainly sufficient to demonstrate that selective attention is a distributed function involving many numerous functionally specific structures.

Hatfield, Landers, and Ray (1984, 1987) investigated the cortical processes of world-class marksmen as they aimed at a target. They found that alpha EEG power measured at the left hemispheric temporal site T3 showed a marked increase across the 7.5-s interval before a shot, while increasing only slightly at the corresponding right-side site T4, indicating a decrease in left-hemisphere activation. Hatfield et al. suggest that this increase in alpha activity on the left side of the brain, and continued activation on the right side of the brain in experienced shooters just prior to firing, indicated a reduction in excessive self-instruction and covert verbalisations and a shift to an external attentional focus. Increased electrical activity in the left hemisphere (location of Broca's and Wernicke's areas) appears to be reflective of the analytical-verbal type of processing suggested by an internal focus, whereas increased levels in the right hemisphere are more prominent in the spatial-type tasks suggested by an external focus (Ray & Cole, 1985).

Lawton et al. (1998) state that this interpretation is generally compatible with the description of optimal performance states presented by Williams and Krane (1993), especially the "thoughtless" and "selfless" elements. Although it would appear, on one level, that an athlete thought about "nothing" during a given performance (i.e., analytical processing), activation of visual-spatial systems is apparently considerable (Hatfield & Hillman, 2001). Therefore a more accurate explanation would be that the athlete was not aware of any thought processes.

Furthermore, evidence from outside Sport Psychology research by Cooper, Croft, Dominey, Burgess, and Gruzelier (2003) suggest that in situations or tasks where attentional demands require inhibition of non-task relevant areas or processes, one would expect to find increased alpha activity. They suggest that increased alpha activity is not a simple index of cortical idling, but that it is a measure of active processing necessary for internally driven mental operations. These findings can be applied to the concept of attentional focus, in that an external focus may not only require directing attention to appropriate external stimuli through effective cortical activation, but athletes must also actively inhibit unnecessary information processing (as reflected by an increase in alpha power), such as movement-related information.

Further research by Landers et al. (1994) looked at the relationship between electrocortical activity and attentional focus during stages of learning archery. Landers et al. found that at the start of learning archers produced equal amounts of alpha across both left and right hemispheres. However, as the task became better learned, an increase in alpha activity was evident in the left hemisphere, supporting the earlier findings of Hatfield et al. (1984, 1987). The hemispheric asymmetry appeared during the preparatory period just before execution (<5s). Deliberate practice and effort over an extended period of time can fundamentally alter and specifically shape the involved neural processes (Bell & Fox, 1996; Smith, McEvoy, & Gevins, 1999). In light of the beneficial effects of an external attentional focus during motor learning demonstrated by

Wulf et al. (e.g., Wulf & Prinz, 2001), research needs to address the cortical changes that may take place using different attentional focusing instructions.

In the only study to date to assess cortical activity during different attentional states induced through instruction, Radlo et al. (2002) assessed the influence of attentional focusing strategies on novice dart throwing performance and EEG alpha power. Novices using an external strategy performed significantly more accurately than those using an internal strategy and displayed a significantly greater decrease in left hemisphere alpha activity. This does not support the increased left hemisphere alpha activity observed by Hatfield et al. (1984, 1987). However, it does support the findings of Landers, et al. (1994) who showed that increased alpha activity in archers was associated with poorer performance whilst decreased alpha activity resulted in more accurate performance. Additionally, Salazar et al. (1990) found that too great an increase in the alpha band resulted in poorer performance. The authors suggested that it is possible that findings regarding hemisphericity may be different due to alternative sites being used. Furthermore, EEG is multiply determined and one cannot expect to identify a specific psychological state based on EEG signature taken by itself (Lawton et al., 1998).

Smid et al. (2004) addressed movement-related attention in proprioception, which has provided important information regarding peoples' ability to adopt an internal focus of attention. Smid et al. asked whether people who are forced to focus on their own movements have more sensitive movement awareness and assessed event-related potentials (ERPs) during hard-to-detect or easy-to-detect passive movements of the knee joint which were either attended or unattended to. Results demonstrate that attention-related activity to movement is differentially distributed anatomically and can vary in activation level and that an attention-dependent ERP effect seems to concern focusing of attention to movement. These findings show that if people voluntarily focus their attention to the afferent information of their movements (an internal focus) they can have good movement awareness. Smid et al. suggest that there may be multiple levels of awareness associated with movement perception and by identifying specific brain regions involved during an internal focus, Smid et al. are supporting the ability to activate and suppress specific functions. In conclusion, if athletes could be trained to activate appropriate areas of their brain through methods such as biofeedback, a more effective attentional focus may be the result.

Heart Rate

Heart rate (HR) is one of the simplest biological parameters to measure, and can provide unequivocal information on neurogenic mechanisms as the brain is intimately interconnected with the autonomic nervous system. This interrelationship has been extensively examined during psychomotor performance (Hatfield & Hillman, 2001). For example, Landers, Chrisrina, Hatfield, Daniels, and Doyle (1980) revealed that elite marksmen unconsciously fired their shots between heartbeats, an effect not found for less-experienced shooters. Heart rate is perhaps the most commonly used index in sport psychophysiology, and research has generally demonstrated that HR deceleration is a sign of effective preparation for a task.

Much of the research into attentional influences on heart rate have developed from early work by Lacey (1967). Lacey's 'Intake Rejection' hypothesis proposes that when a task is being performed that requires an external attentional focus, a deceleration in HR and less cortical activity will occur immediately before motor initiation. Likewise, when a task requires an internal attentional focus, HR acceleration and greater cortical activity will be evident at that time.

Cardiac changes have been measured as athletes prepare and perform sports skills. For example, Landers, Boutcher, and Wang (1986) and Helin, Sihvonen, and Hanninen

(1987) reported that heart rate decreased in the period preceding the arrow release in archery and the trigger pull in gunshooting, respectively. Konttinen and Lyytinen (1992) also found cardiac deceleration and this may be interpreted as support for the Lacey Intake Rejection hypothesis that HR deceleration occurs during attentional anticipation of an external event. Boutcher and Zinnser (1990) found that collegiate golfers had lower heart rates than novice golfers immediately before and after 12-foot putts. Post-task interviews revealed that 86% of the collegiate golfers, but only 10% of beginner golfers, used a non-analytical attentional strategy. Boutcher and Zinsser suggested that cardiac deceleration in self-paced skills may be related to having a non-analytical or kinaesthetic attentional focus. Stern (1976) found that participant waiting to sprint up a flight of stairs or on an ergometer exhibited HR acceleration following the 'get-set', signal and a deceleration immediately prior to 'go'.

When considering HR during motor activity however, care must be taken in interpreting any data. Collins (2002) indicates that getting ready for a major muscular effort will require considerable physical preparation and it is likely that the general "geeing up" of the system that takes place will mask or confound more subtle changes, such as those due to an increased mental focus. Lacey's (1967) distinction between environmental intake and rejection would explain HR deceleration during the preparatory period in shooting as being caused by the shooters' attention being directed *outwards* – focusing not only on the visual target but also on the best way to stabilise and align the gun (Konttinen & Lyytinen, 1992). Two alternative theories discuss heart rate deceleration as part of the beneficial effects of an external focus. Coles (1984) believes it mainly affects motor readiness, while Obrist (1968) suggests that it is a result of decreased muscle tension and metabolic rate. Specifically, Obrist et al's (1974) cardiac coupling hypothesis suggests that HR deceleration is a concomitant to motor quietening associated with a more internal focus. Such quietening, however, is in contrast to the definition of the detrimental effects an internal focus would have on the motor system proposed by researchers such Wulf and colleagues, and Singer.

In Radlo, et al's (2002) study, novice dart throwers using external focus instructions experienced a HR deceleration immediately prior to dart release and performed with less eroor, while those using the internal strategy showed a HR increase. Additionally, when the 4 best and worst throws were compared the best shots had significantly decelerated HR in the two epochs leading immediately before each throw. However, Radlo et al. state that Lacey's intake-rejection hypothesis needs to be substantiated more in other research in order for it to be plausible as explaining a factor related to achievement in sport situations.

Electromyography

Vance, Wulf, Töllner, McNevin, and Mercer (2004) research is the first direct evidence for differential neuromuscular control mechanisms induced by different attentional foci. Using Electromyography (EMG) to measure the differences in electrical activity associated with muscle contractions Vance et al. hoped to support the Constrained Action Hypothesis proposed by Wulf and Prinz (e.g., 2001). Under the assumption that "automaticity" imparts greater economy in movement production, Vance et al. expected to see more discriminate motor unit recruitment under external than under internal for conditions. Participants performed bicep curls under both internal (focus upon their arms) and external (focus on the curl bar) focus conditions to examine the immediate effects of the type of attentional focus on performance. EMG activity of the biceps and triceps brachii muscles during the curls were measured. Integrated EMG (iEMG) activity, which reflects the combined influence of temporal (movement time) and spatial (EMG amplitude) characteristics of muscle activity, was also calculated. Movement times were not controlled in Experiment 1, and were generally executed with greater speed when participants were instructed to adopt an external focus. Whereas

Experiment 2 controlled movement time through the use of a metronome. In both experiments iEMG activity was reduced under external focus conditions. That iEMG activity was reduced under external conditions when movement time was controlled indicates that differences in movement time or velocity cannot account for these differences. There was also evidence that an external focus of attention was associated with more effective recruitment of motor units.

Additionally, Vance et al. (2004 Experiment 1) observed that not only did an external focus result in reduced iEMG activity of the biceps muscles (i.e., the agonist), it also caused reduced iEMG for the triceps muscles (i.e., the antagonist). To facilitate the effectiveness and efficiency of biceps activity, tricep activity should be as low as possible. That reduced triceps activity was achieved to a greater extent with an external than with an internal focus suggests that movement economy was enhanced, at least in part, through more effective coordination between agonist and antagonist muscle groups (Vance et al.). Movement economy can be increased through a more effective recruitment of muscle fibres within a muscle (intramuscle coordination; Hollman & Hettinger, 2000) or through enhanced coordination between muscles (intermuscular coordination; Hollmann & Hettinger).

Vance et al. (2004) point out that it is unclear whether the external focus instructions resulted in a reduction of muscular activity or whether the internal focus instructions led to an increase in activity, as compared with muscle activity in so-called normal conditions. The inclusion of a control condition in future research of this kind would help address this limitation. On the practical implications of their findings, Vance et al. suggest that in sports in which (maximum) forces have to be generated in a short period of time (e.g., shot put, discuss, power-lifting), focusing on the object that the force is being exerted upon may result in more effective performance than would focusing on the bodily movements that produce the action. The coordination within and between muscles is critical for the effectiveness and efficiency of performance of tasks that require force production (Hollmann & Hettinger, 2000). Therefore, it is suggested that an external focus can benefit force production skills.

Cowling, Steele, and McNair (2003) investigated the effects of different instructions upon movement and muscular activity during a landing movement. Their instructions directed participants' attention to either the angle of the knee bend or to activate muscular units involved in landing during a single legged landing task. Participants were not only unable to selectively recruit the hamstring muscles as requested, but in an attempt to do so, they altered their quadriceps muscle synchronisation in a manner that is suggested to impose a greater risk of injury. Cowling et al. concluded that simply asking participants to alter the manner in which they recruit their hamstring muscles, without any accompanying training on how to achieve this, was not beneficial in altering the muscle activity displayed during dynamic landing. This study demonstrates that muscular specific internal focus instructions during a dynamic movement produces inappropriate muscular activation and movements.

A dynamic approach to the role of attentional focus during motor performance

"The ability to concentrate on the activity pursued is a crucial condition of success, that is, the ability to maintain the mental focus and to shift it according to the changing mental environment" (Näätänen, 1992).

As we have seen, researchers like Wulf et al. and Singer et al. suggest that an external focus is seen to be the desired state for optimal performance and that an internal focus should be avoided at all costs. In light of the research carried out (the majority of this being by Wulf and colleagues) this seems a correct proposal. However, this seems to reflect a certain lack of flexibility in both the research and the conceptualisation of attentional focus. Nideffer (e.g., 1979) and Naatanen (1992) have suggested that a certain degree of attentional flexibility is needed for optimal performance. Researchers such as Wulf and Singer have provided a valuable framework and advancement in research on attentional focus. However, recently some researchers have emerged who have tried to advance the field to include a degree of flexibility and, importantly, to provide a role for the internal attentional focus. That this took so long is surprising, considering Masters (1992) suggested that perhaps skill-focused attention in experts should no longer be considered a negative trait that must be avoided at all costs. Furthermore, Moran (1996) suggested that there may also be different types of internal attentional focuses.

In one such study, Hodges and Franks (2000) did not find that instructions that directed attention towards the arms during learning in a bimanual coordination task were always detrimental to performance. The effects of instruction were dependent on how performance was assessed during practice (i.e., with or without feedback). Although the internal instruction group demonstrated more error at the start of practice, all instructions provided in addition to movement demonstration (regardless of attention focus) were beneficial to learning. This was particularly pronounced when learning was assessed in the absence of concurrent feedback, as compared to the performance of a demonstration-only group. It was proposed that these additional instructions served to direct attention onto other aspects required to perform the task, such as the processing of kinaesthetic feedback.

Previous research by Clingman and Hilliard (1990) explored the efficacy of different types of internal and external attentional focuses on race-walking performance. 'External focus' instructions emphasised paying attention to things which were unrelated to the walk such as the environmental features surrounding the track, not in line with the definitions of Wulf and colleagues. Internal focus instructions required participants to either focus on their stride length or their 'cadence' (i.e., speed of leg movement). When performers focused onto the cadence, they walked faster than when they focused on stride-length. Clingman and Hillard concluded that the advantage gained from an internal attentional focus is dependent upon what the athlete is attending to. This evidence demonstrates that detrimental effects of an internal focus in motor skill execution may not be as simple as first thought. For example, stride length and cadence are both related to an internal focus as they direct attention to the mechanics of walking. However, that one produces better performance than the other suggests that there may be different levels of the internal focus. It may be that focusing upon stride length is clearly an internal focus, whereas cadence seems to mix elements of both internal and external focuses. In a sport where limited information is available for an external focus point on environmental effects, cadence may offer the best external focus available for race walkers (and possibly other athletes such as runners). Wulf and Prinz (2001) suggested that there is an optimal distance that an external focus is both away from the intended effect to be distinguishable from performance mechanics, but also not too distant so that it loses all relevance to the movement. It may be possible that a similar range applies to the internal focus. Some types of internal focus that may be related to the performance but not to the actual mechanics of the performance, could be potentially beneficial particularly if no other external focus is available.

In a series of studies (Beilock & Carr, 2001; Beilock et al., 2002), Beilock and colleagues were primarily interested in the role the internal focus plays in the breakdown of skilled performance, with specific reference to choking under pressure. They found that well-learned golf putting does not require constant online control and that attention is free to process secondary task information. Additionally, directing experienced golfers to attend to a specific component of their swing produced less than optimal performance (Beilock, et al., 2002, Experiment 1). This, they suggest, is because the performers were attending to the step-by-step components of skill execution and so it is in line with the previous research by Wulf et al., Singer et al. and Masters.

However, Beilock, et al. (2002) point to researchers who suggest that close attentional monitoring and attentional control benefits novice performance in the initial stages of learning (Anderson, 1983; Fitts & Posner, 1967). They indicate that this has now been challenged by Wulf (e.g., 1998, 2000) and Singer (e.g., 1993), who both propose that attending to skill execution at the initial stages of learning may actually hinder performance. Therefore, Beilock et al. suggest, a controversy remains over the types of attentional mechanisms thought to support less experienced or less practised performance processes.

To investigate this, they assessed the attentional mechanisms supporting soccer dribbling performance at different levels of skill (Beilock et al., 2002, Experiment 2). They achieved this in two ways: first, skilled and novice individuals performed a soccer dribbling slalom task under a dual-task condition involving an auditory word-monitoring task (dual task condition) and a condition in which individuals were prompted to focus on a specific component of the dribbling task – the side of the foot that last made contact with the ball (skill-focused condition). Second, the effects of these attentional manipulations on dominant and non-dominant foot performance within soccer skill level were assessed. Beilock et al. utilised different methodology from the specific instruction-based approach of Wulf at al. and Singer et al. Whilst dribbling a ball through a slalom course, participants were instructed to verbalise the side of their foot that was currently in contact with the ball (i.e., inside or outside) when they heard a specific tone, ensuring a constant and relevant monitoring of the skill being produced.

For dominant-foot dribbling, novices performed worse at the dual-task condition (designed to distract attention from task performance), in comparison with the skill-focused manipulation (designed to draw attention toward the task at hand). Furthermore, novices substantially improved in dribbling speed from the single-task practice condition to the skill-focused condition. Experienced soccer players on the other hand exhibited the opposite effect, performing worse in the skill-focused condition compared with either the dual-task or practice condition. For non-dominant-foot dribbling, performance differed. Both novice and experienced soccer players performed better in the skill-focused condition than in the dual-task or practice condition. Furthermore, experienced performer's dominant- and non-dominant-foot dribbling speed in the practice differed in that non-dominant-foot dribbling skill was not at the same performance level as their dominant-foot skill. This finding was supported by Beilock, et al. (2002, Experiment 1) who demonstrated that skill-focused instructions during a golf-putting task disrupted expert golfers performance but a dual-task did not. Novice golfers on the other hand benefited from skill-focused attention. The fact that the differential impact of the attentional manipulations in the present study was evident not only between skill levels but within experienced performer's dominant and non-dominant feet performance speaks to the robust nature of the impact of attention on skill performance (Beilock et al.). The finding that focused attention on the skill being carried out benefits novice performance did not support the propositions of Wulf and colleagues.

In light of these findings, Perkins-Ceccata, Passmore, and Lee (2003) assessed whether the effects of attentional focusing instructions on golfers' pitching performance depended upon their skill level. Internal focus instructions directed participants to concentrate on the form of the golf swing and to adjust the force of their swing depending upon the distance of the shot. External focus instructions directed participants to concentrate on hitting the ball as close to the target as possible. Perkins-Ceccato et al. found that highly skilled golfers did benefit from using an external focus when compared to an internal focus. However, low-skilled golfers performed better with the internal focus instructions in comparison to the external instructions. These differential roles of attentional focus as a function of skill support empirical findings of Beilock et al. (2002) and again, these findings seem to oppose the overall findings of Wulf et al. (e.g., 2000). However, it is worth noting that the instructional manipulation used in this study does not accurately reflect Wulf et al's definitions of Internal and External focuses, something problematic considering the body of research developed by Wulf and colleagues. Specifically, the internal focus did not emphasize focusing on the specific arm movements needed to produce movements, so this may not be a true internal focus. Furthermore, the external focus is relatively distant when considering similar research conducted by Wulf et al. (2000) who demonstrated that focusing on more remote effects (more distant external focuses) is not always beneficial as it may be far removed from the processes producing the effects. Also in light of the Wulf et al's distance of focus findings, the internal instructions used by Perkins-Ceccato et al. more directly represent a mid-point external focus. For example, the internal instructions "focus on the form of the golf swing" used by Perkins-Ceccato et al. is similar to the beneficial external instructions "focus on the movements of the club head" used by Wulf et al. This represents a common problem with inconsistent instruction criteria use in attentional focus studies using instructional manipulations. In addition, Perkins-Ceccato et al. indicate Beilock at al's findings as support, but Beilock et al. specifically avoid instructional manipulation of attentional focus. Perkins-Ceccato et al's findings may well provide support for Wulf and Prinz's (2001) notion that an optimal distance may exist for an external focus, one which is easily distinguishable from bodily movements but still related to the movements producing the effect.

In light of this, the findings of Perkins-Ceccato et al. can be reassessed. Their findings could still be seen as representing a difference in the effectiveness of attentional focus depending upon skill level. However, it may be more accurate to state that they represent the extent of the distance at which novices can effectively direct their attention in comparison to skilled performers. Specifically, it seems that novice performers can gain benefits from an external focus that is still (closely) related to the movements that produce them. Whereas skilled performers may be able to effectively direct their attention at the more distal point of the desired outcome (e.g., distant target), an issue identified for further research by Wulf and Prinz (2001).

Definitional inconsistencies or differences in instructions to induce different attentional focuses mean that cross comparisons of research is difficult. The current quantity and quality of research has led to some comparisons of approach (e.g., Wulf & McNevin, 2003), and it may well be at a stage where more effort should be used to ensure consistency. Wulf and McNevin (2003) have pointed to the problems of comparing research, particularly when full details of the instructions used to induce attentional focuses are not disclosed. For example, in Masters (1993) and Hardy et al's (1996) studies on golf-putting, no exact instructions regarding the explicit condition are reported other than the instructions were "on how to putt a golf ball" (Masters, 1993, p.

347). The research by Beilock et al. (2001, 2002) provides a valuable approach to the implications of different attentional focuses during performance and learning; however, they do not consider the external focus definitions offered by Wulf et al. for a full comparison.

The research carried out by Beilock et al. (2001, 2002) and Perkins-Ceccato et al.(2003) adds weight to the notion that the role of attentional focus in performance is not as clear-cut as previously thought. Significantly, Beilock et al. advocate that skill-focused attention may not always be detrimental to well-learned performances. Beilock et al's (2002) study demonstrates that skill-focused attention applied to current real-time performance disrupts execution. However, if applied in other circumstances, such as practice situations, in which performers are consciously attempting to dismantle their skill and modify certain parts in accord with data collected by self-regulatory activities, an internal skill-focus of attention can be beneficial. Self-regulatory activities, including the allocation of attention to performance outcomes and goal attainment, self-evaluation, and self-reactions detract from lower level performances of novices yet enhance skill execution at later stages of learning and higher levels of proficiency (Kanfer & Ackerman, 1989). Self-regulatory activities are thought to require attentional capacity for successful initiation and implementation, and may disrupt novel skill execution by recruiting attentional resources needed for control of task performance Kanfer and Stevenson (1985). However, more experienced performance, which does not rely on constant attentional control, may not deteriorate. Instead, Beilock et al. (2002) suggest, self-regulatory functions may be implementable in parallel with proceduralised control processes, serving to store information about the outcomes and evaluations of performance (rather than an unfolding of their step-by-step components) that is needed for subsequent cognitions about ones' abilities, effort, and strategies for task control (Kanfer & Ackerman, 1989; Kluwe, 1987). Significantly Beilock et al.

propose that self-regulatory attention and skill-focused attention differ in a crucial way: self-regulatory attention is metacognitive and aimed at plans that precede skill execution and the products that follow skill execution (Brown, 1987), whereas skill-focused attention is cognitive and aimed at the component steps that constitute execution itself (Beilock & Carr, 2001).

Beilock et al. (2002) state that skill-focused attention may become embedded in the metacognitive activities of self-regulation. Under this presumption, individuals may attend to specific components of their skill (i.e., implement skill-focused attention) to alter control strategies and execution processes that, through self-regulatory actions, have been deemed unproductive or maladaptive to progress toward a desired goal state. Significantly, this monitoring of performance may be temporarily detrimental to skill execution, as performers will most likely have to slow down and break down previous execution procedures to attend to and alter these processes. This decrement is in line with Wulf et al.'s predictions, however, Beilock et al. (2002) suggest that ultimately these changes should produce performance benefits as movement will become refined through practice.

Recently, (Gray, 2004, Experiment 1) supported previous research by demonstrating that when experienced baseball batters were given a secondary task that requires continuous attention to a component of swing execution (i.e., the direction in which the bat was moving), batting performance deteriorated. Expanding previous analysis of skill breakdown, Gray used kinematic swing analysis which suggested that this performance degradation is at least partially due to the fact that skill-focused attention in experts interfered with the sequencing and timing of the different motor responses involved in swinging a baseball bat. An increase in movement variability is what would be expected when a performer shifts control from encapsulated procedures to step-by-step cognitive control (Gray). Furthermore, expert baseball players also made significantly more errors when judging the direction of movement of their bat than did novices. What was apparent was that choking under pressure is not due to an overloading of attentional capacity caused by the distracting effects of pressure as proposed by Wine (1971) but is caused by an inward shift of attentional focus as proposed by Baumeister (1984).

Gray (2004) additionally suggested that the concept of attentional focus may be along a continuum. In the second experiment, Gray proposed for the first time that normal variations in performance level may be associated with a continuum between high and low levels of skill-focused attention. Again using experienced baseball batters, Gray demonstrated that when the mean performance for the batters was poor (i.e., a batting 'slump'), the number of errors in the skill-focused attention judgement (bat direction) was lower than when the mean performance level was high (i.e., a hot streak). This effect, Gray stresses, is quite different from previous theories that have proposed that skill-focused attention primarily occurs in experts under a high degree of pressure (Baumeister, 1984; Masters, 1992).

In contrast to the approaches discussed earlier, Gray (2004) proposed that a high level of skill is not characterized by only one type of attentional allocation. Important for developing the conceptualisation of attentional focus during performance, Gray suggests that when engaged in an extended period of below average performance, expert baseball players appear to increase the amount of attention focused on the skill in an attempt to gain access to step-by-step execution of the swing. By doing so, it is proposed that the batter attempts to break out of the performance slump (Taylor, 1988) by identifying and controlling problematic components of the skill. When a higher level of performance is achieved, skill-focused attention decreases substantially, and performance again becomes largely proceduralized. In their study of a world class rugby kicker's pre-performance routines, Jackson and Baker (2001) made observations that would seemingly support Grays assertion, stating that "performers are less likely to make changes to their routines when they are doing well, so that their routine's consistency merely reflects rather than causes their superior performance" (p.62).

From the data indicating accuracy of batter's ability to indicate the direction of the bat during a swing, Gray (2004) argued that skill-focused attention should not be thought of as an all-or-nothing phenomenon, as the knowledge about movement execution was negatively and roughly monotonically related to the current level of performance. R. Gray reiterates Beilock et al's (2002) suggestion that attention to skill execution in experts may be crucial for breaking down, altering, and adapting proceduralised knowledge that the performer has judged to be unproductive on the basis of cognitive self-regulation of his action. However, where Beilock et al. suggest that this occurs during practice situations, Gray proposes that this can take place during performance itself.

Traditional skill acquisition theory states that there are distinct independent stages through which performers progress. Gray (2004) suggests that the progression from the cognitive stage, through the associative stage, to the procedural stage may not be so unidirectional. Instead expert performers may continually cycle back and forth between these stages depending on the current level at which they are performing. Gray's proposal that attention may be on a continuum along which performers can shift, mirrors previous conceptualisations of attention by Nideffer (e.g., 1979) and Naatanen (1992). To allow effective attentional control, Gray suggests that it is as important for an athlete to learn strategies for moving quickly and effectively from the cognitive to the procedural stage (i.e., techniques for acquiring new procedural knowledge) as it is to achieve that level in the first place.

The notion that attentional focus exists along a continuum suggests a degree of flexibility, but also poses the question of whether the two focuses could be combined in specific circumstances. This has not yet been proposed or tested; however, research has been carried out which may shed light onto the possibility. One such study is that of Campenella et al. (2000), who were interested in the combined effects of verbal instruction and visual biofeedback during concentric quadriceps and hamstrings peak torque. Their verbal instruction directed participants to push (knee extension) and pull (knee flexion) throughout the entire muscle contraction, instructions which are in line with Wufl et al's internal focus of attention definition. The visual biofeedback gave participants a curve graph of their torque output, providing a direct external measure of their performance during each movement. The results indicated that changes in peak torque were not revealed with verbal instruction alone, suggesting that focusing upon the movements may have broken down the execution and therefore limited force output. Indeed, Campenella et al. suggest as much by observing that participants synchronised knee extensions and flexions with the verbal encouragements, thus inhibiting maximum force. Participants provided with visual feedback only demonstrated increases in peak torque. This suggests that when participants' attention was directed towards the external measure of force output, movements were more efficient. Both findings so far support the theories of internal and external focus as proposed by Wulf and colleagues and Singer. The result that does not support their approach is when visual feedback and verbal instruction were combined participants demonstrated significantly greater quadriceps and hamstring peak torque values when compared to a 'no feedback' condition and 'verbal instructions only' condition. This suggests that in specific situations performance can be improved by appropriately combining the two attentional focuses. Research is needed to address this issue and to investigate how combining the two attentional focuses can be possible, considering their differences.

Although this research calls into question some of the conclusions made by Wulf et al. and Singer et al., there are some notable issues that this previous research can bring to the newer research. What Beilock et al. and Gray have achieved is to expand the concept of the internal focus and to see it as a state that is useful in performance. This expands the limited conceptualisation of the internal focus by Wulf et al. and Singer et al. However, Wulf et al's definition of the external focus is critical in understanding the concept of the external focus. Bringing these two areas of research together should expand the understanding of attentional focus, and finally utilise notions such as flexibility which have long been suggested as being critical to performance (e.,g., Nideffer). This more dynamic approach to understanding attentional focus would help see motor control as a complex integration task suggested by Naatanen (1992). Naatanen proposed that in addition to concentrating on selection and release of an optimal motor program, one continually utilises the sensory feedback from the ongoing motor behaviour and from the effects of this behaviour on the situation, including the changing spatial relation of our body to the environment.

The research discussed above has important practical implications. Currently, as Woodman and Hardy (2001) note, many practitioners and researchers advocate the use of process goals as important methods of retaining or regaining focus during performance (Bull, Albinson, & Shambrook, 1996; Kingston, Hardy, & Markland, 1992; Kingston & Hardy, 1997). In light of the current research, this approach could be seen as encouraging the use of a more internally directed focus of attention, and may well lead to the breakdown of motor skill execution. In line with the suggestions of Wulf and colleagues, encouraging a focus on more global aspects of performance will be beneficial because they promote automaticity rather than a dechunking of the skill into parts.

Attentional Focus and Special Populations

As mentioned previously, the growing body of research demonstrating the effects of different attentional instructions has developed to influence areas of application such as physical therapy. Although research is limited on this topic, there are some examples of attentional focusing instructions being assessed for their applicability with special patient populations. In an attempt to assess differences in the effectiveness of different attentional strategies (Landers, Wulf, Wallmann, & Guadagnoli, in press) have conducted research assessing the possible benefits of different attentional focuses for patients with Parkinson's Disease who have a history of falling. Parkinson's Disease (PD) is a progressive neurodegenerative disease that characteristically produces a variety of motor control problems and movement disorders including bradykinesia, rigidity, resting tremor, as well as deterioration in balance and postural control. Landers et al. point out that the cumulative effects of these impairments often result in considerable functional limitation and disability, thereby predisposing the individual to falling. Due to the advantages of an external focus during balance tasks in previous research, Landers et al. aimed to assess whether attentional focusing instructions would benefit PD patients with a history of falling. Participants were tested under 'baseline', 'internal' and 'external' conditions on three different balance tests: i) eyes open, fixed support surface and surround; ii) eyes closed, fixed support and surround, and; ii) eyes open, sway-referenced support surface and fixed surround. Results indicated that whilst the type of attentional focus did not differentially affect postural stability under the conditions that required participants to stand still on a stable surface with eyes open or eyes closed, results did indicate clear effects during sway-referenced balance, the most challenging condition. Instructing participants to focus on keeping rectangles under their feet (external focus) resulted in less sway than instructing them to focus on keeping their feet horizontal (internal focus) or not giving them instructions at all (baseline). During the sway-referenced balance condition, no participants recorded a fall (completely lost their balance and had to be supported by safety harnesses) during the external focus condition, but there were recorded falls during the internal and control conditions.

Canning (2005) assessed the implications of using different attentional focusing instructions on PD patients' walking. Participants with mild to moderate PD walked at a comfortable speed under 2 baseline conditions: (i) walking with hands free, no specific instructions and (ii) walking carrying a tray and glasses, no specific instructions; and 2 experimental conditions: (i) walking carrying a tray and glasses with instructions to attend to maintaining big steps while walking and (ii) walking carrying a tray and glasses with instructions to direct attention towards balancing the tray and glasses. When instructed to direct their attention towards walking while carrying the tray and glasses, participants walked faster and with longer strides than when they were given no specific instructions, to a level comparable to when they walked with hands free and with no adverse effects on the carried tray. Canning suggests that the specific instructions used directed attention either internally (focusing upon walking with big steps) or externally (focusing upon the tray). The finding that Parkinson's patients' walking performance improved with an internal focus goes against the suggestions and findings of Wulf and colleagues. Indeed, Canning proposes that whilst the current findings are inconsistent with the suggestions that an internal focus interferes with automatic processes, it is not unexpected that instructions, which promoted conscious control of the movement of walking, improved walking performance. This is because a reduced velocity and stride length during walking observed in Parkinson's patients is thought to reflect a loss of automaticity of well-learned movements due to defective function of basal ganglia (Morris, Iansek, Matyas, & Summers, 1994). Canning concludes that the general suggestion that directing learner's attention to the effects of their movements be incorporated into rehabilitation practice (McNevin et al., 2000;

Wulf & Prinz, 2001) may not be appropriate in all circumstances for people with Parkinson's Disease. Although this is a possibility, and may be evidence that an internal focus may be useful in specific circumstances, caution must be raised in the comparison between Wulf and colleagues' definition of attentional focuses and that of Canning. For instance, Canning's internal focus condition is to instruct patients to focus upon stride length. As discussed earlier, Clingman & Hilliard's (1990) found that walkers focusing on their cadence walked faster than when focusing on their stride-length, suggesting possible difference in the effects of different internal focuses. But an internal focus in line with Wulf et al's definition would directly focus the patient's attention to the leg movements being produced. Regarding the external manipulation, although research has indicated the benefits of using an external focus during a supra-postural task (e.g., McNevin & Wulf, 2002), the dual task approach used by Canning does not allow for a full comparison of internal and external instructions. Other studies using external focus manipulations during walking with Parkinson's patients have used markers on the floor to indicate stride length or the use of metronome or music to control stride frequency (e.g., Morris et al., 1994; Morris, Iansek, Matyas, & Summers, 1996).

Limitations and Considerations for Future Research

One issue with a number of studies conducted on the effects of different attentional strategies during motor performance and learning has been a limited use of control groups for comparison. For example, although Wulf and colleagues found evidence for positive effects in performing a backhand shot in tennis and putting a golf ball (Maddox, Wulf, & Wright, 1999; Wulf et al., 1999), neither study used a control condition. This limits discussion as to whether an external focus of attention is beneficial, or whether an internal focus is detrimental to learning relative to non-instructed conditions. Future research should assess attentional manipulations in comparison to control no-instruction conditions. Wulf and McNevin (2003) make similar suggestions by highlighting that the only previous studies to incorporate a control group was the study by Wulf et al. (1998, Experiment 1) using the ski-simulator task and Wulf, et al. (2003). In these studies, internal focus and control conditions had similar effects, and both were less effective then an external focus condition. In their experiment Wulf and McNevin found that a control condition produced performance no different from an internal focus and a secondary task condition, whereas an external focus was beneficial compared to both conditions. These findings supported findings of Wulf et al. (1998, Experiment 1) and provide evidence for the benefits of an external focus. An internal focus, on the other hand, does not seem to degrade learning relative to no instructions - perhaps because learners spontaneously direct attention to the coordination of their movements when confronted with a novel motor skill (Wulf & McNevin). Further research incorporating control groups would increase confidence in the conclusion that an external focus is *beneficial*, rather than an internal focus being detrimental, to learning (Wulf & McNevin, p4).

Another methodological limitation has been the consistent lack of manipulation checks. Wulf and Prinz (2001) highlight this as a concern, and suggest that future research should use participant interviews to verify the deployment of the instructed attentional focus. Due to there being no research addressing this, there is little information regarding what participants are attending to and what their experiences are of different attentional conditions. However, Wulf and colleagues have yet to produce such findings or include manipulation checks in their methodology, even in the experimental studies published subsequently. Data on the experiences of participants using different attentional instructions should provide valuable information regarding the proposed mechanisms underlying attentional focusing effects. The only relevant study to date assessing participants' experiences was conducted by (Beilock, Bertenthal, McCoy, &

Carr, 2004, Experiment 2). However their specific research aim was to assess how participants felt instructions affected their performance whilst focusing upon either hitting a golf ball onto a target as accurately or as quickly as possible rather than specific internal and external instructions. Using a 7-point Likert scale novice participants rated the speed instructions as detrimental to performance compared to accuracy instructions, whilst experts indicated the opposite, a finding reflecting their performance on the task. This approach offers a valid method for assessing participants' experiences via the use of post-task questionnaires.

As discussed earlier in relation to psychophysiological research into attentional focus, McNevin and Wulf (2002) have suggested that future studies should examine more directly – e.g., by using electromyographic, kinematic, or kinetic analysis – how the focus of attention affects the control of body parts attended to, as well as those of other parts of the body. Such research would illustrate the more subtle differences and mechanisms affected by different attentional strategies. This research would also provide more direct evidence for the discussion of hypotheses such as common-coding theory. By observing how movements change under different conditions, the validity of such models can be tested. Furthermore, the nature of any psychophysiological and motor event must be understood through triangulation with performance data *and* post-hoc self-report on what the athlete was trying to achieve mentally (Collins, 2002).

Wulf and Prinz (2001) indicate that future research should address to what extent the performer's attentional focus affects the accuracy and/or variability of his or her performance. The limited scoring systems used in previous experiments using two dimensional tasks (e.g., Wulf et al., 1999; Wulf et al., 2000) did not capture these performance characteristics.

Another aspect for consideration is how these findings can be applied to real life situations. Although Wulf and colleagues stress the importance of instructions for manipulating attentional focus, it remains unclear how this can be effectively transferred to sporting situations. However, one aspect may be the use of self-talk. Lavallee et al. (2004) state that as a cognitive self-regulatory strategy, self-talk has been recommended as a technique for focusing attention (Weinberg, 1988; Williams & Leffingwell, 2002). In support of this strategy, Landin and Hebert (1999) demonstrated a link between training in trigger words in tennis (such as 'split, turn') and self-reported improvements in concentration on court. In a similar vein, Hardy, Gammage, and Hall (2001) reported that athletes used self-talk for staying 'focused' (p.315). It may be that self-talk could be used by athletes to keep them focused appropriately during performance and learning. Research needs to address the feasibility of this idea, as well as its application.

One progress on recent research will be a consideration of group sizes. Many previous studies have used small group sizes due to the nature of tasks involved, but larger group sizes would benefit any conclusions made from subsequent findings. However, increasing the number of participants in an experiment increases the chances of obtaining statistically significant results, even if it represents a tiny effect of little practical importance (Murray & Dosser, 1987). A significant mean difference simply indicates that the difference observed in the sample data is very unlikely to have occurred by chance. To provide an indication of how large an effect actually is, it is recommended that researchers report a measure of effect size (Gravetter & Wallnau, 2005). Where possible partial eta-squared (η^2) will be used to assess the effect sizes of any significant relationships identified (SPSS calculates partial eta-squared, η_p^2). Values for eta-squared approximately correspond to the following effect size conventions (Cohen, 1992): small (0.01), medium (0.06), and large (0.14).

Present Research

As has been presented, the interest in the concept of attentional focus during motor skill execution and learning has grown considerably in the past decade. This rapidly expanding area is growing more influential, with applications arising in both sports skill learning and rehabilitation from injury. Nevertheless, research needs to address a number of concerns in the area for a fuller understanding of proposed mechanisms and possible applications. Firstly, consideration of kinematic and psychophysiological factors involved in bodily movement should be considered for better understanding of how different attentional focusing strategies influence different body parts and systems. Secondly, for better ecological validity, efforts need to be taken to consider factors which occur outside the laboratory. Thirdly, little effort has been given to the experiences of participants using different instructions, so consideration should be given to assessing this.

The present research will progress down two distinct lines of investigation. The first line will address the effects of attentional focus during standing balance, an area addressed by Wulf and colleagues (e.g., Wulf et al., 1998, Experiment 2; Wulf, McNevin, et al., 2001; McNevin & Wulf 2002). As a factor critical to the successful performance of movement, the effects of attentional focusing strategies on balance will have important implications. The second line of research will assess the effects of attentional focusing strategies on the performance and learning of a self-paced motor execution task: dart throwing. In self-paced tasks, the ability to focus one's attention in preparation for a movement is essential. Preparatory and attentional factors (location, duration, distribution, intensity) primarily distinguish requirements associated with the execution of self-paced events, where there is plenty of time to go through routine, or ritual, before initiating the act. Externally-paced events typically require rapid anticipation, decision-making and reactions (Singer, 2000). Furthermore, self-paced activities provide more control over psychophysiological variables than externally-paced activities. For the present study, dart throwing will provide a useful self-paced task for the assessment of the influence of attentional focusing strategies.

Although long since stated, Martens' (1979) view that the real future of sport psychology lies in applied field research is still highly appropriate. The modern sport psychologist faces balancing the following issues laid down in this example by (Nideffer & Sagal, 2001). An applied psychologist wanting to help an athlete cope with stress needs sufficient (research-based) knowledge about coping behaviours and sources of stress as well as relevant data about the particular sport he or she is dealing with. Likewise, a sport psychologist researching coping processes needs to understand and help to impart the practical implications of the knowledge such research generates. Throughout this thesis, attempts will be made to make results relevant to 'real' situations, employing a degree of ecological validity. Effort will be made to discuss possible applications of findings. Each study is briefly introduced below, and will be discussed in full in the following chapters.

Study 1: Experiment 1: The effects of Attentional Focus during a Supra-Postural task on standing balance: a replication and expansion of McNevin and Wulf (2002)

The principle aim of this study was to replicate the work of McNevin and Wulf (2002) and validate their attentional focusing findings for standing balance. In light of limitations and suggested future directions, the study had two further aims to expand the understanding of the subject area: firstly, kinematic assessment of arm movements during the supra-postural task. Secondly, the assessment of participants' experiences of attentional manipulations using a post-task questionnaire.

Study 2: Experiment 2: The effects of Attentional Focusing Strategies on Novice Darts Performance and Heart Rate: a replication and expansion of Radlo et al. (2002)

The principal aim of this study was to replicate both the performance and heart rate findings of Radlo et al. (2002) to further validate their attentional focusing findings. Furthermore, the study has 2 additional aims for expanding this research: Firstly, to assess the performance findings under different attentional focusing strategies against a control group, which was lacking in Raldo's original study and therefore limiting conclusions that could be made. Secondly, to assess participants' experiences of the attentional focus manipulations via post task questionnaire.

Study 3: The effects of fatigue and attentional focus on balance performance

Study 3 consisted of 2 experiments which looked at the effects of fatigue upon balance performance under different attentional focuses. Fatigue is a naturally occurring condition during prolonged motor execution, in particular during sports. The effects of attentional focusing strategies on motor execution have so far not addressed such naturally occurring conditions, and fatigue poses a useful condition to test the of attentional focus effects. Two different types of fatigue were used in this study, localised and generalised. Only physical fatigue was used as it is not in the scope of this thesis to address how different types of fatigue (e.g., mental) interact with attentional focus.

Experiment 3a: The effects of Attentional Focusing Strategy upon Standing Balance Before and After Generalised Fatigue

The role of attentional focus during performance of a single legged balance task on an unstable platform will be assessed. The study is seen as a progression of the work done in Experiment 1. To progress this line of research, this experiment will assess balance on an unstable platform rather than standing balance. This mirrors much of Wulf et al's work on attentional focus as many of their key studies utilised balance tasks on unstable platforms. Advancing Wulf et al's work will be addressed on a number of factors. Firstly, Wulf et al. primarily use a single dimension balance task in the medial-lateral plane (side to side). This study will utilise a more dynamic balance task, with unstable balance on a platform that can move in all directions round a central point. Experiment 3a will assess any changes in the effectiveness of different attentional focusing strategies whilst in a generalised fatigued state. Specifically, a generalised fatigue state, induced through physical exercise, will fatigue many of the bodies muscular and cardiovascular systems.

Experiment 3b: The effects of Attentional Focusing Strategy upon Standing Balance Before and After Localised Fatigue

Experiment 3b will attempt to replicate the findings of Experiment 3a by assessing the role of attentional focus on a dynamic balance task before and during a localised physical fatigued state. Whereas Experiment 3a assessed generalised fatigue of the standing leg, the localised fatigue protocol aims to produce fatigue specific to the leg muscles through carrying out leg exercises. The main aim will be to address any possible changes in the effects of attentional focus whilst balancing on a locally physically fatigued leg.

Study 4: Practicing and performing a motor skill using attentional focusing strategies

Study 4 consists of two experiments addressing similar issues. The specific aim of these experiments was to assess what effects different attentional focuses used in practice will have on subsequent performance. As Beilock et al. (2002) suggest, the role of attentional focus may be different in times of practice and performance. Specifically, an internal focus may be beneficial during practice situations whereas an external is beneficial during performance. On the other hand, Wulf et al. (e.g,. 2002) claim that an external focus must be used at all times, and that novices benefit more from using externally directed instructions than internal ones (Wulf & Prniz, 2001).

Experiment 4a: The effects of Attentional Focusing Strategy During Practice on Novice Darts Performance

Participants will be given the chance to practice where little emphasis is placed on performing as accurately as possible, followed by a performance session of dart throwing where performing as accuracy as possible is the main aim. This practice session will give participants the chance to use the same or different attentional focusing strategy that they will be using in the performance session, resulting in four different groups: (Practice - Performance) Internal - Internal, Internal - External, External - Internal, External - External. The principle hypothesis here is that the attentional focus used in the practice session should affect the accuracy in the performance session. A secondary aim of this study is to assess participants' experiences of each attentional focusing strategy using a during-task questionnaire.

Experiment 4b: The effects of Combined Attentional Focusing Strategies During Practice on Novice Darts Performance

Participants will be given the opportunity to practice a darts task before a performance session. This practice session will include instructions emphasising both Internal and External attentional focuses, giving participants the chance to practice using both focuses. In the follow-up performance session participants will be given a single attentional focus to use throughout the task. The aims of this study are to assess the effects of changing attentional focuses during practice, and the effects this has on subsequent performance. A secondary aim is to assess participants' experiences of each attentional focusing strategy using a during-task questionnaire. Furthermore, this study offers the chance to assess the effects of participants' preferences for specific attentional focuses after practice on subsequent performance.

CHAPTER 2

THE INFLUENCE OF ATTENTIONAL FOCUSING STRATEGIES DURING SUPRA-POSTURAL TASKS ON STANDING BALANCE, MOVEMENT KINEMATICS AND PARTICIPANTS' EXPERIENCES

Efficient balance and postural control is critical to the performance of both highly-skilled and everyday actions. Balance requires a delicate interplay between various afferent and efferent mechanisms, and is typically controlled very effectively and without the awareness (McNevin & Wulf, 2002). The everyday maintenance of human standing balance is an outstanding feat. Postural reflexes are continually evoked to maintain the stability, with three main sensory systems contributing inputs to these reflexes: visual, vestibular, somatosensory. Together, these make up the proprioceptive system, which is responsible for collecting information about the body itself.

Whilst balancing, Wulf and colleagues have demonstrated that directing a performer's attention towards the movement execution of a balancing task (an Internal focus) will degrade postural control when compared to when attention is directed towards movement outcomes (an External focus) (e.g., Wulf et al, 1998, Experiment 2; Wulf, McNevin, et al., 2001). Wulf and Prinz (2001) conclude that actions will be more effective if they are planned in terms of their intended outcome or effect, rather than in terms of the specific movement patterns.

From their research assessing attentional focus influences on balance performance, Wulf and colleagues have drawn parallels with research addressing the influence of supra-postural tasks during balance. For example, Stoffregen, Pagualayan, Bardy and Hettinger (2000) found that participants visually searching for letters in a block of text exhibited reduced postural sway during a quiet standing task than participants who were asked to simply inspect a blank piece of paper in front of them. Similarly, Riley, Stoffregen, Grocki, and Turvey (1999) found that participants lightly touching a loosely hanging curtain with their eyes closed also reduced postural fluctuations. Specifically, Riley et al. found that participants instructed to touch the curtain – with the goal to minimize movements of the curtain resulting from the touch ("touch relevant " condition) – reduced postural fluctuations, compared to not touching it. Participants instructed that touching the curtain was irrelevant to the study ("touch irrelevant" condition) exhibited the same postural fluctuations under no-touch conditions.

From their own findings McNevin and Wulf (2002) suggested that supra-postural tasks may well be influencing the participants' attentional focus during the balance tasks. Specifically, the findings of Riley et al. (1999) and Wulf et al. (e.g., Shea & Wulf, 1999; Wulf et al., 1998, Experiment 2; Wulf & McNevin, 2003) appear to be similar in that postural fluctuations were reduced when participants' attention was directed away from the act of "standing still" and to an effect of this act on the environment. Although it is not clear whether participants during Riley et al.'s (1999) study directed their attention externally onto the sheet or internally onto their finger, it seems likely that participants directed more attention to the curtain as they were instructed to "minimize movement of the curtain that might result from their touch" (Riley et al., 1999, p. 805).

In light of this, Wulf and colleagues were interested in the following issue: Does the effect of a supra-postural task depend on whether it induces an external or internal attentional focus? Wulf et al. (2003) investigated the effects of attentional focus induced through a supra-postural task by assessing participants' balance performance on a stabilometer whilst holding a tube horizontal. Participants were instructed to either focus upon keeping their hands horizontal (internal focus) or keeping the tube horizontal (external focus). The participants using the external focus had more effective balance and also held the tube more horizontal during the task. These results demonstrated that attentional focus instructions can influence not only postural control but also the supra-postural task, further emphasising the importance of direction of attention during movement execution.

McNevin and Wulf (2002) investigated whether attentional focus, manipulated through a supra-postural task, will influence static balance control. In their study, a replication and adaptation of Riley et al. (1999), participants stood on a force platform with their eyes closed whilst postural changes were monitored. During the two attentional focusing conditions, participants were required to point their index finger so that it was lightly touching a loosely hanging curtain. During the baseline, participants stood still without a touch task. In the external condition, participants were instructed to "try to minimize movement of the sheet over the duration of the trial", whereas the Internal condition instructions were "try to minimize movement of the index finger over the duration of the trial". These two attentional manipulations were in line with Wulf's guidelines, that an external focus should emphasises an intended outcome or effect of a movement, whereas an internal focus emphasises the movements being carried out. Although McNevin and Wulf did not demonstrate any differences between the attentional focuses influence on postural sway, attentional focus was shown to influence the frequency of responding. Using an External focus, participants' postural adjustments were small and very rapid. In contrast, when these same individuals used an Internal focus, the frequency and amplitude of postural adjustments were no different than those recorded during quiet standing. McNevin and Wulf's findings demonstrate that the wording of instructions can significantly affect the performers' focus of attention and, consequently, the control strategies adopted by them. Furthermore, attentional focus manipulations can significantly influence the performance of well-learned tasks, such as static balance.

The purpose of the present study was to replicate and extend McNevin and Wulf's (2002) study. Firstly, This study aimed to assess not only the effects of attentional focusing strategies upon standing balance, but also the arm movements during the supra-postural task. Although not the specific aim of McNevin and Wulf's study (2002), one aspect missing was the examination of the effects the attentional focuses have on the supra-postural tasks. Wulf et al. (2003) did assess the effects of attentional focus induced through supra-postural task instruction on both balance and supra-postural task performance. However, this assessment was based around the outcome measure of how horizontal a tube was held during the balancing task. The present studies assessment will be in line with the suggestions of McNevin and Wulf (2002) that future research needs to assess movement directly through kinematic analysis of movement effects. Such data would demonstrate how the focus of attention affects the control of body parts that are being attended to, as well as those other parts of the body.

Postural sway was measured whilst participants lightly touched a sheet with their fingertips. Participants were instructed that they should minimize movements of the sheet. To induce an External focus, participants were instructed to minimize the movements of the sheet itself. To induce an Internal focus, participants were instructed to minimize sheet movements by focusing upon minimizing the movements of their finger. Kinematic data was collected using movement sensors placed at anatomically significant points of the task: the finger tip, wrist, elbow and shoulder.

The second expansion of McNevin and Wulf's (2002) study is to investigate participants' experience of focus instructions though the use of a post-task questionnaire. Previous studies have assessed participants' attentional focus preferences (e.g., Wulf, Shea, & Park, 2001), however, none have yet addressed participants' experiences of the different focus types. As an initial attempt to address this issue, this post-task questionnaire was based around closed response questions. These questions will assess preference and also the experience of each instruction set, such as difficulty and mental demands. These questions were proposed as they relate to attentional issues. For example, how difficult are participants finding the instructions to carry out, and are there any differences between the two focus types? Are there differences in participants ability to maintain each type of focus? These two questions may indicate reasons why specific attentional focus instructions are more successful than others. Similarly, any differences in the perceived mental demands of each set of instructions could account for differences in the effectiveness of the focusing instructions during balance. Finally, how participants perceive the success of each focus type may provide useful information regarding participants' preferences in addition to their earlier stated focus preference.

Both State and Trait anxiety were measured prior to the task using the State Trait Anxiety Inventory (STAI). This information will be used to assess differences in participant's experiences of each focus type as State and Trait anxiety have been linked to attentional processes. For example, Woodman and Hardy (2001) suggest that, although a simplistic view, most anxiety theories are based on anxiety-induced cognitive interference, such that anxiety uses up attentional resources or working memory (Processing efficiency theory, Eysenck & Calvo, 1992) Relevant to movement execution, Masters' (1992) conscious processing hypothesis states that performers experiencing increased anxiety attempt to perform by consciously controlling their movements using explicit "rules" to perform a task, rather than automatically performing it. Woodman and Hardy summarize that the conscious processing hypothesis predicts that performers whose cognitive anxiety is elevated are more likely to lapse into conscious controlling of a normally automatic skill. Therefore differences in levels of state or trait anxiety may lead to differences in participants' ability to utilise different attentional styles. However, research has not addressed whether anxiety levels will interfere with participants' experiences of using an External focus of attention. Those individuals with higher levels of anxiety may, due to distraction or limited resources, find it difficult to use an external focus of attention which may be reflected in the ratings of their experiences. The present research will address how differences in state and trait anxiety may influence participant's experience of different focus instructions.

Hypothesis

1. Attentional focusing instructions will affect arm movement kinematics during a supra-postural task
2. Attentional focusing instructions used during a supra-postural task will influence postural control
3. Participants will demonstrate clear differences in their experiences and preferences of using different attentional strategies. This will also be related to individuals' anxiety levels.

Method

Participants

21 participants (14 Male, 7 female) volunteered to participate in this study. All were students or employees at the University of Hull. Participants ranged between 18 and 56 years of age. None of the participants were initially aware of the purpose of the study, but were debriefed after participation. Participants were required to review and sign an informed consent form before continuing. Due to technical problems with CODA movement analysis equipment, data from 19 (13 male, 6 female) participants was included in the analysis of arm movements during the task. No participants had any neurological or balance problems or previous injury. The University of Hull Department of Psychology Research Committee approved the protocol used in this study.

Apparatus and data processing

Ground Reaction Forces

The reaction force supplied by the ground as we stand on it is called the ground reaction force (GRF), which is basically the reaction to the force the body exerts on the ground. The GRF, along with the weight, is an important external force. The GRF is a three-component vector representing the forces in the vertical, anterior-posterior and medial-lateral planes. Each component measures a different characteristic of movement. The vertical component is primarily generated by the vertical acceleration of the body and is of highest magnitude. As body mass is short term fixed, the force experienced by the floor is dependent on the acceleration of the body acting upon it. If the GRF is less than body weight, then the weight of the body is not being supported by the floor and this signifies acceleration downwards. For example, when you crouch there is a downward acceleration of the body and so the GRF will be reduced. And conversely, when thrusting the body upwards (as in a jump) additional force or acceleration is required to thrust upwards, and this is experienced by the floor. When the vertical force is normalised to body weight, the resultant time-series is the acceleration profile of the movement.

To measure changes in GRF during the balance task, a Kistler Force Platform was used running at 1000 Hz. GRF data for each trial was assessed in the anterior-posterior and medial-lateral planes and calculated using Kistler's BioWare software. GRF data was used here, as opposed to centre of pressure (COP) used by McNevin and Wulf (2001). COP represents the "average" of the forces acting at each point of contact (i.e. each foot). There could be movement, and yet this might not be indicated by the COP.

Motion Analysis

CODA motion analysis camera (running at 200 Hz) and sensors were used to measure the movement of different arm components during each trial. The CODA scanner unit (mpx 30) is an automatic 3-dimensional motion analyser. The measurement unit contains three pre-caliberated, active camres which direct infra-red light to active sensors (infra-red LED's). The sensors are non-invasive, and include a small power pack. Movement of the diode relative to the skin was minimized by attaching sensors with double sided Velcro tape. The reference origin for the CODA sensor coordinate data was set at the centre of the force platform, from this reference point motion analysis software calculates relative movement. Sensors were placed on the finger-tip, wrist, elbow and shoulder, see Figure 2.1. These positions was chosen because of their anatomical significance to movement and their progressive distance from the point of focus of attention (e.g., finger tip). All sensors were arranged so that they faced the CODA camera when the participant was stood in the pointing position. Movement was recorded in the medial-lateral, posterior-anterior, and vertical axis. The CODA camera was placed 3m to the right of the participant so as to pick up all movement of the sensors placed onto the body (see sensor placement, Figure 2.1). The position of the finger on the sheet was observed before each trial to ensure that any folds in the sheet did not obscure the sensor from the camera's view. Figure 2.2 indicates the set-up of the experimental area, showing positions of camera, curtain, participants and force platform. The motion analysis software provides the user-interface to the CODA hardware for real time display and data acquisition.

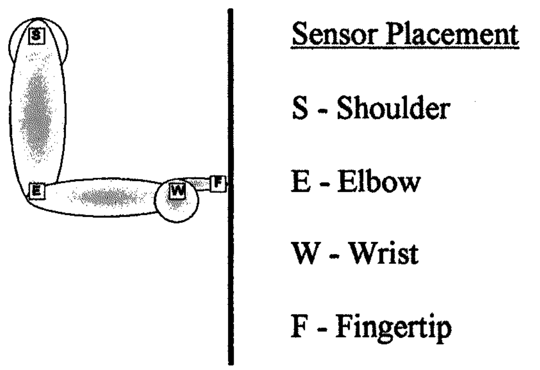


Figure 2.1: Arm movement sensor positions

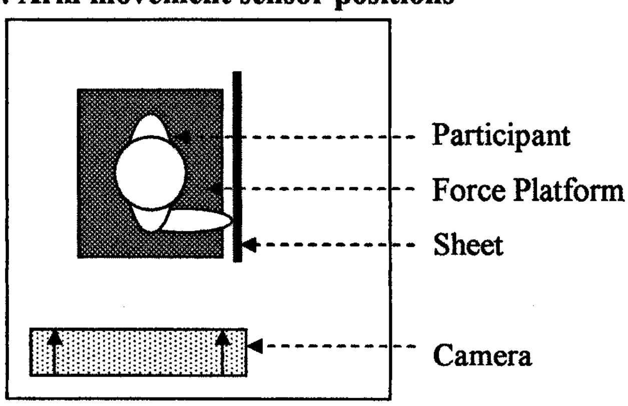


Figure 2.2: Experimental area setup (top down-view)

Sensors were attached to the skin or to tight clothing. Loose clothing would not provide accurate body movement recordings, so participants were directed not to wear such items.

Post Task Questionnaire

Upon competition of the task, participants immediately filled in a post-task questionnaire (Appendix 3). The first question aims to assess participants' focus preferences between either the Internal or External focus instructions that they have just used. Following this, four questions were asked about the experience of each focus. These were: How difficult was it to carry out these instructions? How difficult was it to maintain these instructions? How mentally demanding were these instructions? and How successful do you think these instructions were for performing the task? These were answered on a five-point likert scale (1 = not at all, 5 = very highly).

Trait Anxiety

Trait anxiety was assessed using by administering the Trait scale of the State-Trait Anxiety Inventory (Spielberger, Gorsuch, & Lushene, 1970) (Appendix 1) prior to the task beginning.

Experimental procedures

Upon arrival at the laboratory, participants were introduced to the task. Informed consent was given and participants were aware that they could stop participating at any point. Participants were naïve as to the purpose of the study, specifically the influence of attentional focusing instructions. Participants were then given opportunity to change into comfortable clothing if necessary and clothes that allowed access to bodily sites that markers were to be attached to. Participants were also instructed to take their shoes off. Once ready, participants were given STAI questionnaires to fill out.

After completing the questionnaires, participants were directed to a quiet area where body sensors were attached. A female experimenter attached body sensors to female participants and a male experimenter attached body sensors to male participants. Once all sensors were attached the participant was given a short time period (approx 5 minutes) to become accustomed to the sensors on their skin. Once accustomed to the sensors and the lab, participants were introduced to the test area (e.g., force platform, CODA camera) and the task explained to them. Once participants were stood on the force platform, they kept same foot positions for the duration of the experiment.

The task consisted of three 30-s trials. During each trial, participants were instructed to stand quietly, feet shoulder width apart, on the force platform. The right upper arm was positioned to be slightly abducted, the forearm internally rotated, and the elbow flexed at 0° horizontal. In front of the participant was a sheet suspended from 2m high hanging loosely to 5cm from the floor. During focus trials the sheet was positioned so that the tip of the participant's right extended index finger made light contact with the sheet. During all trials, participants were required to keep their eyes shut.

A baseline movement trial was carried out with the sheet placed out of reach and participants standing quietly in the pointing position. The sheet was brought into reach for the next two focus trials, the distance was individually adjusted so that the participant could easily touch the sheet in the required fashion. Participants were observed for safety at all times. Following the baseline trial the internal and external focus conditions were randomly counterbalanced in order across participants. In the two focus trials participants were informed that the main aim of the task was to "minimize the movement of the sheet for the duration of the trial". Prior to the internal focus trials, participants were instructed to "Try to minimize movement of the index finger over the duration of the trial". Prior to the external focus trial, participants were instructed as follows: "Try to minimize movement of the sheet over the duration of the trial by focusing your attention on the sheet itself" (all instructions are presented in Appendix 8). Instructions were administered in writing and orally by the experimenter so that the participants had time to understand what was being asked; there was also opportunity to ask questions. Participants were instructed that each trial would begin and end on the experimenter's signal and would last 35 seconds. At the command to begin participants would immediately close their eyes and start following the instructions given. Data was collected from 5 seconds into the trial to ensure the participant had begun, and collection using the CODA camera and Force Platforms were manually synchronised. Participants were debriefed once they had completed post task questionnaires.

Dependent Variables

Kinetic data: Force platform

Ground reaction force (GRF) data was collected in Newton's (N)in three orthogonal directions, of which anterior-posterior and medial-lateral planes were analysed. The vertical force profile was ignored as there would be little variation in this direction with the task being carried out. The GRF data is indicative of whole body acceleration around the centre of mass, since the GRF data will highlight the reaction at the foot-ground level to any body movements. For each directional component of the GRF standard deviation (SD) and range were determined (N). Standard Deviation of movement is indicative of the overall magnitude of body sway during the trial and range of movement is indicative of the maximal amplitude of body sway movements during the trial.

Kinematic data: Arm Movement

To assess bodily movements in more detail, the Standard Deviation and Range of each arm sensor's movement around the stable pointing position was recorded in millimetres (mm). Standard Deviation of movement represented overall movement magnitude and Range of movement represented the overall movement amplitude during each trial. The data for each sensor was recorded in the vertical, medial-lateral, and anterior-posterior planes.

Results

Movement Kinetics: Force Platform Data

Effects of Attentional Focus on the Standard Deviation in Ground Reaction Forces

Table 2.1: Standard Deviation (N) in GRF Data

	Baseline (21)	External (21)	Internal (21)	Combined
Axis	Mean SD	Mean SD	Mean SD	Mean SD
Medial – Lateral	0.44 (0.12)	0.42 (0.14)	0.45 (0.14)	0.44 (0.13)
Anterior – Posterior	0.78 (0.29)	0.74 (0.27)	0.82 (0.32)	0.78 (0.29)
Combined	0.61 (0.21)	0.58 (0.21)	0.63 (0.23)	

SD of movement frequency of Ground Reaction Forces (GRF) in the Medial-Lateral direction for the Baseline condition were 0.44 (0.12), External condition 0.42 (0.14) and Internal condition 0.45 (0.14). In the Anterior-Posterior direction SD of GRF movement for the Baseline condition were 0.78 (0.29), External condition 0.74 (0.27) and Internal condition 0.82 (0.32). Overall, SD of GRF movement in the Baseline condition was 0.61 (0.21), the External focus condition was 0.58 (0.21), and the Internal focus condition was 0.63 (0.23). SD of GRF movement in the medial-lateral direction was 0.44 (0.13) and in the anterior-posterior direction it was 0.78 (0.29).

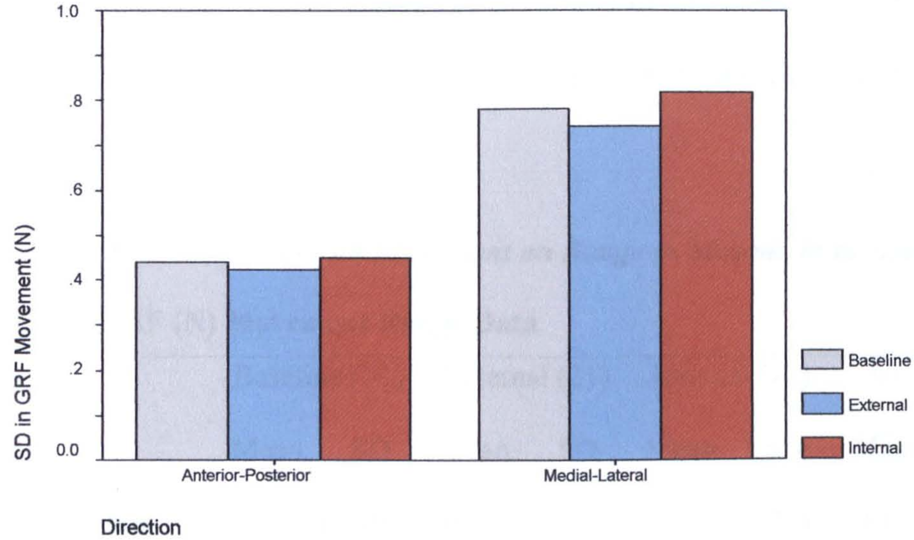


Figure 2.3: SD in GRF (N)

A Focus (3) X Direction (2) repeated measures ANOVA revealed main effects for Focus ($F_{(2, 40)} = 3.30, p=0.046$, partial eta squared [$\eta_p^2$] =0.14) and Direction ($F_{(1, 20)} = 62.81, p=0.001, \eta_p^2=0.76$). Least Significant Difference (LSD) post-hoc analysis revealed that SD of GRF movement in the External condition was significantly less than in the Internal condition ($p=0.003$) but was not significantly different from the baseline condition ($p= 0.21$). The Internal condition was not significantly different from the baseline condition ($p=0.31$). A larger SD was observed in the Anterior-Posterior direction (0.78, SE=0.06) than in the Medial-Lateral direction (0.44, SE=0.03). No significant interaction between Focus and Direction was observed ($F_{(2, 40)} = 1.25, p=0.30, \eta_p^2 = 0.06$).

Further analysis using a One-way within-subjects ANOVA of the effects of attentional focus in each direction showed no significant effects of attentional focus in the medial-lateral direction ($F_{(2, 40)} = 0.96, p=0.39, \eta_p^2 = 0.046$). A relationship tending towards significance was highlighted in the Anterior-Posterior direction ($F_{(2, 40)} = 2.96, p=0.06, \eta_p^2 = 0.13$). LSD analysis revealed that the SD of GRF movement was significantly less in the External condition when compared to the Internal condition ($p=0.01$), but not to the baseline condition ($p=0.22$). The baseline and Internal conditions did not significantly differ (p=0.33). Analysis of the effects of attentional focus in the Anterior-Posterior direction revealed no significant effects of focus strategy ($F_{(2, 40)}$ = 0.96, p=0.39, $\eta_p^2 = 0.05$).

Effects of Attentional Focus on Movement on Range in Movement of GRF

Table 2.2: GRF (N) Movement Range Data

	Baseline (21)		External (21)		Internal (21)		Combined	
Axis	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Medial – Lateral	21.11	(4.30)	17.67	(8.05)	21.13	(4.27)	19.97	(5.54)
Anterior – Posterior	5.97	(2.04)	6.04	(2.00)	6.40	(2.82)	6.14	(2.29)
Combined	13.54	(3.17)	11.85	(5.03)	13.77	(3.55)		

Range of GRF movement in the medial-lateral direction for the baseline condition were 21.11 (4.3), External condition 17.67 (8.05) and Internal condition 21.13 (4.27). In the Anterior-Posterior direction Range of GRF movement for the baseline condition was 5.97 (2.04), External condition 6.04 (2.0) and Internal condition 6.40 (2.82). Overall, Range of GRF in the Baseline condition was 13.54 (3.17), the External focus condition was 11.85 (2.03), and the Internal focus condition was 13.77 (3.55). Range of GRF movement in the Medial-Lateral direction was 19.97 (5.54) and in the Anterior-Posterior direction it was 6.14 (2.29).

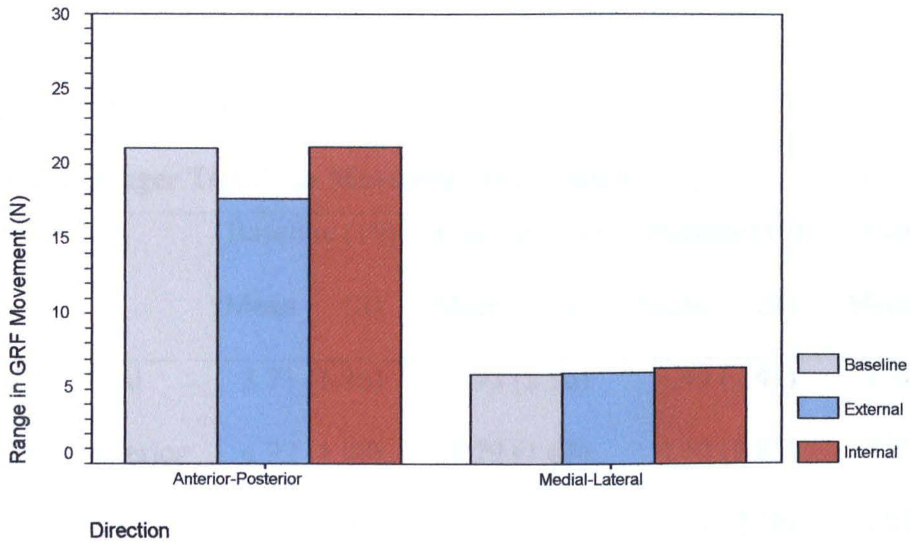


Figure 2.4: GRF Movement Range (N)

A Focus (3) X Direction (2) repeated measures ANOVA revealed a main effect for Direction ($F_{(1, 20)} = 250.18, p=0.001, \eta_p^2 = 0.93$) and a closely significant main effect for Focus ($F_{(2, 40)} = 3.07, p=0.058, \eta_p^2 = 0.13$). Least Significant Difference (LSD) post-hoc analysis revealed the Range of movement in the External condition was significantly less than the Internal condition ($p=0.036$) but was not significantly different from the baseline condition ($p= 0.11$). The Internal condition was also not significantly different from the baseline condition ($p=0.73$). A larger range of movement was observed in the Medial-Lateral direction (19.97, SE=0.79) than in the Anterior-Posterior direction (6.14, SE=0.46). No significant interaction between Focus and Direction was observed ($F_{(2, 40)} = 2.24, p=0.12, \eta_p^2 = 0.10$)

Further analysis using a one-way within-subjects ANOVA of the effects of attentional focus in each direction showed no significant effects of attentional focus in the medial-lateral direction after Greenhouse-Geisser correction (Mauchley's Test of Sphericity proved significant, $p=0.05$) ($F_{(1.57, 31.38)} = 2.70, p=0.09, \eta_p^2 = 0.12$). No significant relationship was highlighted in the Anterior-Posterior direction ($F_{(2, 40)} = 0.78, p=0.47, \eta_p^2 = 0.04$).

Movement Kinematics

Finger Tip: SD of Movement

Table 2.3: Finger Tip SD in Movement Data (mm)

Axis	Baseline (19)	External (19)	Internal (19)	Combined
	Mean SD	Mean SD	Mean SD	Mean SD
Medial - Lateral	3.71 (1.86)	2.93 (1.56)	3.49 (2.47)	3.38 (1.96)
Anterior - Posterior	4.92 (1.98)	3.79 (1.63)	4.10 (1.83)	4.27 (1.81)
Vertical	3.69 (1.98)	2.31 (1.51)	3.27 (2.19)	3.09 (1.89)
Combined	4.11 (1.94)	3.01 (1.57)	3.62 (2.16)	

SD in movement of the finger tip in the medial-lateral direction for the baseline condition were 3.71 (1.86), External condition 2.93 (1.56) and Internal condition 3.49 (sd=2.47). In the Anterior-Posterior direction movement SD of the finger tip for the baseline condition were 4.92 (1.98), External condition 3.79 (1.63) and Internal condition 4.10 (1.83). In the Vertical direction movement SD of the finger tip for the baseline condition were 3.69 (1.98), External condition 2.31 (1.51) and Internal condition 3.27 (2.19). Overall, SD of Finger Tip movement in the Baseline condition was 4.11 (1.94), the External focus condition was 3.01 (1.57), and the Internal focus condition was 3.62 (2.16). SD of Fingertip movement in the Medial-Lateral direction was 3.38 (1.96), in the Anterior- Posterior direction it was 4.27 (1.81) and in the Vertical direction it was 3.27 (2.19).

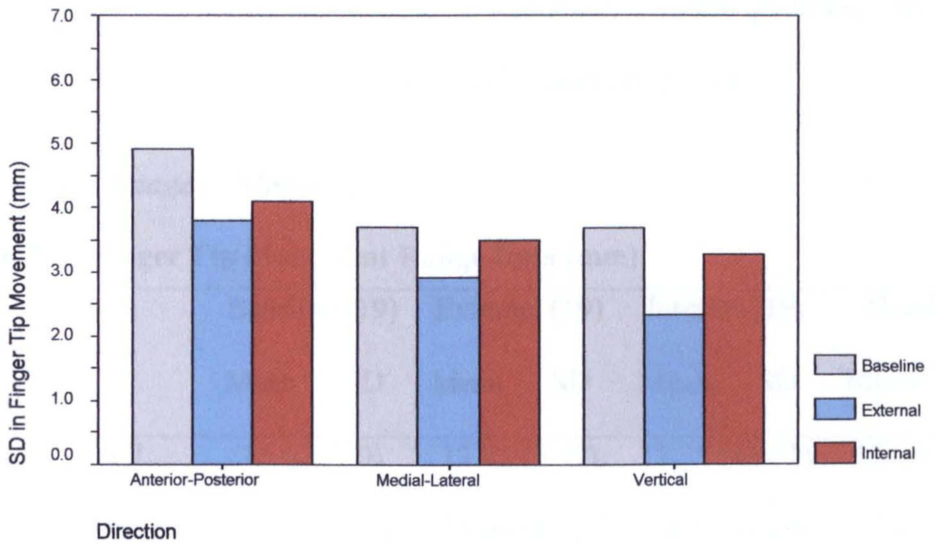


Figure 2.5: Finger Tip Movement SD (mm)

A Focus (3) X Direction (3) repeated measures ANOVA revealed main effects for Focus ($F_{(2, 36)} = 8.98, p= 0.001, \eta_p^2 =0.33$) and Direction ($F_{(2, 36)} = 5.85, p=0.006, \eta_p^2 = 0.25$). LSD post-hoc analysis revealed that SD in movement of the finger tip in the External condition was significantly less than in the Internal condition ($p=0.028$) and the baseline condition ($p= 0.001$). The Internal condition was not significantly different from the baseline condition ($p=0.1$). Significantly larger SD in movement was observed in the Anterior-Posterior direction than in the Medial-Lateral direction ($p=0.04$) and the Vertical direction ($p=0.001$), which were themselves not significantly different ($p=0.48$). No significant interaction between Focus and Direction was observed ($F_{(4, 72)} = 0.41, p= 0.80, \eta_p^2 = 0.02$)

Further analysis using a One-way within-subjects ANOVA of the effects of attentional focus in each direction showed no significant effect of attentional focus in the Anterior-Posterior direction ($F_{(2, 36)}= 2.57, p=0.09, \eta_p^2 = 0.13$), or the Medial-Lateral direction ($F_{(2, 36)}= 2.31, p=0.11, \eta_p^2 = 0.11$). Analysis of the effects of attentional focus in the vertical direction revealed a significant effect of focus strategy ($F_{(2, 36)} = 3.78, p=0.03, \eta_p^2 = 0.17$). LSD analysis revealed that the SD of fingertip movement was significantly smaller in the External condition when compared to the baseline condition ($p=0.01$), but only closely significantly different from the Internal condition (p=0.06). The baseline and Internal conditions were not significantly different (p=0.47).

Finger Tip: Range of Movement

Table 2.4: Finger Tip Movement Range Data (mm)

Axis	Baseline (19)	External (19)	Internal (19)	Combined
	Mean SD	Mean SD	Mean SD	Mean SD
Medial - Lateral	16.62 (7.0)	12.87 (5.49)	17.18 (11.33)	15.56 (7.94)
Anterior - Posterior	21.42 (8.16)	15.65 (6.12)	18.25 (6.45)	18.44 (6.91)
Vertical	15.61 (6.05)	9.69 (5.05)	13.54 (7.88)	12.95 (6.33)
Combined	17.88 (7.07)	12.74 (5.55)	16.32 (8.55)	

Range of finger tip movement in the medial-lateral direction for the baseline condition were 16.62 (7.0), External condition 12.87 (5.49) and Internal condition 17.18 (11.33). In the Anterior-Posterior direction movement Range of the finger tip for the baseline condition were 21.42 (8.16), External condition 15.65 (6.12) and Internal condition 18.25 (6.45). In the Vertical direction Range of finger tip movement for the baseline condition was 15.61 (6.05), External condition 9.69 (5.05) and Internal condition 13.54 (7.88). Overall, Range of Finger Tip movement in the Baseline condition was 17.88 (7.07), the External focus condition was 12.74 (5.55), and the Internal focus condition was 16.32 (8.55). Range of Fingertip movement in the Medial-Lateral direction was 15.56 (7.94), in the Anterior- Posterior direction it was 18.44 (6.91) and in the Vertical direction it was 12.95 (6.33).

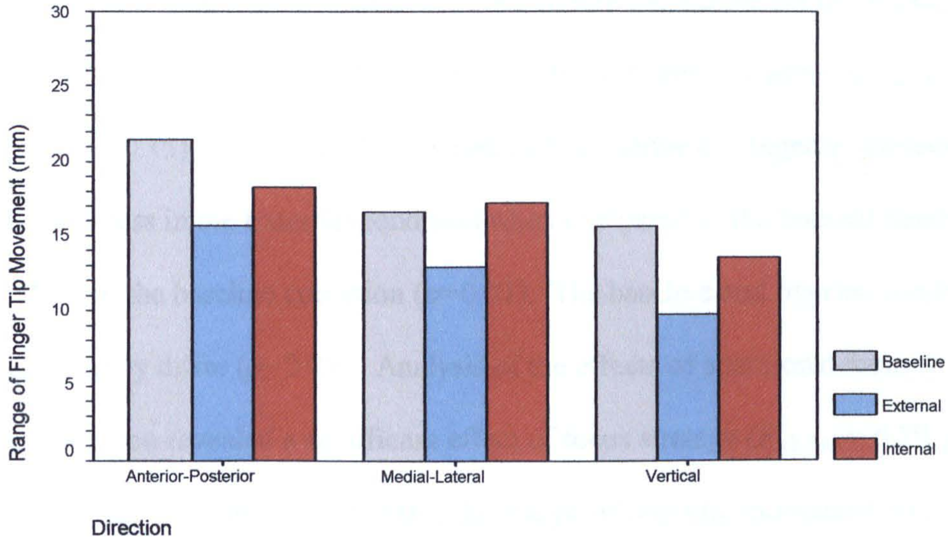


Figure 2.6: Finger Tip Movement Range (mm)

A Focus (3) X Direction (3) repeated measures ANOVA revealed a main effect for Focus ($F_{(2, 36)} = 11.85, p=0.001, \eta_p^2 = 0.40$). Mauchly's Test of Sphericity proved significant for the factor direction ($p=0.26$). Greenhouse-Geisser adjustment revealed a main effect for Direction ($F_{(1.48, 36)} = 9.43, p=0.002, \eta_p^2 = 0.34$). LSD post-hoc analysis revealed that Range of finger tip movement in the External condition was significantly less than in the Internal condition ($p=0.003$) and the baseline condition ($p= 0.001$). The Internal condition was not significantly different from the baseline condition ($p=0.23$). Significantly larger Range of movement was observed in the Anterior-Posterior direction than in the Vertical direction ($p=0.001$) and closely significant from the Medial-Lateral direction ($p=0.053$), which were themselves not significantly different ($p=0.96$). No significant interaction between Focus and Direction was observed ($F_{(4, 72)} = 0.63, p=0.64, \eta_p^2 = 0.03$)

Further analysis using a One-way within-subjects ANOVA of the effects of attentional focus in each direction showed a significant effect of attentional focus in the Anterior-Posterior direction ($F_{(2, 36)} = 4.76, p=0.02, \eta_p^2 = 0.21$). LSD analysis revealed that the Range of Fingertip movement was significantly smaller in the External condition when compared to the baseline (*p=0.002*) condition, but not the internal condition (*p=0.19*).

The Internal and External conditions were not significantly different (*p=0.142*). A significant relationship was highlighted in the Medial-Lateral direction ($F_{(2, 36)} = 3.25$, $p=0.05$, $\eta_p^2 = 0.15$). LSD analysis revealed that the Range of Fingertip movement was significantly less in the External condition when compared to the Internal condition ($p=0.05$), and the baseline condition ($p=0.01$). The baseline and Internal conditions did not significantly differ ($p=0.80$). Analysis of the effects of attentional focus in the vertical direction revealed a significant effect of focus strategy ($F_{(2, 36)} = 6.39, p=0.004$, $\eta_p^2 = 0.26$). LSD analysis revealed that the Range of fingertip movement was significantly smaller in the External condition when compared to the baseline condition (0.003) and the Internal condition ($p=0.03$). The baseline and Internal conditions were not significantly different ($p=0.25$).

Wrist: SD of Movement

Table 2.5: Wrist SD of Movement Data (mm)

Axis	Baseline (19)	External (19)	Internal (19)	Combined
	Mean SD	Mean SD	Mean SD	Mean SD
Medial – Lateral	2.69 (1.59)	2.59 (1.56)	2.68 (1.57)	2.66 (1.57)
Anterior - Posterior	4.98 (2.05)	3.72 (1.76)	4.16 (1.89)	4.29 (1.90)
Vertical	2.53 (1.09)	1.72 (0.97)	2.37 (1.64)	2.21 (1.23)
Combined	3.40 (1.58)	2.68 (1.43)	3.07 (1.57)	

SD in movement of the wrist in the medial-lateral direction for the baseline condition were 32.69 (1.69), External condition 2.59 (1.56) and Internal condition 2.68 (1.57). In the Anterior-Posterior direction SD in movement of the wrist for the baseline condition was 4.98 (2.05), External condition 3.72 (1.76) and Internal condition 4.16 (1.89). In the Vertical direction SD in movement of the wrist for the baseline condition were 2.53 (1.09), External condition 1.72 (0.97) and Internal condition 2.37 (1.64). Overall, SD of Wrist movement in the Baseline condition was 3.4 (1.58), the External focus condition was 2.68 (1.43), and the Internal focus condition was 3.07 (1.57). SD of Wrist movement in the Medial-Lateral direction was 2.66 (1.57), in the Anterior- Posterior direction it was 4.29 (1.90) and in the Vertical direction it was 2.21 (1.23).

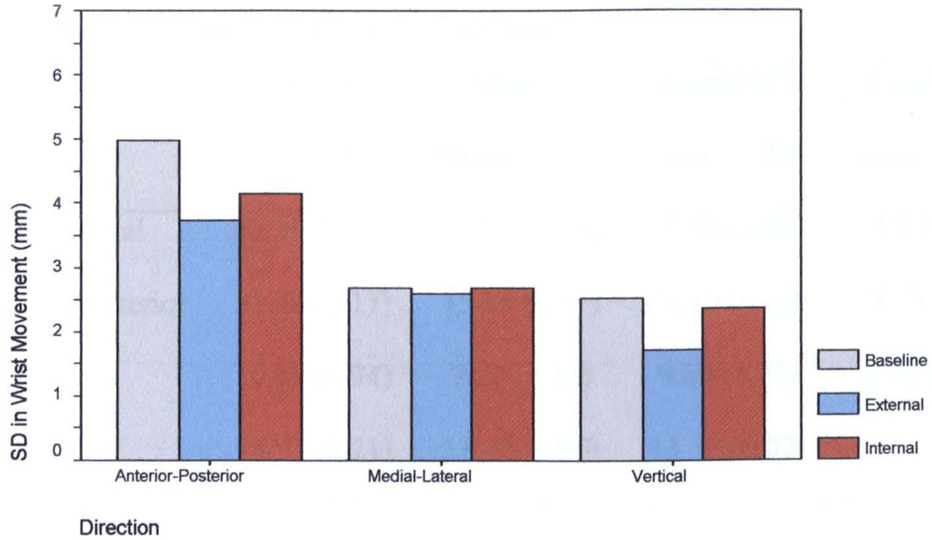


Figure 2.7: Wrist Movement SD (mm)

A Focus (3) X Direction (3) repeated measures ANOVA revealed main effects for Focus ($F_{(2, 36)}$= 4.09, p=0.025, η_p^2 =0.19) and Direction ($F_{(2, 36)}$ = 29.15, p=0.000, η_p^2 =0.62). LSD post-hoc analysis revealed that SD in movement of the wrist in the External condition was significantly less than in the baseline condition (p= 0.004), but not the Internal condition (p=0.17). The Internal condition was not significantly different from the baseline condition (p=0.22). Significantly larger SD in movement was observed in the Anterior-Posterior direction than in the Medial-Lateral direction (p=0.001) and the Vertical direction (p=0.001), which were themselves not significantly different (p=0.18). No significant interaction between Focus and Direction was observed ($F_{(4, 72)}$ = 1.28, p=0.28, η_p^2 =0.07)

Further analysis using a One-way within-subjects ANOVA of the effects of attentional focus in each direction showed no significant effect of attentional focus in the Anterior-Posterior direction ($F_{(2, 36)}$ = 2.72, p=0.08, η_p^2 = 0.13), Medial-Lateral direction ($F_{(2, 36)}$

= 0.081, p=0.92, η_p^2 = 0.004) or the vertical direction ($F_{(2, 36)}$= 2.84, p=0.07, η_p^2 = 0.14).

Wrist: Range of Movement

Table 2.6: Wrist Movement Range Data (mm)

Axis	Baseline (19)	External (19)	Internal (19)	Combined
	Mean SD	Mean SD	Mean SD	Mean SD
Medial - Lateral	12.85 (6.51)	11.51 (5.00)	12.45 (5.66)	12.27 (5.72)
Anterior - Posterior	21.46 (8.17)	15.51 (6.37)	18.19 (6.62)	18.39 (7.05)
Vertical	10.59 (3.94)	7.22 (3.33)	9.89 (5.79)	9.23 (4.35)
Combined	14.97 (6.21)	11.42 (4.90)	13.51 (6.02)	

Range of wrist movement in the medial-lateral direction for the baseline condition were 12.85 (6.51), External condition 11.51 (5.00) and Internal condition 12.45 (5.66). In the Anterior-Posterior direction movement Range of the wrist for the baseline condition were 21.46 (8.17), External condition 15.51 (6.37) and Internal condition 18.19 (6.62). In the Vertical direction, movement Range of the wrist for the baseline condition was 10.59 (3.94), External condition 7.22 (3.33) and Internal condition 9.89 (5.79). Overall, Range of Wrist movement in the Baseline condition was 14.97 (6.21), the External focus condition was 11.42 (4.90), and the Internal focus condition was 13.51 (6.02). Amplitude of Wrist movement in the Medial-Lateral direction was 12.27 (5.72), in the Anterior- Posterior direction it was 18.39 (7.05) and in the Vertical direction it was 9.23 (4.35).

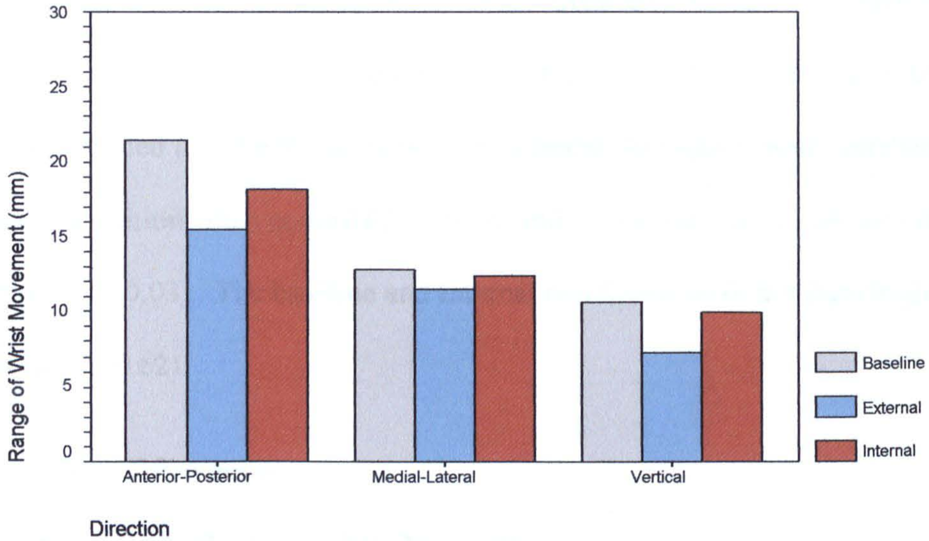


Figure 2.8: Wrist Movement Range (mm)

A Focus (3) X Direction (3) repeated measures ANOVA revealed a main effect for Focus ($F_{(2, 36)} = 8.37, p=0.001, \eta_p^2 =0.32$) and for Direction ($F_{(2, 36)} = 39.61, p=0.001, \eta_p^2 =0.69$). LSD post-hoc analysis revealed that Range of wrist movement in the External condition was significantly less than in the Internal condition ($p=0.04$) and the baseline condition ($p= 0.001$). The Internal condition was not significantly different from the baseline condition ($p=0.16$). A significantly larger movement Range was observed in the Anterior-Posterior direction than in the Vertical direction ($p=0.001$) and the Medial-Lateral direction ($p=0.001$), which themselves were significantly different ($p=0.016$). No significant interaction between Focus and Direction was observed ($F_{(4, 72)} = 1.59, p=0.19, \eta_p^2 = 0.08$)

Further analysis using a One-way within-subjects ANOVA of the effects of attentional focus in each direction showed a significant effect of attentional focus in the Anterior-Posterior direction ($F_{(2, 36)} = 5.06, p=0.01, \eta_p^2 = 0.22$). LSD analysis revealed that the Range of Wrist movement was significantly smaller in the External condition when compared to the baseline ($p=0.003$) condition, but not the internal condition ($p=0.19$). The Internal and External conditions were not significantly different ($p=0.11$). No significant relationship was highlighted in the Medial-Lateral direction ($F_{(2, 36)}= 0.90$,

p=0.42, $\eta_p^2 = 0.05$). Analysis of the effects of attentional focus in the vertical direction revealed a significant effect of focus strategy ($F_{(2, 36)} = 4.49$, p=0.02, $\eta_p^2 = 0.20$). LSD analysis revealed that the Range of wrist movement was significantly smaller in the External condition when compared to the baseline condition (p=0.004) and the Internal condition (p=0.03). The baseline and Internal conditions were not significantly different (p=0.62).

Elbow: SD in Movement

Table 2.7: Elbow Movement SD Data (mm)

Axis	Baseline (19)	External (19)	Internal (19)	Combined
	Mean SD	Mean SD	Mean SD	Mean SD
Medial – Lateral	2.10 (1.28)	2.27 (1.57)	1.89 (1.07)	2.09 (1.31)
Anterior - Posterior	5.12 (2.11)	3.89 (1.86)	4.25 (1.86)	4.42 (1.92)
Vertical	1.42 (0.66)	1.17 (0.60)	1.32 (0.63)	1.31 (0.63)
Combined	2.88 (0.35)	2.45 (1.34)	2.49 (1.19)	

SD in movement of the elbow in the medial-lateral direction for the baseline condition was 2.10 (1.28), External condition 2.27 (1.57) and Internal condition 1.89 (sd=1.07). In the Anterior-Posterior direction SD in movement of the elbow for the baseline condition were 5.12 (2.11), External condition 3.89 (1.86) and Internal condition 4.25 (1.86). In the Vertical direction SD in movement of the elbow for the baseline condition were 1.42 (0.66), External condition 1.17 (0.60) and Internal condition 1.32 (0.63). Overall, SD movement of the elbow in the Baseline condition were 2.88 (0.35), the External focus condition was 2.45 (1.34), and the Internal focus condition was 2.49 (1.19). SD of the elbow movement in the Medial-Lateral direction was 2.09 (1.31), in the Anterior- Posterior direction it was 4.42 (1.92) and in the Vertical direction it was 1.31 (0.63).

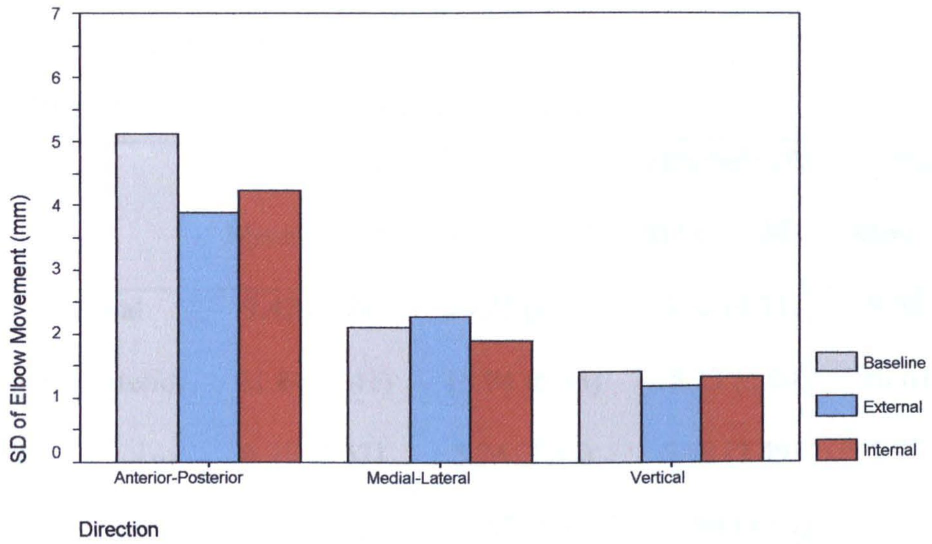


Figure 2.9: Elbow Movement SD (mm)

A Focus (3) X Direction (3) repeated measures ANOVA revealed no main effect of Focus ($F_{(2, 36)} = 1.68, p=0.20, \eta_p^2 = 0.09$). A main effect of Direction was revealed ($F_{(2, 36)} = 75.7, p=0.001, \eta_p^2 = 0.81$). LSD analysis revealed that SD of movement was significantly larger in the Anterior-Posterior direction than in the Medial-Lateral direction ($p=0.001$) and the Vertical direction ($p=0.001$), which were themselves significantly different from each other ($p=0.002$). Due to significance of Mauchley's Test of Sphericity being significant (P=0.001), Greenhouse-Geisser correction was used but did not reveal a significant interaction between Focus and Direction ($F_{(2.26, 40.69)} = 2.83, p=0.064, \eta_p^2=0.14$).

Further analysis using a One-way within-subjects ANOVA of the effects of attentional focus in each direction showed no significant effect of attentional focus in the Anterior-Posterior direction ($F_{(2, 36)} = 2.70, p=0.08, \eta_p^2 = 0.13$), Medial-Lateral direction ($F_{(2, 36)} = 0.94, p=0.40, \eta_p^2 = 0.05$) or the vertical ($F_{(2, 36)} = 0.91, p=0.41, \eta_p^2 = 0.05$).

Elbow: Range of Movement

Table 2.8: Elbow Movement Range Data (mm)

	Baseline (19)		External (19)		Internal (19)		Combined	
Axis	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Medial - Lateral	9.42 (4.79)		10.22 (6.27)		9.02 (4.31)		9.55 (5.12)	
Anterior - Posterior	21.84 (8.41)		15.94 (6.73)		18.23 (6.69)		18.67 (7.28)	
Vertical	6.39 (2.57)		5.24 (2.35)		5.68 (2.49)		5.77 (2.47)	
Combined	12.55 (5.26)		10.47 (5.12)		10.98 (4.50)			

Range of elbow movement in the medial-lateral direction for the baseline condition were 9.42 (4.79), External condition 10.22 (6.27) and Internal condition 9.02 (4.31). In the Anterior-Posterior direction movement range of the elbow for the baseline condition were 21.84 (8.41), External condition 15.94 (6.73) and Internal condition 18.23 (6.69). In the Vertical direction range of elbow movement for the baseline condition was 6.39 (2.57), External condition 5.24 (2.35) and Internal condition 5.68 (2.49). Overall, Range of Elbow movement in the Baseline condition were 12.55 (sd=5.26), the External focus condition was 10.47 (5.12), and the Internal focus condition was 10.98 (4.50). Amplitude of Elbow movement in the Medial-Lateral direction was 9.55 (5.12), in the Anterior- Posterior direction it was 18.67 (7.28) and in the Vertical direction it was 5.77 (2.47).

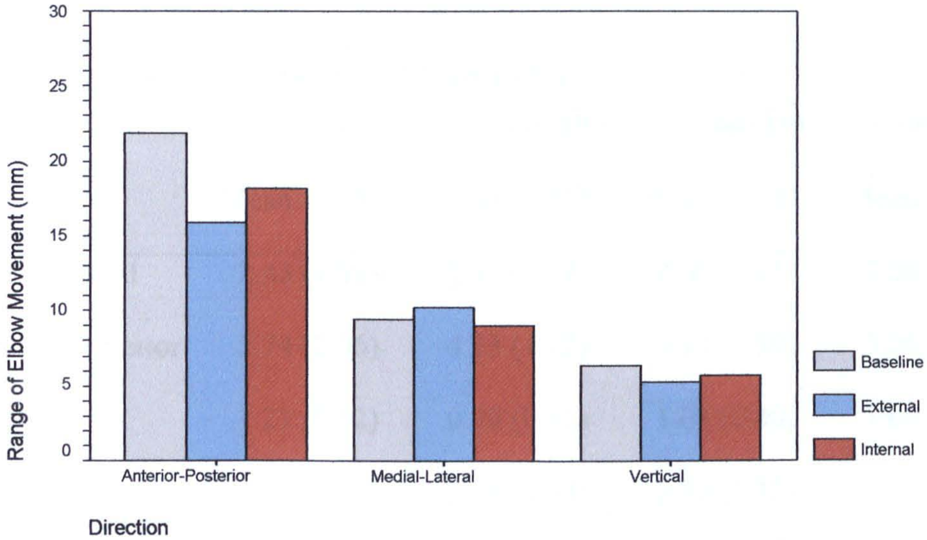


Figure 2.10: Elbow Movement Range (mm)

A Focus (3) X Direction (3) repeated measures ANOVA did not reveal a main effect for Focus ($F_{(2, 36)} = 2.70$, p=0.081, η_p^2 =0.13). A significant main effect of direction was identified ($F_{(2, 36)} = 88.65$, p=0.001, η_p^2 =0.83). LSD revealed a significantly larger range of movement was observed in the Anterior-Posterior direction than in the Vertical direction (p=0.001) and the Medial-Lateral direction (p=0.001), which were themselves significantly different (p=0.001). Due to Mauchly's Test of Sphericity proving significant (p=0.001), Greenhouse-Geisser adjustment revealed a significant interaction between Focus and Direction was observed ($F_{(2.52\ 45.29)} = 5.08$, p=0.006, $\eta_p^2 = 0.22$).

Further analysis using a One-way within-subjects ANOVA of the effects of attentional focus in each direction showed a significant effect of attentional focus in the Anterior-Posterior direction ($F_{(2, 36)} = 4.97$, p=0.01, $\eta_p^2 = 0.22$). LSD analysis revealed that the Range of Elbow movement was significantly smaller in the External condition when compared to the baseline (p=0.006) condition, but not the internal condition (p=0.25). The Internal and External conditions were not significantly different (p=0.06). No significant relationship was highlighted in the Medial-Lateral direction ($F_{(2, 36)} = 0.69$, p=0.51, $\eta_p^2 = 0.04$) or the vertical direction ($F_{(2, 36)} = 1.92$, p=0.16, $\eta_p^2 = 0.10$).

Shoulder: SD of movement

Table 2.9: Shoulder Movement SD Data (mm)

	Baseline (19)	External (19)	Internal (19)	Combined
Axis	Mean SD	mean SD	Mean SD	Mean SD
Medial - Lateral	2.43 (1.59)	2.32 (1.79)	2.08 (1.11)	2.28 (1.50)
Anterior - Posterior	5.74 (2.06)	4.33 (1.72)	5.11 (1.89)	5.06 (1.89)
Vertical	1.21 (0.52)	0.98 (0.51)	1.08 (0.40)	1.09 (0.48)
Combined	3.13 (1.39)	2.54 (1.34)	2.76 (1.13)	

SD of shoulder movement in the medial-lateral direction for the baseline condition were 2.43 (1.59), External condition 2.32 (1.79) and Internal condition 2.08 (1.11). In the Anterior-Posterior direction SD of the shoulder movement for the baseline condition was 5.74 (2.06), External condition 4.33 (1.72) and Internal condition 5.11 (1.89). In the Vertical direction SD of the shoulder movement for the baseline condition was 1.21 (0.52), External condition 0.98 (0.51) and Internal condition 1.08 (0.40). Overall, SD of Shoulder movement in the Baseline condition was 3.13 (1.39), the External focus condition was 2.54 (1.34), and the Internal focus condition was 2.76 (1.13). SD of Shoulder movement in the Medial-Lateral direction was 2.28 (1.50), in the Anterior-Posterior direction it was 5.06 (1.89) and in the Vertical direction it was 1.09 (0.48).

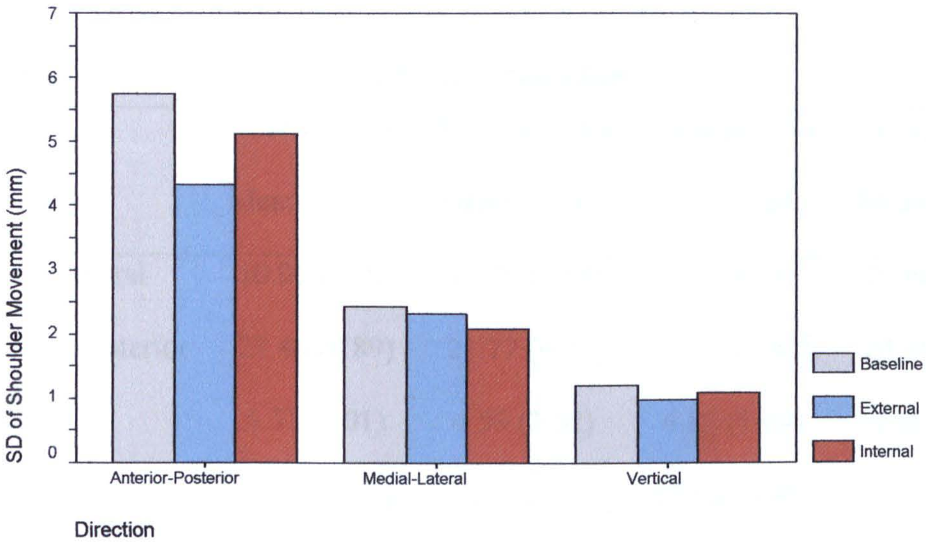


Figure 2.11: Shoulder Movement SD (mm)

A Focus (3) X Direction (3) repeated measures ANOVA revealed no main effect for Focus ($F_{(2, 36)} = 2.37, p=0.11, \eta_p^2 = 0.12$). A main effect was identified for Direction ($F_{(2, 36)} = 110.56, p=0.001, \eta_p^2 = 0.86$). LSD analysis showed that SD of movement was significantly larger in the Anterior-Posterior direction than in the Medial-Lateral direction ($p=0.001$) and the Vertical direction ($p=0.001$), which were themselves significantly different ($p=0.001$). Mauchly's Test of Sphericity proved significant for the interaction between Focus and Direction ($p=0.001$), but Greenhouse-Geisser did not reveal a significant interaction ($F_{(3.02, 54.39)} = 2.55, p=0.065, \eta_p^2 = 0.12$).

Further analysis using a One-way within-subjects ANOVA showed a significant effect of attentional focus in the Anterior-Posterior direction ($F_{(2, 36)} = 3.43, p=0.04, \eta_p^2 = 0.16$). LSD analysis revealed that the SD of Shoulder movement was significantly smaller in the External condition when compared to the baseline ($p=0.02$) condition, but not the internal condition ($p=0.16$). The Internal and External conditions were not significantly different ($p=0.28$). No significant relationship was highlighted in the Medial-Lateral direction ($F_{(2, 36)} = 0.47, p=0.63, \eta_p^2 = 0.03$) or the vertical direction ($F_{(2, 36)} = 1.53, p=0.23, \eta_p^2 = 0.08$).

Shoulder: Range of Movement

Table 2.10: Shoulder Movement Range Data (mm)

	Baseline (19)		External (19)		Internal (19)		Combined	
Axis	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Medial - Lateral	10.96 (5.59)		10.70 (6.58)		10.14 (4.58)		10.60 (5.58)	
Anterior - Posterior	27.46 (8.89)		21.77 (9.23)		24.24 (7.82)		24.49 (8.65)	
Vertical	5.51 (2.01)		4.59 (2.02)		4.86 (1.49)		4.99 (1.84)	
Combined	14.64 (5.50)		12.34 (5.94)		13.08 (4.49)			

Movement Range of the shoulder in the medial-lateral direction for the baseline condition were 10.96 (5.59), External condition 10.7 (6.58) and Internal condition 10.14 (4.58). In the Anterior-Posterior direction Range of shoulder movement for the baseline condition were 27.46 (8.89), External condition 21.77 (9.23) and Internal condition 24.24 (7.82). In the Vertical direction Range of shoulder movement for the baseline condition was 5.51 (2.01), External condition 4.59 (2.02) and Internal condition 4.86 (1.49). Overall, Range of Shoulder movement in the Baseline condition was 14.64 (5.50), the External focus condition was 12.34 (5.94), and the Internal focus condition was 13.08 (4.49). Range of Shoulder movement in the Medial-Lateral direction was 10.60 (5.58), in the Anterior- Posterior direction it was 24.49 (8.65) and in the Vertical direction it was 4.99 (1.84).

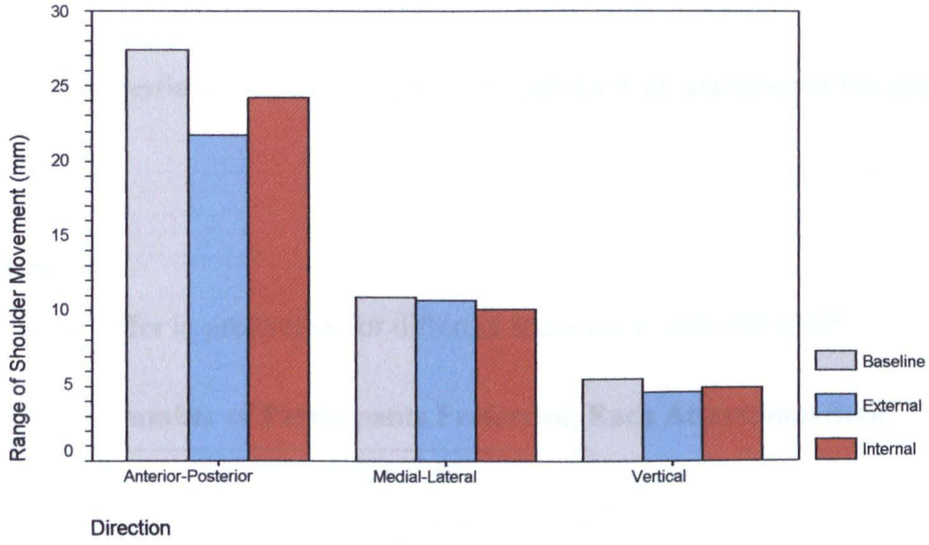


Figure 2.12: Shoulder Movement Range (mm)

A Focus (3) X Direction (3) repeated measures ANOVA did not reveal a main effect for Focus ($F_{(2, 36)} = 2.96, p=0.065, \eta_p^2 = 0.14$). Mauchly's Test of Sphericity proved significant for the factor Direction ($p=0.034$). Greenhouse-Geisser adjustment revealed a significant main effect for Direction ($F_{(1.51, 27.12)} = 112.2, p=0.001, \eta_p^2 = 0.86$). LSD post-hoc analysis revealed significantly larger range of movement in the Anterior-Posterior direction than in the Vertical direction ($p=0.001$) and significant from the Medial-Lateral direction ($p=0.001$), which were also themselves significantly different ($p=0.001$). A significant interaction between Focus and Direction was observed ($F_{(4, 72)} = 4.40, p=0.003, \eta_p^2 = 0.19$)

Further analysis using a One-way within-subjects ANOVA of the effects of attentional focus in each direction showed a significant effect of attentional focus in the Anterior-Posterior direction ($F_{(2, 36)} = 5.57, p=0.01, \eta_p^2 = 0.24$). LSD analysis revealed that the Range of Shoulder movement was significantly smaller in the External condition when compared to the baseline ($p=0.002$) condition, but not the internal condition ($p=0.16$). The Internal and External conditions were not significantly different ($p=0.11$). No significant relationship was highlighted in the Medial-Lateral direction ($F_{(2, 36)} = 0.22, p=0.81, \eta_p^2 = 0.01$) or the vertical direction ($F_{(2, 36)} = 1.80, p=0.18, \eta_p^2 = 0.09$).

Post Task Questionnaire: Participant's Experience of Attentional Focusing Strategies

Preferences

Did people differ in preference for different focus states after the task?

Table 2.11: Number of Participants Preferring Each Attentional Style

Preferred Focus	Number
Internal	9
External	10
Valid Total	19
Missing	2

There were no differences in the choices of either most comfortable or preferred focus type. Nine participants chose the Internal focus as most comfortable and preferred style, whilst 10 chose the External focus. Analysis revealed that those who chose one focus as most comfortable were the same ones to choose that focus as their preferred choice.

Subjective Ratings of Attentional Focusing Strategies

Participants answered subjective experience questions on a scale from 1 (low) to 5 (high).

Table 2.12: Participants' Ratings of Strategy Experience Questions

Question	Attentional Focusing Strategy	Mean	SD
Difficulty to carry out	Internal	2.65	(1.14)
	External	2.55	(1.23)
Difficulty to maintain	Internal	2.45	(1.10)
	External	2.65	(1.27)
Mental Demands	Internal	2.60	(1.14)
	External	2.60	(1.27)
How successful	Internal	2.35	(0.81)
	External	2.85	(1.14)

Paired Samples t-tests did not reveal significant differences between participants' ratings between Internal and External Attentional Strategies in their ratings of Difficulty to Carry Out ($t=0.36$, df = 19, $p=0.73$), Difficulty to Maintain ($t=0.66$ df = 19, $p=0.52$), Mental Demands ($t=0.00$, df = 19, $p=1.0$). A significant difference was revealed for ratings of how successful participants believed each attentional focusing strategy was ($t=2.13$, df = 19, $p=0.047$), with the External strategy being rated as more successful than the Internal strategy with scores of 2.85 (1.14) and 2.35 (0.81) respectively.

Differences in experience of Internal Focus depending on ratings of preference for focus post task:

Table 2.13: Participants' Internal Strategy Experience Question Ratings Depending Upon Strategy Preference

Internal Focus	Preferred Focus	Mean	SD
Difficulty to carry out	Internal	2.22	(0.83)
	External	3.10	(1.29)
Difficulty to maintain	Internal	2.22	(0.97)
	External	2.7	(1.25)
Mental Demands	Internal	2.56	(0.73)
	External	2.7	(1.49)
How successful	Internal	2.56	(0.73)
	External	2.1	(0.88)

With regards to participants who preferred the internal focus instructions, independent samples t-tests did not identify any significant differences between participants ratings of Difficulty to Carry Out ($t=1.74$, $df = 17$, $p=0.10$), Difficulty to Maintain ($t=0.92$, $df = 17$, $p=0.37$), Mental Demands ($t=0.26$, $df = 17$, $p=0.80$), or how successful each focus was ($t=1.23$, $df = 17$, $p=0.24$).

Differences in experience of External Focus depending on ratings of preference for focus post task:

Table 2.14: Participants' External Strategy Experience Question Ratings Depending Upon Strategy Preference

External Focus	Preferred Focus	Mean	SD
Difficulty to carry out	Internal	3.0	(1.22)
	External	2.20	(1.23)
Difficulty to maintain	Internal	3.33	(1.12)
	External	2.10	(1.20)
Mental Demands	Internal	3.0	(1.32)
	External	2.30	(1.25)
How successful	Internal	2.67	(1.22)
	External	3.00	(1.54)

For participants who preferred the external focus instructions, Independent Samples t-tests did not identify any significant differences between participants ratings of Difficulty to Carry Out (t=1.42, df = 17, p=0.17), Mental Demands (t=1.19, df = 17, p=0.25), or how successful each focus was (t=0.61, df = 17, p=0.55). A significant relationship was identified for ratings of Difficulty to Maintain focus (t=2.31, df = 17, p=0.03). Participants who rated the Internal focus as their preferred focus rated the External focus as being more difficult to maintain (3.33, sd=1.12) than those who preferred the External focus (2.10, sd=1.20).

Participants' choice of Preferred focus style and their Anxiety Scores

Table 2.15: Participants Anxiety Data Depending on Preferred Attentional Style

Anxiety Measure	Preferred Focus	Mean	SD
State Anxiety	Internal (9)	1.69	(0.30)
	External (10)	1.58	(0.39)
Trait Anxiety	Internal (8)	2.07	(0.40)
	External (10)	1.69	(0.24)

Independent Samples t-tests did not reveal significant differences between participants' ratings of State Anxiety as dependent upon their preferred focus style (t=0.67, df = 17, p=0.51). A significant difference was identified between ratings of Trait Anxiety (t=2.51, df = 16, p=0.02). Individuals who preferred the Internal focus scored significantly higher in Trait Anxiety (2.07, df = 0.40) than those who chose the External focus (1.69, df = 0.24). One participants' Trait Anxiety score was not included in the analysis due to incompletely filled in questionnaire.

Discussion

Ground Reaction Force Data

Combined GRF data analysis revealed larger SD of movement in the Internal condition than in the External and baseline conditions. However, SD of GRF movement did not differ between the External condition and the baseline. This suggests that, in this case, the Internal focus degraded postural control by increasing SD of perturbations but the External condition did not benefit balance when compared to a baseline. Analysis reveals that significantly larger SD of GRF movement was evident in the Anterior-Posterior direction, indicating that this task promoted movement in this plane. Further analysis revealed that, although only tending towards significance, the external focus of attention demonstrated smaller SD of movement in the Anterior-Posterior direction when compared to the internal but not the baseline conditions. This finding indicates that the effects of focusing strategies may be seen more clearly in the direction of the primary task, as indicated by larger movement SD in the Anterior-Posterior direction.

Overall, range of GRF was significantly smaller in the External condition than the Internal condition, but not significantly different than the baseline condition. As with the SD data, the Internal focus condition has degraded postural control, whereas the External focus has not shown any benefits when compared to the baseline. A smaller range of movement suggests that using an External focus promoted fewer large fluctuations in postural stability. Whereas an Internal focus seems to be characterised by larger postural movements. Further analysis shows that significantly larger range of movement of GRF was evident in the Anterior-Posterior direction, but the effects of focusing strategies on range of movement were not different in each direction.

McNevin and Wulf (2002) found no difference in postural sway under each attentional condition, but did find differences in the frequency of responding data. Results from this study do highlight differences in overall postural sway between the two attentional conditions, with the external focus demonstrating significantly less movement SD and less range in postural change movement than the internal condition. As the External and Internal conditions did not differ from the baseline, but did differ from each other it is hard to indicate the direction of the effect. The current study's findings support those of McNevin and Wulf by demonstrating that Internal focus instruction for a supra-postural task degrade postural stability, characterised by larger and more numerous postural fluctuations. This is in line with the *Constrained Action Hypothesis*, which proposes that an internal focus overrides and disrupts automatic movement processes. Furthermore, the advantages of the external focus support Wulf and colleagues proposed mechanisms involved in adopting an external focus of attention.

The finding that the Baseline condition was no different from the Internal or the External conditions goes against previous findings. For example, Wulf and colleagues have demonstrated that an External focus seems enhances motor performance, whereas an Internal focus neither enhances nor degrades performance compared to control conditions (e.g., Wulf et al., 1998). However, these previous studies required the execution of skills or more dynamic balance tasks, where baseline or control conditions may be more appropriate. In line with McNevin and Wulf (2002), the present study's baseline condition was actually different from the main experimental task. The baseline task did not require the touching of the sheet, and as such provides a limited control comparison for the two focus conditions which did require the execution of the supra-postural task and only demonstrates normal standing balance fluctuations. Therefore, the two attentional conditions can be considered separately from the baseline condition in post hoc tests. Therefore, the McNevin and Wulf study is another example of poor consideration of control conditions when assessing the effects of attentional focus during movement. This study could have benefited from a "no-focus touch" condition for comparison, if such a condition could actually be operationalised. Future studies need to consider more effectively the issue of control conditions.

The differences in results between the two studies may be due to slight differences in the methodology employed in each case. As McNevin and Wulf (2002) note, differences in the qualities of the hanging sheet could well explain these differences. However, as the present study replicated the methodology of McNevin and Wulf, this seems unlikely. What may be the case is that differences in the measurement of postural stability can alter the interpretations made from the data. McNevin and Wulf's study recorded Centre of Pressure (COP) as a measure of postural stability, whereas the present study assessed basic movement data: SD (Frequency) and Range (Amplitude) of GRF movement in each direction. McNevin and Wulf did find that the External focus demonstrated greater frequency of responding (fast Fourier transformations, FFT), compared to both Internal and baseline conditions. Due to technological limitations, the present study was unable to calculate FFT for a comparison.

The present findings demonstrate that an individual's postural control can be influenced by the attentional focus adopted during a supra-postural task. Specifically, the External focus demonstrated smaller and fewer postural movements when compared to the Internal condition. McNevin and Wulf suggest that future research should assess the performance on the supra-postural task in order to examine if and how minor variations in supra-postural tasks can affect performance on postural and supra-postural tasks. In line with this, the next question we asked was: do attentional focusing strategies alter the performance of a supra-postural task?

Arm Movement Kinematics Data

Overall (combined directions) frequency and amplitude of finger tip movement data demonstrated significantly less and smaller variation in movement when participants used the External focus than during both the Internal and Baseline conditions. This finding supports those of Wulf, Hoss, and Prinz (1998) where an External focus was beneficial when compared to both an Internal and control condition during a balance task. The larger amplitude of movement in the baseline and internal conditions supports the notion that an internal focus degrades movements by disrupting their execution, in this case through increasing the size of movements produced in a task requiring small variations. The smaller amplitude of motion in the external condition supports the theory that an external focus promotes more automatic movement execution.

Significantly larger fingertip movement frequency was observed in the Anterior-Posterior direction than in the Medial-Lateral direction and the Vertical direction, a finding most likely due to the direction of the touching task. Similarly, a significantly larger amplitude of movement in the Anterior-posterior direction was observed compared to the Vertical direction and closely significantly different from that in the Medial-Lateral direction. Movements of the curtain were more likely to occur in the anterior-posterior direction due to the placement of the curtain. Further analysis revealed that the effects of attentional focus were most evident in the vertical direction, with the external focus exhibiting reduced movement frequency when compared to internal and baseline conditions. This indicates that the external focus promoted more efficient control of movement in the vertical dimension, whereas the internal focus allowed finger movements to increase in this dimension of movement. It may well be that, due to the action of gravity on this pointing task, the vertical direction was the hardest direction to effectively control and the external focus offered protection from these effects.

Analysis of the amplitude of fingertip movement revealed that in the medial-lateral (the direction with the largest movement amplitudes) and the vertical directions, the external focus condition exhibited a significantly smaller amplitude of movement than both the

Internal and baseline conditions. In the anterior-posterior direction, the external focus exhibited a significantly smaller amplitude of movement when compared to the baseline, but not the internal condition. These data suggests that at the fingertip, the beneficial effects of an external focus are more pronounced than that of the frequency data. For such a fine motor control task, this may not be surprising. Performance decrements will be seen in the overall amplitude of movements produced, and the smaller amplitude of movements seen in the External condition suggest more efficient and automatic control of fingertip movements.

As the finger tip was the point of focus these findings are interesting. Previous studies have not assessed the effects of attentional focus instructions on the movements involved in supra-postural tasks. As the fingertip was the point emphasised through the instructions, the effects here show that attention is specifically affecting the area focused upon. These findings are also more supportive of the hypothesised influence of attentional focuses than the balance data. With the external focus showing clear benefits when compared to both the internal and baseline conditions. Of interest now is whether the same relationship is exhibited at each point along the pointing arm.

Overall frequency of wrist movements in the External condition was significantly less than in the baseline condition, but not different from the Internal condition. The Internal condition was not significantly different from the baseline. Frequency of wrist movement was significantly less in the vertical and medial lateral conditions than the Anterior-Posterior condition. Although the data shows that the frequency of wrist movements in the External condition was less than in both other conditions, the lack of significance against the internal condition does not support the previous research highlighting benefits of the external focus. Further analysis did not reveal any significant influence of attentional focusing strategies in each of the three directions.

Different than the frequency data, amplitude of wrist movement was significantly larger in both the Internal and baseline conditions when compared to the External condition. Whereas the effects of focus on frequency of movement may not be pronounced at this joint, the amplitude of movement variation is influenced by attentional focus, a relationship also observed at the fingertip. This suggests that the main influence on the control of arm movements is the size of movements carried out during the task. The smaller amplitude of movement demonstrated in the External condition supports research demonstrating more efficient movement execution and control using external focus instructions.

A larger amplitude of wrist movement was identified in the Anterior-Posterior direction when compared to the Vertical and Medial-Lateral directions. Again suggesting that the demands of this task promoted larger movement amplitude in the anterior-posterior direction. Further analysis revealed a reduced amplitude of movement under the external condition in the anterior-posterior direction when compared to the baseline, but not the Internal condition. Furthermore, in the vertical direction, the External focus exhibited a reduced amplitude of movement when compared to both the Internal and baseline conditions. No relationship was identified for the Medial-Lateral direction. This suggests that the benefits of an external focus of attention are more pronounced in the vertical plane of movement, a finding similar to that for the fingertip. Due to the positioning of the arm, control of the movement of the hand in the vertical direction would be critical to task success.

As the first joint not to be directly involved in the pointing task, and just required for support of the pointing forearm, the elbow may not reflect a large degree of movement variability. As such the overall frequency and amplitude of movement under each focus condition did not significantly differ. Again, effects may be observed in the Anterior-Posterior direction due to a significantly larger movement frequency and amplitude in this direction when compared to the Vertical and Medial-Lateral directions. This is further emphasised by a significant interaction between focus and direction. However, when broken down, the frequency data revealed no significant relationship for the influence of each focus strategy in each direction. The amplitude data, however, did reveal that the External condition exhibited reduced amplitude of movement in the Anterior-Posterior direction when compared to the baseline condition, but not the Internal condition. There were no differences identified in the medial-lateral or vertical directions, a finding not surprising when considering the constraints on the elbow during the task. The physical position of the elbow and the body next to the elbow during the task would lead to greatly reduced movement in these directions. Therefore, the Anterior-Posterior dimension offered the only plane for possible movement effects, but the external focus was only seen to be beneficial when compared to the baseline. Suggesting that, in the case of elbow movement, the supra-postural task significantly reduced amplitude of movement compared to the no-touch baseline condition.

As the next most distant joint from the point of focus and task, and as a more stable joint due to its connection to the body trunk, the shoulder may elicit further reductions in movement variation and possible fewer effects of attentional focus. However, movement of the shoulder may be more indicative of postural movements, and may reflect movement similar to GRF data. No main effects of focus type were identified for either the overall amplitude or frequency of movement of the shoulder. The frequency and amplitude of movement of the shoulder in the Anterior-Posterior direction was significantly larger than that in the Medial-Lateral and Vertical direction. Again, this may lead to focus effects being more pronounced in this direction. For the frequency and amplitude of shoulder movement data, both were found to be reduced under the external condition in the Anterior-Posterior direction when compared to the baseline, but not the Internal condition. But no relationship was identified for the

Vertical or Medial-Lateral direction, a finding not surprising giving the physical limitations of movement in these directions of the shoulder.

General Movement Discussion

Overall balance data analysis revealed that the external focus of attention promotes more effective postural control when compared to the internal focus of attention. This relationship was more pronounced in the anterior-posterior direction, the principal direction of movement involved in this task due to the direction of force being applied by the finger on the sheet. Arm movement analysis revealed that at the fingertip, an external focus demonstrated more efficient movement control when compared to the internal and baseline conditions, with specific reference to reducing the amplitude of movement produced. The effects of attentional focus were most pronounced in the vertical direction. Again, the amplitude of movement in the wrist demonstrated significant reductions in movement under the external condition when compared to the internal and baseline. This relationship was most pronounced in the vertical direction. An external focus of attention was not found to influence movement at the elbow, other than reduced movement in both supra-postural task conditions when compared to the baseline. Finally, the shoulder demonstrated no effects of attentional focus on movement, a finding unsurprising given physical limitations of movement and its distance from the task and point of focus.

Overall, these findings suggest that the effects of attentional focus strategies used during a light-touch supra-postural task can influence in the postural control and arm movements involved in the task. Due to the lack of a proper comparison condition, it is difficult to demonstrate whether the internal focus degraded or the external focus benefited movement efficiency. However, when compared to the baseline condition collected, it seems that the internal focus degraded balance performance when compared to an external focus which did not differ from the baseline. This supports the theory behind the constrained action hypothesis, where an internal focus onto the actions being executed disrupts movement quality by interfering with otherwise automatic processes.

For arm movement mechanics, specifically the movements of the fingertip and the wrist, the external focus showed clear benefits over both the internal focus and baseline conditions. Suggesting that, when it came to the supra-postural task, the external focus benefited performance by producing more efficient movements and reducing erroneous movements. Due to the small distance between the two focusing conditions, in that the external required participants to focus upon the movements of the curtain and the internal focus required participants to focus upon the movements of their finger, that a difference was demonstrated is evidence of the direct influence attentional focusing strategies can have upon movement quality. The arm movement findings support previous research which have demonstrated the benefits of an external focus when compared to an internal focus and control conditions (e.g., Wulf, Hoss, & Prinz, 1998; Wulf et al., 2003). It also provides evidence to support theories such as Prinz's "common coding theory" and Latash's "working end-point", where movements are hypothesised to be more efficient if they are controlled by a focus upon the desired outcome or goal of the movement.

The arm movement findings, specifically the finger tip movements, do not mirror the GRF data. Specifically, the GRF data showed that the Internal focus degraded performance (both amplitude and frequency of movement) when compared to the External focus and Baseline. A finding not supporting previous studies by Wulf and colleagues (e.g., Wulf, Hoss, & Prinz, 1998). On the other hand, finger tip movements demonstrated that the External focus benefited performance whereas the Internal focus was as detrimental as the baseline condition, a finding supporting the research by Wulf and colleuages (e.g., Wulf et al,. 2003). These differences are interesting, as it demonstrates that although attentional strategies used during a supra-postural task effects postural control, the more direct and pronounced effects are found in the actual task which is being focused upon. This has been demonstrated by studies assessing directly the effects of attentional focus upon balance (e.g., Wulf et al., 2001), dart throwing (e.g., Raldo et al., 2002), soccer (e.g., Wulf et al., 2000, experiment 2), tennis (Maddox et al., 2000) and golf (Wulf et al., 1999). This thesis should now progress to assessing the direct effects of attentional strategies upon task performance.

Post Task Questionnaire Analysis

This paper offers the first experimental evidence regarding participants' experiences of using different attentional focusing instructions using a post-task questionnaire. Although using simplistic questions, some valuable insight has been provided into how participants perceive the different focuses of attention they have been asked to use. No difference was observed in the number of participants preferring internal and external instructions, a finding not supportive of previous results (e.g., Wulf et al, 2001, experiment 2) which demonstrated clear preferences for an external focus. However, this approach has not been applied on enough occasions to suggest consistent trends in participants' preferences. Future research needs to address which focus types do participants prefer and whether this is different under certain conditions or during different skills. What may be more informative regarding participants' preferences is their experience of using each focus type.

Overall there were no significant differences in participants' ratings of how difficult each set of instructions were to carry out, how difficult they were to maintain, or how mentally demanding they were. This suggests that any effects seen in movements changes under different the attentional instructions was not due to difficulty in understanding, executing or maintaining these focus types. It may be the case that these questions do not adequately cover the experiences of participants' strategy use or that regarding the task used here, these experiences of each focus did not differ greatly. In a task that produces more obvious effects of attentional strategy success, such as an accuracy task, the experiences of each focus strategy may show more differences. There was a significant difference in participants ratings of how successful they felt each focus was. Participants rated the External focus as significantly more successful during the task than the Internal focus. Indeed, in the post task comments one participant suggested that "I found the more I focused on my finger the more it moved", demonstrating a sensitivity to the detrimental effects of an internal focus. This may contradict the earlier suggestion of no overriding population preference for a particular focus. That participants rated the External focus as more successful in this task does suggest that participants were aware of the benefits that this focus gave, therefore suggesting that participants do have a natural leaning towards external focus instructions when they are given and that this may be related to the success they feel it gives. However, this does not explain the large number of participants who did state that the Internal focus was there preferred focus which they would use again.

For further analysis and to hopefully assess possible explanations for the above discrepancy, participants ratings of their experience of each focus type was assessed separately with regards to which focus type they preferred. For the experience of the Internal focus, participants who rated the Internal or External focus as their preferred focus type did not differ in their ratings of how difficult this focus was to carry out, difficulty to maintain focus, the mental demands or how successful this focus was. For the experience of the External focus, participants who rated the Internal or External focus as their preferred focus type did not differ in their ratings of how difficult this focus was to carry out, the mental demands or how successful this focus was. They did significantly differ in their ratings of how difficult the external focus was to maintain, with participants who preferred the internal focus rating the external focus as significantly harder to maintain than those who actually preferred the External focus. This suggests that the reason participants chose the Internal focus as their preferred focus may not be down to how successful they thought this focus was, but that they found the External focus too difficult to maintain. It may be the case that some participants may be more naturally inclined towards an internal focus and that this may relate to their level of skill in a task. What is difficult to assess here is the level of expertise in the task administered. Level of expertise may influence preferred focus type, with novices findings it harder to use an external focus. To assess this issue, future research may need to use skills where level of expertise can be controlled for.

Interesting findings were demonstrated when State and Trait anxiety was analysed for differences between participants who preferred each focus type. No significant differences were identified between participants who preferred either the internal or external focus and their levels of state anxiety. For trait anxiety however, participants who preferred the Internal focus scored significantly higher in trait anxiety than those participants who preferred the External focus. This finding may reflect the data discussed earlier that participants who chose the internal focus as their most preferred were also most likely to rate the external focus as more difficult to maintain. As those who preferred the Internal focus scored higher in trait anxiety, it may be that the reported difficulty to maintain an external focus is related to the influence elevated anxiety levels have on attentional resources and working memory. Higher trait anxious individuals may find it easier to maintain an internal focus due as this may be a more natural focus for them to attain. This finding has implications for the application of attentional focus instructions, although further research is needed. Before directing a learners' or performers' attentional focus during movement, it may be necessary to consider the individuals' level of trait anxiety as this may influence the success the focus type has and the participant's experience of using it.

Methodological Issues

Unfortunately, this research did not address participants' experience of the baseline condition. This was due to the primary aim being to assess differences in experiences of the different focus types. However, in light of the findings, it seems that data regarding participants experience of the baseline "no instruction" condition would be valuable for full interpretation of results. This data would help explain why in research, and with the arm movement data here, has demonstrated that a control strategy is often as detrimental as an internal strategy. It could be that participants naturally adopt an internal strategy when confronted with a novel situation, something advocated by Wulf and colleagues (e.g., 2004). However given Wulf et al.'s (2001) suggestion that participants generally prefer an external focus, the proposal that participants may also naturally use an internal focus does not seem to comply. It may also be that participants have no direction in the control condition find tasks harder as they need to develop and carry out their own control strategies.

By placing sensors onto each joint of the arm, although useful for movement analysis, may well have changed the attentional manipulations from those used in the initial study by McNevin and Wulf (2002). The movement sensors and the larger camera used to measure movements of the sensors could have increased the difficulty of attaining a true External attentional focus due to constant reminder of a very Internal analysis. By emphasising that this study was interested in arm movements, participants could have found it difficult to ignore the sensors assessing their arm movements, thus increasing an Internal focus of attention. Furthermore, it has been shown that the presence of a camera or even a mirror can increase an individuals internal focus (e.g., Innes & Gordon, 1984; Liao & Masters, 2002). Even though efforts were made to place less emphasis on the sensors used, with time given for participants to become used to their presence, and that the camera was not in fact visually recording participants, the emphasis of the Internal focus was probably unavoidable. Although not an explanation for any reduced effects of the Internal focus, it is necessary to highlight these methodological concerns that may hinder future research assessing attentional focus and kinematic differences.

Implications for future research

For the scope if this thesis, these findings provide a foundation on which to develop further research. This can be achieved along three lines. Firstly, the influence of attentional focus on postural control remains an important avenue for investigation given its importance in both athletic performance and everyday activities. Therefore, further research needs to address the direct influence of attentional focusing instructions on postural control, rather than through a supra-postural task. These findings would have more relevance to developing appropriate instructions for applied fields such as coaching and rehabilitation. Furthermore, it seems that this avenue of research would now benefit from the use of a more dynamic test of balance, rather than quiet standing. The small effects that have been demonstrated in this current study may well have larger implications when applied to balance during more difficult conditions, something which has been demonstrated using unstable platforms by Wulf et al. (e.g., Wulf, Hoss, & Prinz 1998; Wulf et al. 2001). As Wulf and colleagues have consistently demonstrated that attentional focusing strategies can influence balance performance, other factors which have been shown to effect the ability to balance now need to be considered. One such factor which has been shown to influence postural control is fatigue, which is an inevitable factor involved in motor skills execution. Chapter 4 will consider the influence of fatigue further.

The second line of research is through skill execution. Whereas previous studies have principally used outcome measures (e.g., accuracy) to assess performance, this study assessed the effects of attentional focus on specific arm movements. The effects of attentional focus instructions on arm movement kinematics demonstrated here suggest that fine motor skills executed with the arm can be affected by direction of attention. Specifically, disturbances were larger the closer to the point of focus, suggesting that skills where attention can be directed towards the hand can be influenced by attentional focusing instructions. One such skill which incorporates arm movements and is particularity suitable for attentional manipulations through instruction, is dart throwing. Even small changes in the movements of the arm during a throw can result in large differences in accuracy. Therefore, one line of research to follow here will be the influence of attentional focusing instructions on dart throwing performance. If, as shown here, attention directed towards the hand can cause differences in movements, then dart accuracy will be significantly reduced under internal focus conditions. Furthermore, darts accuracy would also be significantly effected by any changes in a participant's postural stability, like those demonstrated here.

The third line of research supported in this study is the investigation of participants experiences of attentional manipulations. Findings here suggest that there may be differences in the experiences of participants, and that some may find specific instructions difficult. Future lines of research will attempt to address differences in experiences of attentional instructions using different tasks with more obvious results. Due to the more obvious measures of performance success, dart throwing may be a more fruitful line of research for participants experiences rather than balance tasks. Chapters 3 and 5 will continue to the line of research started here, assessing participants experiences of attentional focusing instructions during motor skill execution and learning.

Summary

The present study demonstrated that different attentional focusing instructions can influence the both balance and arm movements during a supra-postural task. Balance performance was shown to be more effective when an external focus was being used during the supra-postural task, when compared to baseline and internal instructions. An external focus produced more efficient movement at the finger tip and wrist during a light touching task. Such results have important implications for other tasks which require standing postural control whilst carrying out a skill, such as accuracy skills (e.g., darts, archery). Furthermore, they show the influence even subtle difference in instructions can have upon movement efficiency. Participants also seem to be aware of how successful each strategy is, regardless of not identifying the different strategies as more difficult or mentally demanding. However, those who preferred an internal focus rated the external focus as being more difficult to maintain and were also more likely to have higher levels of trait anxiety.

CHAPTER 3

THE EFFECTS OF ATTENTIONAL FOCUSING STRATEGIES ON NOVICE DART THROWING PERFORMANCE AND HEART RATE

Study 1 found that attentional focus manipulations can influence the movements of an arm during a simple pointing and touching task as well as standing balance. Specifically, when attention was directed towards the movements of the finger (internal focus) movements were larger and more frequent than when attention was directed towards the movements of the sheet which was being touched, when movements were smaller and less frequent. This suggests that skills executed with the hand may be particularly vulnerable to attentional focus manipulations. Developing on from this, the present study will investigate the effects of attentional focus manipulations during a dart throwing task. The accuracy of a dart throwing task would be greatly influenced by the changes in hand movements due to different attentional manipulations. Furthermore, Study 1 demonstrated that attentional manipulations on supra-postural tasks can influence postural control. It may also be the case then that dart accuracy will be influenced not only by changes in the movements of the arm, but also by changes in postural control as dart throwing can be considered a supra-postural task. Therefore, a dart throwing task is an ideal task for assessing the influences of attentional strategies on motor performance.

Research has shown that experts direct their attention externally (e.g., Hatfield, Landers, & Ray, 1984, 1987) and novices are traditionally instructed to direct their attention internally on what they are doing during a task (Gallwey, 1981). Influenced by this, Radlo et al. (2002) sought to assess the influence of different attentional strategies manipulated through instruction upon novices' darts performance, brain wave activity and heart rate. Radlo et al.'s findings provided support for the beneficial influence of using an external focus during a self-paced motor skill. Their findings showed that a group of novices using an external strategy performed with less error than an Internal strategy group on the darts task. Furthermore, their findings showed that cognitive strategies can influence the psychophysiology of novices. Changes in alpha power coincided with behavioural output such that when an external focus strategy was used, lower levels of left and right hemisphere EEG alpha power occurred immediately before dart release and this change was associated with superior task accuracy. Participants using the internal strategy produced poorer accuracy scores and an increase in overall alpha production. Participants in the External group also experienced a steady deceleration in heart rate immediately prior to dart release. The internal strategy participants showed a slight decrease in HR until the last heart beat epoch before initiating the toss, after which these participants experienced a significant increase in heart rate.

Radlo et al. (2002) specifically assessed the HR patterns during the best and worst 4 throws completed by each participant, a finding other researchers have had difficulties demonstrating (e.g., Boutcher & Zinsser, 1990; Crews, 1989; Molander & Backman, 1989). Radlo et al.'s results showed that a significant HR deceleration was associated with the best shots while the worst shots were exhibited a significant increase in HR. What was not assessed was the HR patterns exhibited during the best and worst throws for each strategy group. By assessing overall good and bad performances, Radlo et al. have mixed up attentional strategies and may have changed the relationships present. An analysis for each focus group may indicate different HR patterns for successful and unsuccessful throws whilst using each focus type.

What Radlo et al.'s (2002) study does not provide is theoretical discussion of why their attentional manipulations and their associated 'expert'-like physiological states should influence performance in the observed way. Research, reviewed elsewhere, by researchers such as Wulf and colleagues (e.g., 2001) and Singer (e.g., 1994) have suggested possible mechanisms for these benefits. Wulf and Prinz's (2001) advancements on the Common Coding theory is particularly relevant here. Perception and action require a common representational medium for efficient action, and as such external movement end-points or goals provide the best method of achieving this. Wulf and Prinz add to this that the external focus should be, on one hand, as distant as possible, but also on the other hand, as close to the movements that produced them as possible, thus requiring an ideal midpoint to focus upon. The first point is based on research demonstrating that a focus of attention too close to the movements producing them is hard to discriminate from the movements themselves, and movement becomes degraded due to the internal focus that develops. The second point is based upon research demonstrating that focusing too far from the movements being produced can lead to performance decrements due to the distant focus's lack of association with the movements being carried out. For the internal focus, on the other hand, by focusing onto the movements being carried out, an individual breaks down and disrupts automatic processes - present even in unlearned or newly acquired skills - through conscious awareness. Movements thus become slower and more error prone.

As discussed, HR has been suggested to reflect attentional states. For instance, HR deceleration appears to accompany, and to index, the presence of spare capacity or attentional reserves whereas HR acceleration is more prevalent in conditions of processing overload (Abernethy, 2001). However, an increasingly popular measure of mental workload is HR *variability*. 'Heart Rate Variability' (HRV) has become the conventionally accepted term to describe variations of both instantaneous heart rate and RR intervals (RR intervals, or Interbeat intervals, represents the time from the R peak in one heart beat to the R peak in the next heart beat sequence) and has considerable potential to assess the role of autonomic nervous system fluctuations in normal healthy individuals (Task Force of the European Society of Cardiology and The North American Society of Pacing and Electrophysiology, 1996). Across a range of different methods of calculating variability, heart rate variability appears to decrease with increasing attentional demands of tasks (Vincente, Thornton, & Moray, 1987), making it one of the more promising physiological indicators of attentional workload or effort (Abernethy, 2001). Unfortunately, HRV has received little or no usage in assessing the attentional demands of different sports tasks, probably due to methodological problems which see cognitive associated cardiac changes 'swamped' by the cardiac activity associated with physical activity. However, sports with limited physical activity requirements, such as aiming activities, may offer an opportunity to study HRV. The present study will attempt to assess HRV during novice dart throwing under different attentional conditions.

The present study aimed to replicate and expand upon Radlo et al.'s (2002) study. One progression will be the emphasis on instructions used. Specifically, in addition to the attentional strategies used by Radlo et al., the instructions will emphasis Wulf and colleagues' guidelines for defining each attentional focus. Prior to receiving the internal instructions, participants will be told to "focus onto the movements of the arm during each throw using the instructions given". The external instructions will emphasise "focusing onto the goal of the dart throw by using the instructions given".

Another progression will be the inclusion of a control condition. Study 1 highlighted the need for appropriate control conditions for effective comparison of focus strategies against "no instruction" states. Radlo et al. (2002) themselves stress that, by not including a control condition in their own study, they have limited the possible interpretations of their data. In applied situations, where a no-instruction state is generally never advocated, the lack of control condition is of less concern when the direct comparison between focus strategies. But for true comparisons to be made to assess the direction of the relationship (e.g., does the internal focus degrade or the external focus improve performance?), the Control condition is critical. Although there are difficulties in oprationalising a no-instruction condition, effort has been made in the present study to create a "just do it", no-instruction approach.

Another progression from the Radlo et al. (2002) study, and a continuation of the findings from Study 1 is that of participants' experiences of the strategies they have been given to use. Study 1 demonstrated that there were no significant differences in the preferences of the external focus over the internal focus strategy. However, participants rated the external focus as being more successful than the internal focus. There were no overall differences in the ratings of how difficult each strategy was to carry out, how difficult they were to maintain, or what level of mental demands they required. But when compared between focus preference, those who preferred the internal focus rated the external focus as being more difficult to maintain. One limitation of the previous study was that the task effects were extremely subtle, and therefore participants' experiences of them may be reduced. The present study offers a task where the possible differences between the accuracy of the different strategies is larger, and therefore the experiences of the participants may differ. Furthermore, the between-subjects design of the present study may indicate differences between the groups assigned to each strategy.

Study 1 demonstrated that trait anxiety significantly influenced specific ratings of participants' experience of each focus condition. This study sought to further assess this finding. The dart task provides a potentially more anxiety-provoking situation than just quiet stance due to its obvious performance measurements. Therefore, pre-test state anxiety will be measured to assess differences between each focus group's experiences of their instructions. Specifically, state anxiety will be measured after the task has been introduced to the participants so as to assume full awareness of the task and therefore appropriate anxiety levels.

Hypotheses

1. The different attentional strategies will significantly affect novice darts throwers accuracy.
2. The different attentional strategies will significantly affect novice darts throwers' heart rate characteristics prior to each dart throw.
3. Novice darts throwers will show significant differences in their experiences of using different attentional strategies, and this will be affected by anxiety.

Method

Participants

Sixty-seven participants volunteered to participate in this study, 30 males and 37 females (mean age = 20). Participants were made up of psychology undergraduate students earning course credit, other undergraduate students and university staff. Participants were randomly allocated to either the Control, External or Internal focus group. Twenty-two participants (10 males and 12 females) were allocated to the Control condition; Twenty-two participants (11 males and 11 females) were allocated to the External condition; and twenty-three participants (9 males and 14 females) were allocated to the Internal condition. The University of Hull Department of Psychology Research Committee approved the protocol used in this study.

Participants were all novice dart throwers. Radlo et al. defined novice dart throwers by the criterion that none selected had thrown darts on more than five previous occasions. Furthermore, potential participants recording a mean score less than 3.5/9 on 5 practice throws were excluded from the study (the lower the score the better the performance). Furthermore, data from participants who consistently failed to hit the target at all was also removed.

Instrumentation

Dart Target and Darts

Paper overlay sheets were placed over a cork background for the target. The target was printed on white sheets of paper which were easily replaced after use, limiting information to subsequent participants regarding previous performances. The target consisted of 10 black concentric circles (line weight 13) for scoring purposes. The centre circle was 10cm in diameter, and each successive circle was 10cm larger in diameter. Each circle was numbered 0 – 9, with a zero score being a perfect shot in the centre circle of the target. The target was placed on a wall, 366cm (12ft) from the thrower, and centred 183cm (6ft) above the floor. Standard darts were used in the study. Each dart was numbered (1-4) so that scoring each throw would be possible.

Heart Rate Monitor

Polar S810i™ heart rate monitor watches and Polar T61™ chest transmitters were used to obtain HR data from participants throughout the task. This system allows a convenient and comfortable method of data collection during activity, with HR activity transmitted from the chest strap to the watch receiver where it is recorded for later download or online recording. To enable accurate measurement of heart rate, the watch receiver was set to collect every R-R interval. R-R interval recording measures and records each individual heart beat, allowing for accurate inter-beat interval (IBI) measurement. An IBI is the time in ms from the it-wave peak in one heart beat to the it-wave peak in the next heart beat sequence. Therefore, an IBI is inversely proportional to the typical HR measurement in which HR is calculated according to how many it-wave peaks are recorded in 60s. When a person experiences HR deceleration, the time between one heart beat and another actually increases. Thus, as an IBI increases within a given time period, HR decelerates. An IBI that is decreasing is representative of an accelerating HR.

Polar Precision Performance™ SW 4 software was used to record the data using online real-time recording and the heart rate recorder watch was attached to a USB IR data receiver which transferred the heart rate to the computer in real-time. For data collection to be accurate the watch was placed within 1m of the participant during testing. Online recording allowed the time of dart throws to be marked onto the data by the software. Using a handheld switch attached to the computer through the mouse port, the experimenter manually marked the data as close as possible to the throw release. To improve accuracy, the experimenter practised this technique for a complete 50 throw trial with a colleague before the study began. For data analysis, the software allowed the 6 IBIs before each throw to be identified and recorded. This raw data was input into SPSS for analysis. For analysis of good and bad throws, the HR data of the 4 best and 4 worst throws for each participant were selected.

Measures

State anxiety was assessed by administering the State scale of the State-Trait Anxiety Inventory (Spielberger, Gorsuch, & Lushene, 1970) (Appendix 2) prior to the task beginning. To ensure measurement of task anxiety levels, participants completed this questionnaire after being introduced to the lab, having the task explained to them and having the HR monitors attached.

After completing all their throws, participants were required to fill out a post-task questionnaire (Appendix 4). This consisted of 4 questions answered on a 5 point Likert scale of 1 = low and 5 = high. These questions were: How difficult was it to carry out these instructions?; How difficult was it to maintain these instructions throughout the task?; What was the level of the mental demands?; How successful do you think this condition was in making your dart throws accurate? Another question was: Approximately, on how many of the throws do you think you used the instructions? This was answered as a percentage ranging from 0 to 100 rising in tens. A space was also available for open comments on experience and the instructions used; detail was encouraged.

Procedure

Upon arrival at the human performance laboratory, participants were introduced and allowed to become familiar with the laboratory surroundings, and then asked to read and sign an informed consent form. HR measurement equipment and procedure was introduced and participants were given the opportunity to decline from participating in the HR data collection if they felt uncomfortable with the procedure. Opportunity was given for participants to ask questions.

Participants were instructed on how to fit the heart rate chest strap if they agreed to take part and were then directed to a private room to put the chest strap on. Once the strap was fitted, its transmission to the HR monitor was tested, and if this was successful the participant was given 5 minutes quiet time to become accustomed to wearing the chest strap. During this time participants filled in state anxiety questionnaires.

Once participants were finished filling in questionnaires and were comfortable, they were directed to the dart board. Instructions regarding where to stand were given and the procedure was again made clear. Once ready, participants listened to verbal instructions corresponding to their particular strategy group and participants were asked to try to use the instructions before and during their throw. The instructions were adapted from those found successfully to induce appropriate attentional states in the Radlo et al. (2002) study. Individuals in the Internal focus group were instructed to focus onto the movements that they were carrying out during each throw and use the instruction they were given to do this. Specifically: 1) feel the weight of the dart in their hand; 2) think about drawing the dart back to the ear; 3) feel the bend in the elbow; and 4) feel the dart as it left the finger tips. Individuals in the External focus groups were directed to focus on the outcome of the task and use the instructions given to help achieve this. Specifically: 1) focus on the centre of the dart board; 2) slowly begin to expand upon perspectives of the dart board; 3) then refocus to the centre of the dart board, expanding the centre and, making it as large as possible; and 4) toss the dart when so focused (all instructions are presented in Appendix 8). These scripted instructions were recorded onto a CD by the experimenter and repeated before every practice throw and before every 1st and 3rd throw of every block.

The length of time needed to use each instruction set was appropriate as it gave time for more accurate assessment of HR between each throw conducted. It was repeatedly stressed that it was important to use the instructions before and during every throw. After administration of either the internal or external instructions, each participant performed 10 practice throws using their particular strategy. This was followed by 40 test throws, divided into 10 blocks of 4 throws each.

After completing the test throws participants were directed to fill out post-task state measures and a post-task experience questionnaire (mentioned above). The instructions were assumed to have effectively manipulated participants' attentional focus. To further investigate this, a post-task questionnaire was administered to investigate 3 issues concerning the attentional manipulation: How difficult was it to carry out the instructions? How difficult was it to maintain these instructions? How mentally demanding were your instructions? How successful do you feel these instructions were? And additionally how many trials they used the instructions. Participants were also given the opportunity to give open comments on their post-task questionnaire.

Once completed, participants were debriefed both orally and in writing as to the aims of the experiment. Any questions were answered, and contract details were made available so that future questions could be addressed. A short report based on the results of the study was made available to all participants in the study, all of whom were contacted via email.

Data Manipulation

Performance Data

The mean score of each block of 4 throws was used as a measure of accuracy during the task. This results in 10 separate scores representing progression through the task. Darts missing the target completely were scored as a 9.

Heart rate data

Data from 9 was removed from the analysis for participants with large amounts of missing heart rate data, those who had refused to take part in the heart rate measurement and participants whose data was contaminated by problems with the equipment. This resulted in a final population of 58 participants. Missing values in the remaining participants' data were calculated using SPSS function 'Replace Missing Values'. The SPSS function 'Replace with mean of (3) nearby points' was used to calculate new values. Heart rate variability was calculated as the standard deviation of IBIs (ms) during the four epochs prior to each throw. This standard deviation measure is the simplest variable to calculate from the data collected, with other more accurate measures requiring larger periods of data recording.

Results

Performance Data

Performance scores were based on where a dart landed within the 10 concentric circles of the dart board. A perfect score of 0 was recorded if a dart was thrown into the centre of the dart board (bull's-eye), while a score of 9 was recorded if a dart landed in the last circle or missed the board completely. Ten trial blocks consisting of four throws were completed, totalling 40 throws.

Table 3.1: Accuracy scores for each attentional strategy

	Focus Condition			
Block	Control (22)	External (22)	Internal (23)	Total (67)
	Mean SD	Mean SD	Mean SD	Mean SD
1	3.48 (1.42)	3.83 (1.21)	5.13 (2.08)	4.18 (1.76)
2	3.62 (1.48)	3.30 (1.47)	4.60 (2.02)	3.86 (1.76)
3	3.12 (1.11)	3.57 (1.58)	4.63 (2.14)	3.80 (1.78)
4	3.00 (1.34)	3.83 (1.27)	4.21 (1.76)	3.70 (1.54)
5	3.50 (1.69)	3.37 (1.56)	4.50 (1.73)	3.81 (1.72)
6	3.39 (1.27)	3.10 (1.40)	4.03 (1.81)	3.52 (1.55)
7	3.29 (1.49)	3.55 (1.36)	3.98 (1.71)	3.62 (1.54)
8	3.35 (1.49)	3.31 (1.28)	4.01 (1.98)	3.57 (1.63)
9	2.57 (0.92)	3.21 (1.60)	4.09 (1.97)	3.32 (1.67)
10	2.71 (1.22)	3.63 (1.37)	4.22 (1.64)	3.54 (1.54)
Total	3.20 (1.49)	3.47 (1.41)	4.34 (1.88)	

Performance Scores Analysis

An Attentional Strategy (3) x Trial Block (10) ANOVA with repeated measure on the last factor (Attentional Strategy was inputted as a between subject factor) was carried out. A main effect of block was revealed ($F_{(9,558)}$ = 2.99, p = 0.002, η_p^2 = 0.05). No significant interaction was revealed between Block and Attentional Strategy ($F_{(18,558)}$ = 1.44, p = 0.11, η_p^2 = 0.04). A main effect for Attentional Strategy was revealed, ($F_{(2,62)}$ = 5.419, p = 0.01, η_p^2 = 0.15). Least Significant Difference (LSD) post hoc analysis revealed that the Internal condition was significantly less accurate than the External (p = 0.02) and Control (p = 0.003) conditions, which themselves were not significantly different in accuracy (p = 0.47). Furthermore, η_p^2 shows a large effect size (Cohen, 1992), with group membership accounting for 15% of the variability of throw accuracy. As shown in Figure 3.1, dart throwers using the External and Control strategies recorded a mean score of 3.470 (SE = 0.263) and 3.202 (SE = 0.263) respectively, whereas throwers using the Internal strategy recorded a mean score of 4.339 (SE = 0.251), the lower the score the more accurate the performance. Figures 3.1 and 3.2 highlight this relationship.

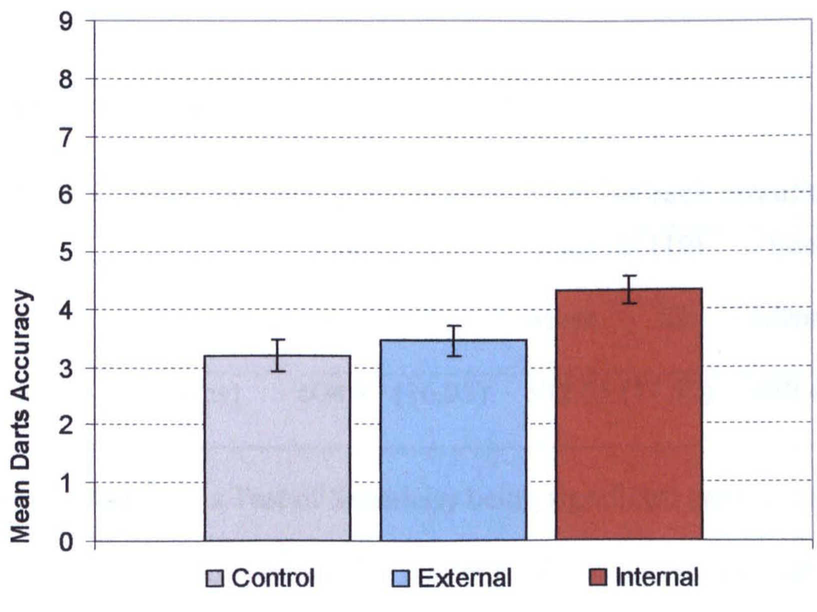


Figure 3.1: Mean accuracy scores for each attentional strategy group (Lower value indicates more accurate score)

Figure 3.2 highlights the performance across trials during each condition. The Test of Within-Subjects Contrasts found a significant Linear Trend for Block ($F_{(1,62)}$ = 11.680, p

$= 0.001$, $\eta_p^2 = 0.16$), and a significant Quadratic trend for Block x Focus ($F_{(2,62)} = 3.90$, $p = 0.03$, $\eta_p^2 = 0.03$).

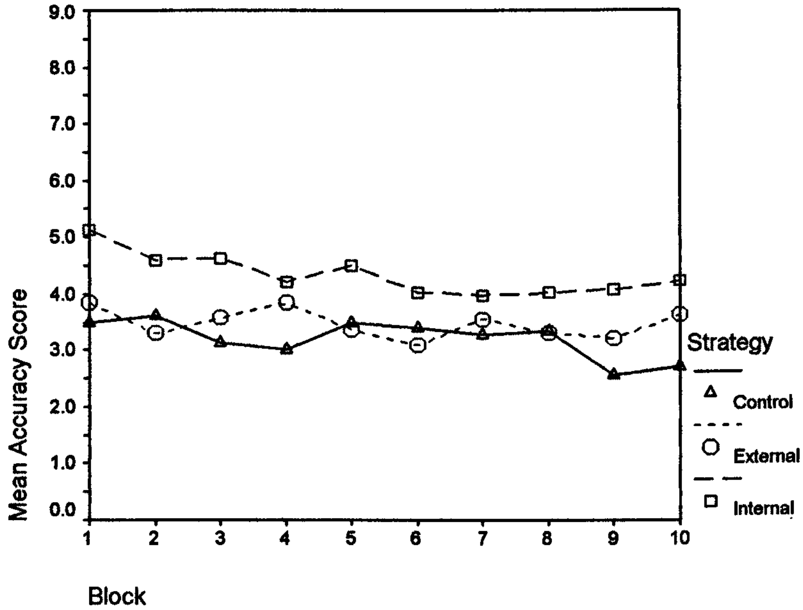


Figure 3.2: Mean accuracy values for each attentional strategy during each block of throws (Lower values indicate increased accuracy)

Heart Rate Data

Table 3.2: Mean IBI (ms) prior to dart throw for each attentional strategy

	Control (21)		External (19)		Internal (18)	
	Mean	SE	Mean	SE	Mean	SE
Average IBIs (ms)	604.89	(16.95)	592.65	(17.82)	680.45	(18.31)

Due to Mauchley's Test of Sphericity being significant ($p<0.05$) for Epoch and Block, Epsilon corrections were used in the form of Greenhouse-Geisser values. Maucheleys Test of Sphericity was not significant for Throw ($p>0.05$).

A Focus (3) x Block (10) x Throw (4) x Epoch (4) ANOVA was performed (with repeated measures on the last three factors). Results did not reveal any interaction between Attentional Focus Strategy and Epoch ($F_{(3.58, 98.33)} = 1.27$, $p = 0.29$, $\eta_p^2 = 0.04$).

A main effect of Focus was identified ($F_{(2,55)} = 6.94$, $p = 0.002$, $\eta_p^2 = 0.20$). A Least Significant Difference (LSD) analysis revealed that the HR for those using Internal strategy (680.45, SE = 18.31) was significantly slower than the Control (p = 0.004, m = 604.89, SE = 16.95) and External (p = 0.001, m = 592.65, SE = 17.82) Conditions, which themselves were not significantly different (p = 0.62). Figure 3.3 highlights the relationship.

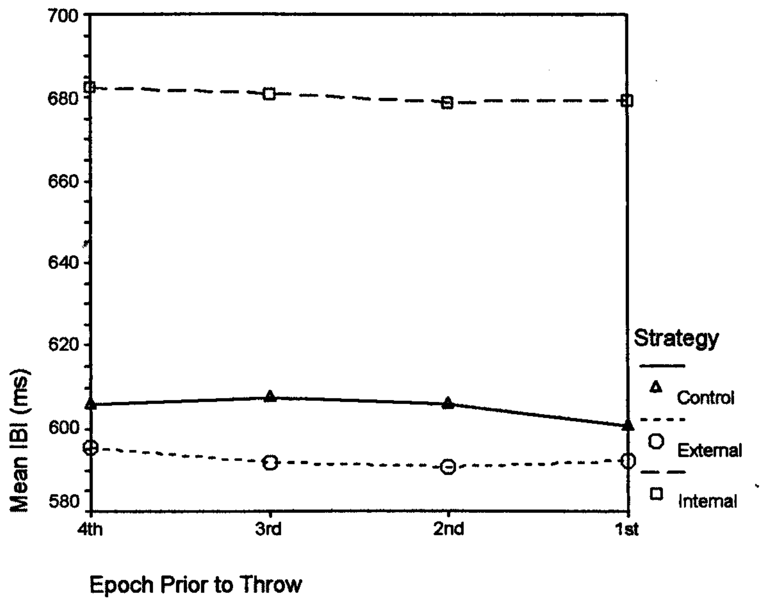


Figure 3.3: Mean IBI values for each attentional strategy at each epoch prior to dart throw

A main effect for Throw was revealed ($F_{(3,165)} = 3.01$, $p = 0.032$, $\eta_p^2 = 0.05$), although η_p^2 reveals this to be only a medium effect size (<0.06). An LSD post hoc analysis revealed that heart rate during throw 2 (m = 620.11, SE = 10.19) was significantly different from heart rate during throw 3 (p = 0.03, m = 629.41, SE = 10.63) and 4 (p = 0.005 , m = 630.74, SE = 11.01). No other significant differences were revealed.

A significant main effect of Epoch was observed ($F_{(1.79, 98.33)} = 3.20$, $p = 0.05$, η_p^2 = 0.06), and η_p^2 reveals this to be a medium effect size. LSD analysis revealed that epoch 1 (m = 627.94, SE = 10.33) was significantly larger (slower) than epoch 3 (p = 0.05 , m = 625.18, SE = 10.18) and epoch 4 (p = 0.04 , m = 624.11, SE = 10.33). Epoch 2 (m =

626.77, SE = 10.17) was significantly larger than epoch 3 (p= 0.04). No other significant differences were revealed. Figure 3.4 highlights this relationship.

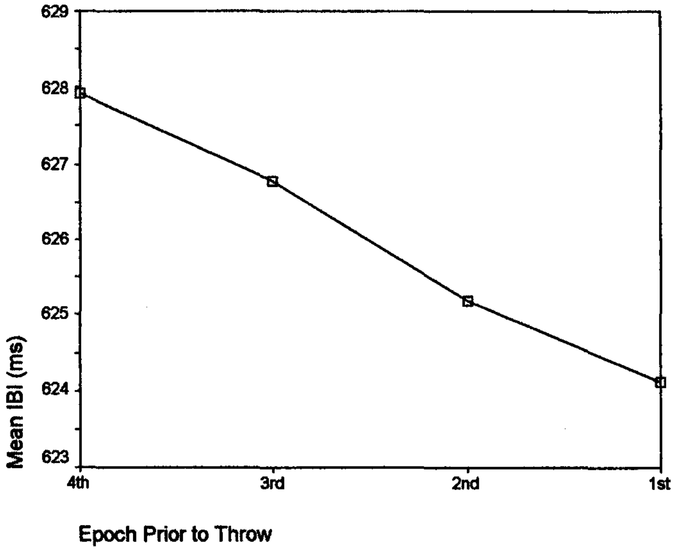


Figure 3.4: Mean IBI (ms) values at each epoch prior to dart throw

HR during Best and Worst Throws

Table 3.3: Mean IBI (ms) values for each attentional strategy prior to the best and worst 4 dart throws

	Focus Condition							
	Control (21)		External (19)		Internal (18)		Total (28)	
	Mean	SE	Mean	SE	Mean	SE	Mean	SE
Best 4 Throws	602.36	(14.18)	605.10	(17.46)	682.25	(25.62)	629.90	(11.07)
Worst 4 Throws	606.10	(14.28)	585.25	(18.26)	678.00	(22.33)	623.11	(10.53)

A Focus (3) x Best 4/Worst 4 (2) x Throw (4) x Epoch (4) ANOVA (with repeated measures on the last 3 factors) did not reveal any significant differences between the HR patterns of the best and worst throws of each participant ($F_{(1, 55)}$ = 2.50, p = 0.12, η_p^2 = 0.04). However, when analysed separately for each focus type, the Best 4/Worst 4 (2) x Throw (4) x Epoch (4) x Focus (3) ANOVAs (with repeated measures on the last 3 factors) a significant difference was revealed for the External focus group ($F_{(1, 18)} = 8.61$, $p = 0.01$, $\eta_p^2 = 0.32$), but not in the Internal ($F_{(1, 17)} = 0.29$, $p = 0.60$, $\eta_p^2 = 0.02$) or Control ($F_{(1, 20)} = 0.25$, $p = 0.62$, $\eta_p^2 = 0.01$) conditions. The average IBIs during the epochs leading up to the best throws in the External (m = 605.10, SE = 17.46) group were significantly larger (slower) than the worst throws (m = 585.25, SE = 18.26). Figures 3.5, 3.6 and 3.7 highlight these trends.

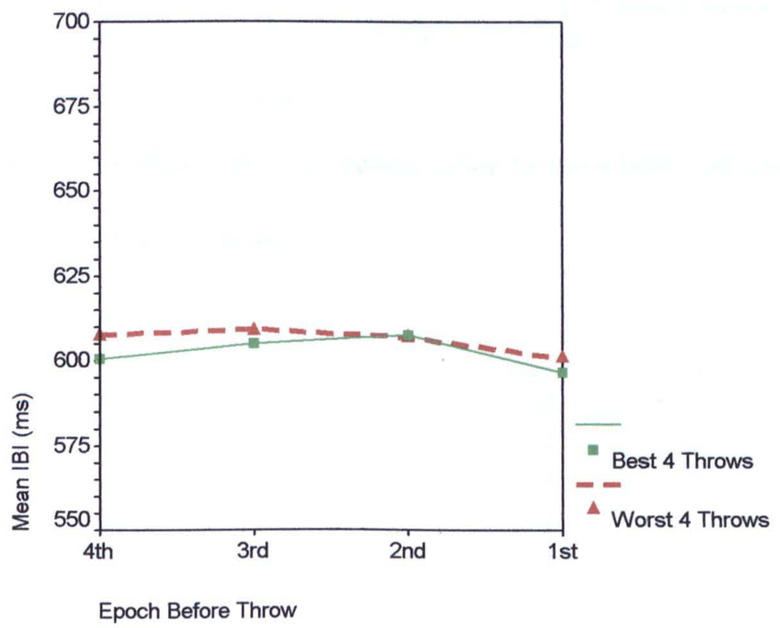


Figure 3.5: Mean IBI (ms) values prior to the 4 best and worst dart throws for the control strategy group

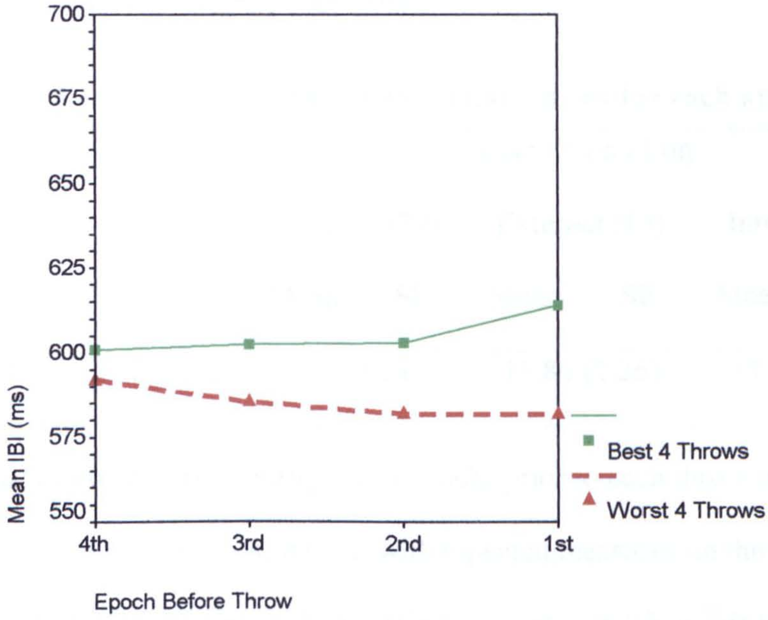


Figure 3.6: Mean IBI (ms) values prior to the 4 best and worst dart throws for the External strategy group

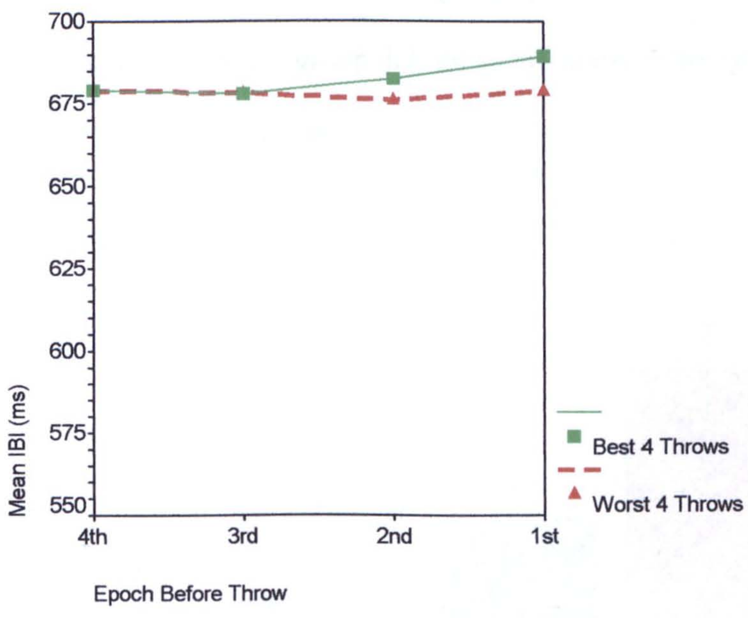


Figure 3.7: Mean IBI (ms) values prior to the 4 best and worst dart throws for the Internal strategy group

Heart Rate Variability (HRV) Data

Table 3.4: HRV (ms) values prior to dart throw for each attentional strategy

	Focus Condition					
	Control (21)		External (19)		Internal (18)	
	Mean	SE	Mean	SE	Mean	SE
IBI Variability (ms)	17.35	(2.15)	15.80	(2.26)	23.43	(2.33)

Analysis of the HRV during the 4 epochs prior to each throw using a 3 (Focus) X 10 (Block) X 4 (Throw) ANOVA (with repeated measures on the last 2 factors) revealed a significant main effect of Focus ($F_{(2, 55)}$= 3.09, p=0.05, η_p^2=0.10). η_p^2 reveals this to be a medium-large effect size, with group membership accounting for 10% of HRV differences. LSD analysis indicated that IBI variability for the External group was significantly lower than the Internal group (*p*=0.02), but not the Control group (*p*=0.62). The Control and Internal group did not significantly differ (*p*=0.06). Figures 3.8 and 3.9 highlight this relationship.

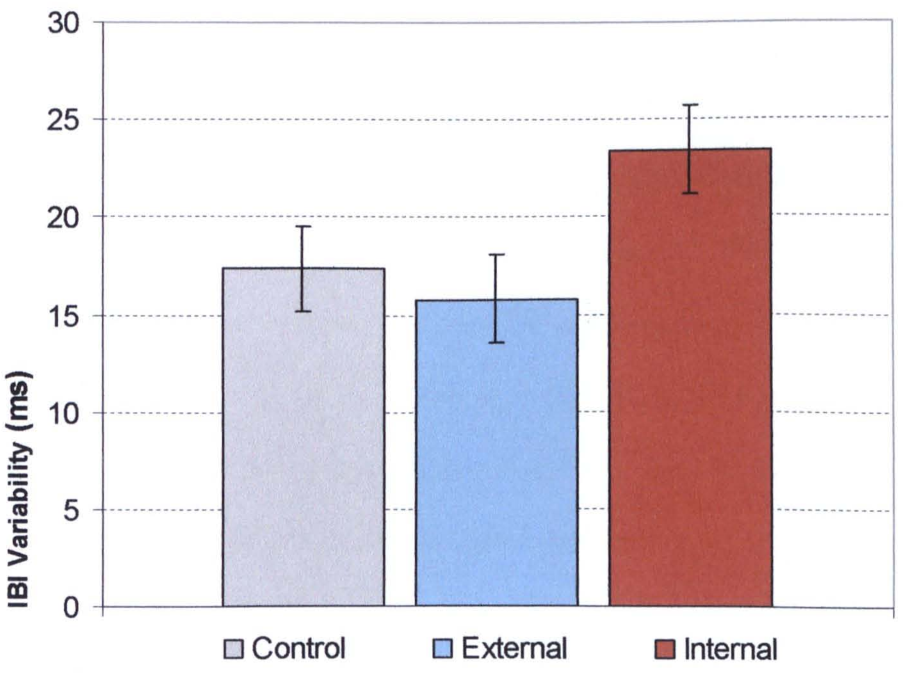


Figure 3.8: HRV (ms) values for each attentional strategy

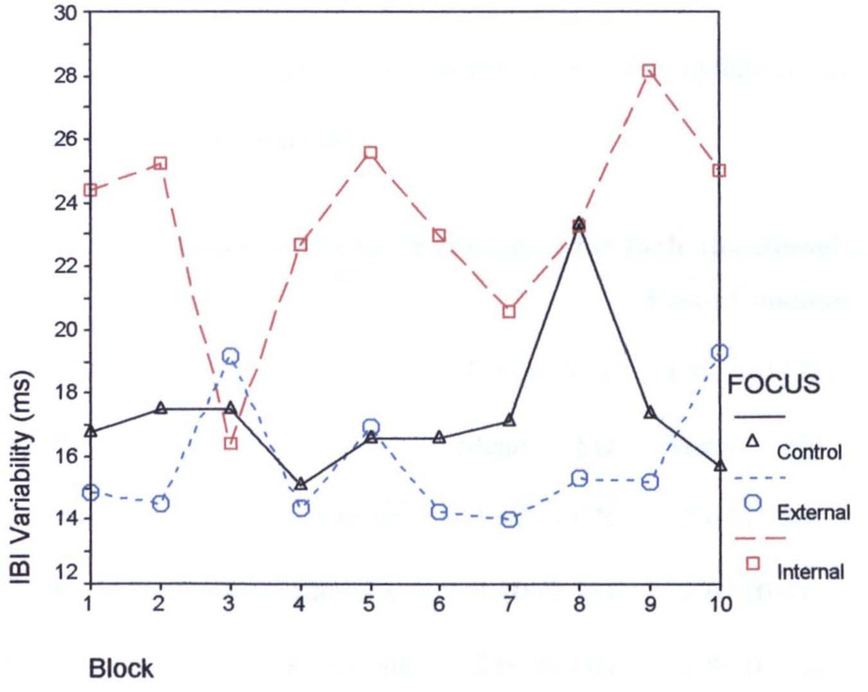


Figure 3.9: HRV (ms) values for each attentional strategy at every block of throws

Post Task Questionnaires Analysis

Analysis of post task questionnaires to assess focus manipulation was analysed used a one-way ANOVA in each case.

Table 3.5: Post-task questionnaire responses for each attentional strategy

	Focus Condition		
	Control (21)	External (21)	Internal (22)
Question	Mean SD	Mean SD	Mean SD
Difficulty to carry out instructions	1.62 (1.07)	2.05 (0.86)	2.5 (1.30)
Difficulty to maintain instructions	2.10 (1.18)	2.67 (0.97)	2.86 (1.39)
Mental demands of the instructions	2.00 (1.00)	2.86 (0.91)	2.95 (1.05)
How successful were the instructions?	3.00 (0.95)	3.43 (0.75)	2.73 (0.83)
Percentage of throws instructions were used	83.33 (14.26)	77.14 (11.46)	77.73 (9.73)

Mean responses to how difficult participants perceived their instructions to carry out were for the Control condition 1.62 (SD = 1.07), External Condition 2.05 (SD = 0.86), and Internal Condition 2.5 (SD = 1.3). The One-Way ANOVA revealed a significant main effect for focus on responses to how difficult it was to carry out the instructions, ($F_{(2,63)} = 3.467, p = .037$). LSD post hoc analysis revealed that participants using the Control strategy rated this as less difficult than those using the Internal conditions (p = 0.01). The External condition was not significantly different from the Control (p = 0.21) or Internal (p = 0.18) conditions. Figure 3.10 highlights this relationship.

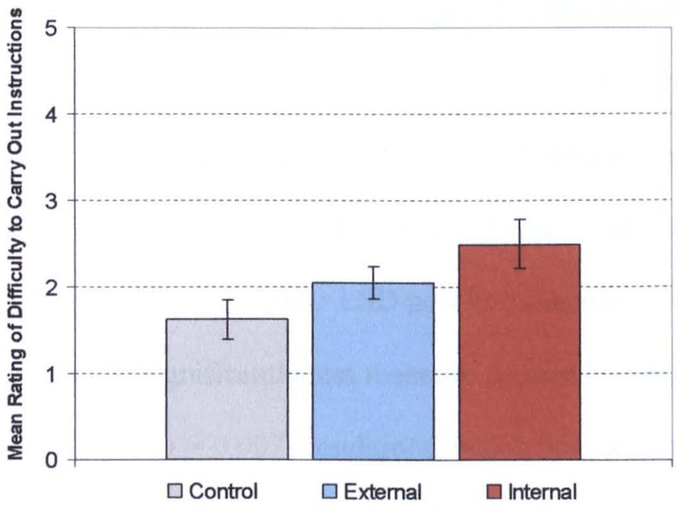


Figure 3.10: Mean responses for "Difficulty to carry out instructions" for each attentional strategy

Mean responses to how difficult participants perceived their instructions were to maintain are for the Control condition 2.1 (SD = 1.18), External Condition 2.67 (SD = 0.97), and Internal Condition 2.86 (SD = 1.39). The One-Way ANOVA did not reveal a significant main effect for focus on responses to how difficult it was to maintain the instructions, ($F_{(2,63)} = 2.379$, $p = 0.10$). Figure 3.11 highlights this relationship.

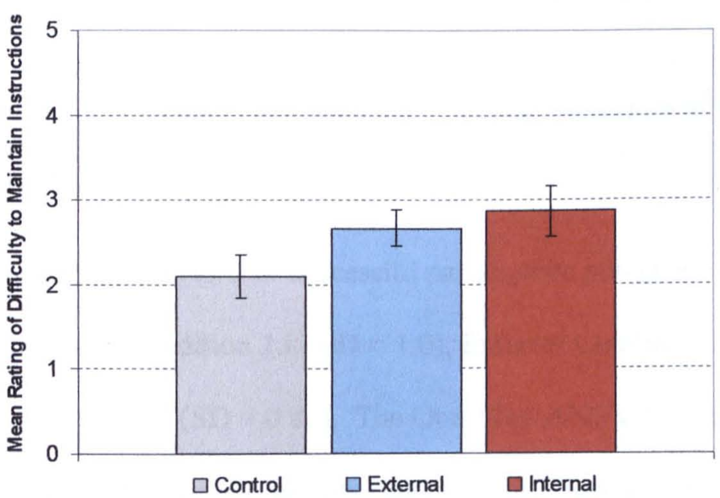


Figure 3.11: Mean responses for "Difficulty to maintain instructions" for each attentional strategy

Mean responses to how mentally demanding participants perceived their instructions to be are for the Control condition 2.00 (SD = 1.0), External Condition 2.86 (SD = 0.91), and Internal Condition 2.95 (SD = 1.05). The One-Way ANOVA revealed a significant main effect for focus on responses to the level of mental demands of the instructions, ($F_{(2,63)}$ = 5.999, p = 0.004). LSD post hoc analysis revealed that the control condition was rated as significantly less mentally demanding than both the Internal (p = 0.002) and External (p = 0.007) conditions, which themselves were not significantly different (p = 0.75). Figure 3.12 highlights this relationship.

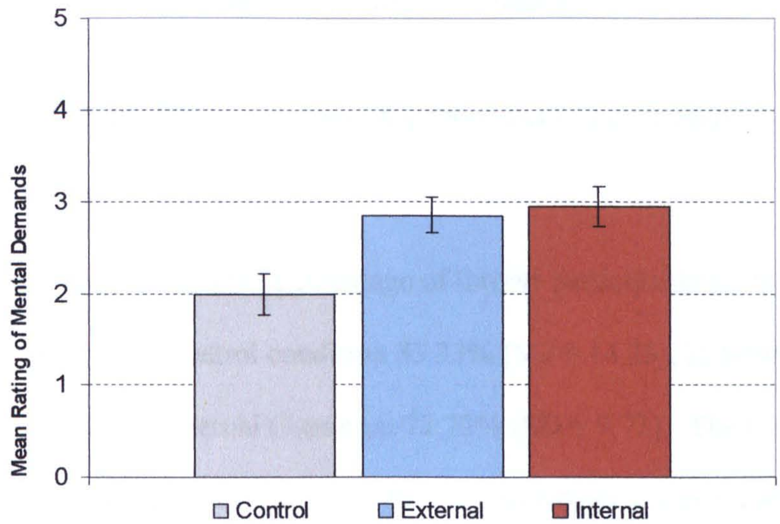


Figure 3.12: Mean responses for "Mental Demands of Instructions" for each attentional strategy

Mean responses to how successful participants perceived their instructions to be are for the Control condition 2.0 (SD = 1.0), External Condition 2.85 (SD = 0.91), and Internal Condition 2.73 (SD = 0.83). The One-Way ANOVA revealed a significant main effect for focus on responses to how successful the instructions were perceived to be, ($F_{(2,63)}$ = 3.753, p = 0.029). LSD post hoc analysis revealed that participants using the Internal strategy rated this as significantly less successful than those using the External strategy (p = *0.008*), while the Control condition was not significantly different from either the

Internal ($p = 0.29$) or External ($p = 0.11$) Condition. Figure 3.13 highlights this relationship.

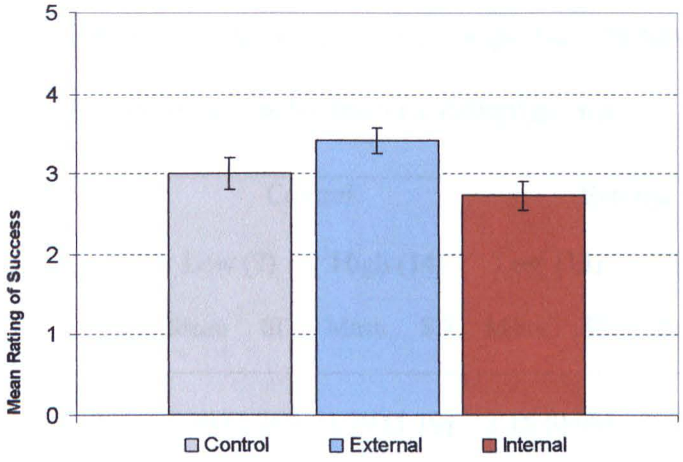


Figure 3.13: Mean responses for "Success of instructions" for each attentional strategy

Mean responses to the percentage of throws participants estimated using the instructions on are for the Control condition 83.33% (SD = 14.26), External Condition 77.14% (SD = 11.46), and Internal Condition 77.73% (SD = 9.73). The One-Way ANOVA did not reveal a significant main effect for the percentage of throws instructions were estimated to have been used, ($F_{(2,63)} = 1.733$, $p = 0.185$). Figure 3.14 highlights this relationship.

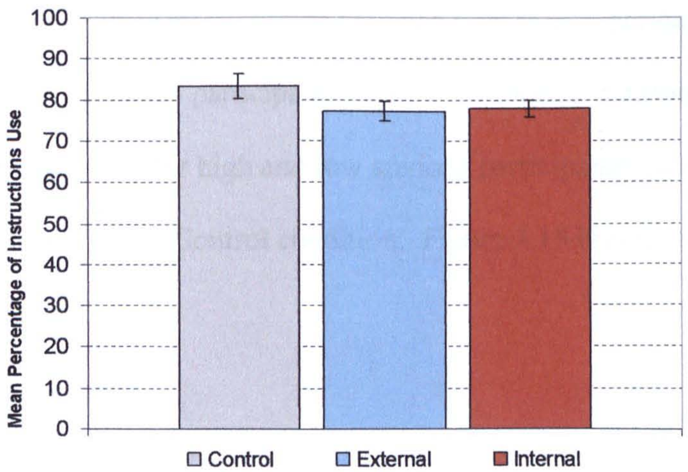


Figure 3.14: Reported percentage of throws where instructions were used

Pre and Post State-Anxiety Relationship with Post Task Experience

Pre-Test State Anxiety

Table 3.6: Post task questionnaire responses for low and high pre-test state anxiety participants in each attentional strategy group

	Control		External		Internal	
	Low (7)	High (14)	Low (13)	High (8)	Low (11)	High (11)
	Mean SD	Mean SD	Mean SD	Mean SD	Mean SD	Mean SD
Difficulty to carry out	1.29 (0.76)	1.79 (1.19)	2.15 (0.99)	1.88 (0.64)	2.91 (1.30)	2.09 (1.22)
Difficulty to Maintain	2.0 (1.0)	2.14 (1.19)	2.62 (0.96)	2.75 (1.04)	3.18 (1.47)	2.55 (1.29)
Mental Demands	1.86 (1.07)	2.07 (1.0)	2.54 (0.88)	3.38 (0.74)	3.27 (1.10)	2.64 (0.92)
How Successful	3.00 (1.0)	3.0 (0.96)	3.46 (0.78)	3.38 (0.74)	3.00 (0.89)	2.45 (0.69)
% Strategy Use	90.00 (11.55)	80.00 (14.68)	74.0 (11.98)	81.25 (9.91)	78.18 (9.82)	77.27 (10.09)

Participants were identified as either high or low state anxious in relation to the median split from the population State Anxiety scores (31.00). Independent Sample t-test were used to analyse relationships between post-task experience ratings of high and low pre-test state anxious participants in the each focus condition. No significant relationships were revealed for high and low anxious participants' ratings of task experience measures in the Control condition. Figure 3.15 highlights this relationship.

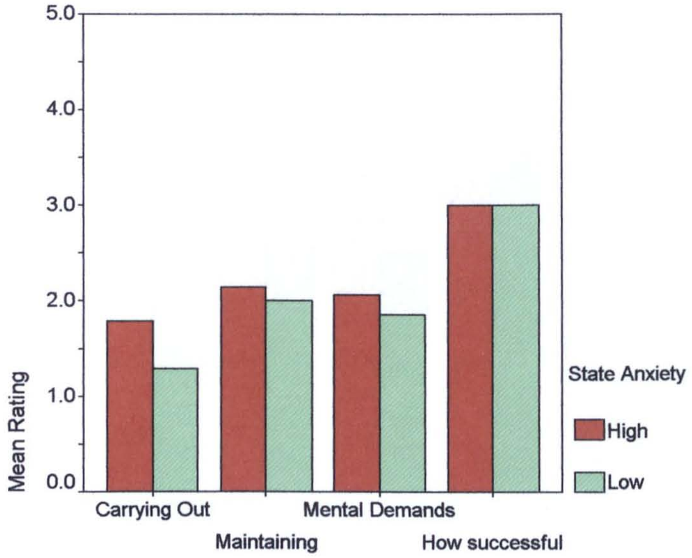


Figure 3.15: Mean post-task questionnaire responses for high and low anxious participants in the Control strategy group

For the External group no significant relationships were revealed by the independent sample t-tests for high and low anxious participants' ratings of Difficulty to Carry Out Instructions, Difficulty to Maintain Instructions, or the perceived Success of the Instructions. A significant difference was revealed for ratings of the Mental Demands of the instructions between high and low state anxious participants ($t = 2.24$, $df = 19$, $p < 0.05$), with mean ratings of 'Mental Demands' for high anxious participants larger at 3.38 (SD = 0.74), whilst low Anxious Participants scored lower at 2.54 (SD = 0.88). Figure 3.16 highlights this relationship.

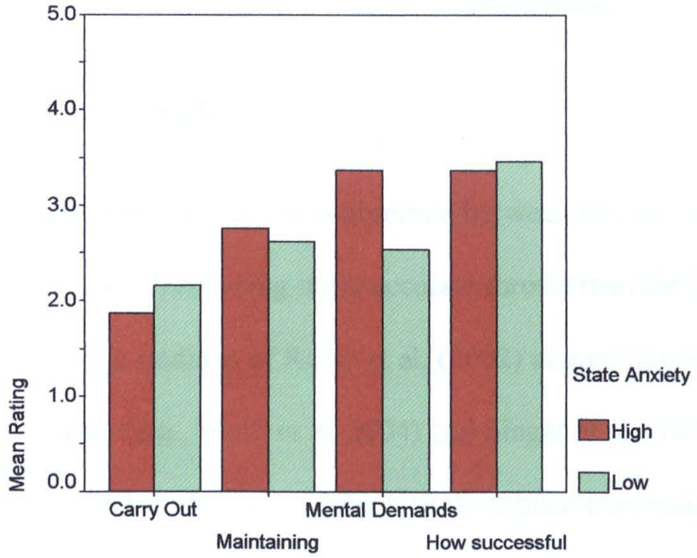


Figure 3.16: Mean post-task questionnaire responses for high and low anxious participants in the External strategy group

No significant relationships were revealed by the independent sample t-tests for high and low anxious participants' ratings of task experience measures in the Internal condition. Figure 3.17 highlights this relationship.

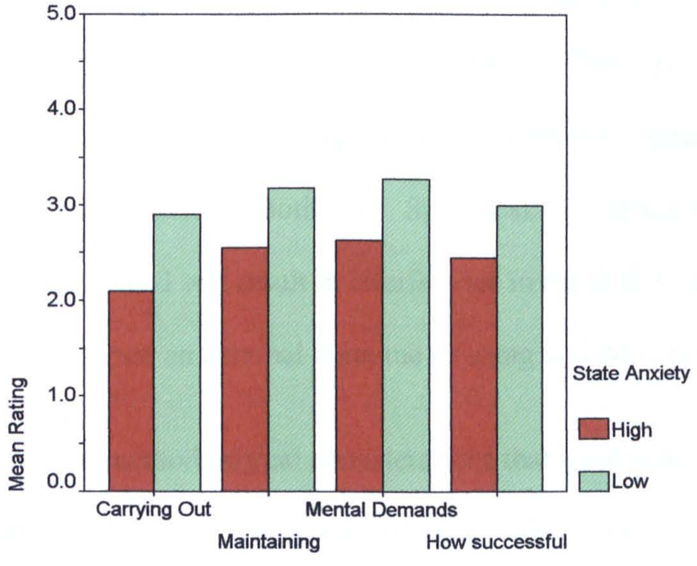


Figure 3.17: Mean post-task questionnaire responses for high and low state anxious participants in the Internal strategy group

Discussion

Performance Data

A significant difference was observed between attentional focusing strategies, with an external focus producing more accurate throws than the internal focus of attention. This supports the findings of Radlo et al. (2002) as well as those findings of Wulf and colleagues (e.g., Wulf, et al. 2004) and Singer et al. (1994). However, what Radlo et al.'s original study did not offer was theoretical explanation as to why such an effect would occur, other than as a result of the 'expert'-like physiological states that the participants exhibited. Without a control group a true discussion was difficult, but the presents study included a control group. The findings showed that the internal focus performed significantly less accurately when compared to the control group, but that the external focus demonstrated no significant difference in performance when compared to the control group. This suggests that, in this case, the internal focus degraded performance due to interference with movement execution, rather than the external focus promoting more accurate performance. That the internal focus was shown to degrade accuracy when compared with a control condition provides support for the "constrained action hypothesis". Specifically, focusing on the movements of a skill being produced will result in interference in the skill's execution when compared to focusing upon an external outcome or using no instructions at all.

There are methodological considerations that need to be considered in light of these findings. Firstly, it has become apparent that operationalising a 'control' – 'no-instruction' condition is not simple. Participants, even when given no instructions, will attempt to execute their own strategies, and if the theories of those like Wulf or Nideffer are true, then they will automatically resort to either an internal or external focus due to their preferences. Additionally, a control 'no-instruction' condition is not necessarily a 'no-focus' condition itself, in that, without instructions, this comparison group are more closely related to the External focus group due to the lack of attention paid to movement awareness. Even though an external focus, under Wulf's definition, has not been emphasised in the control group, the main aim of the task was accuracy and so this relates more to an external focus. Similarly, the target itself may help to promote an external focus in the Control condition.

Although this explains the improved performance of the control group as compared to the Internal group, this does not explain why the external focus did not show benefits when compared to the control group. One explanation may be that the external focus emphasised in this study was either (a) too difficult a focus for novices to fully benefit from or (b) it may have been too distant a focus for fully effective results. Regarding the former, the idea that this external focus may have been mentally demanding is discussed fully later, in light of findings from the post-task questionnaire. Regarding the latter point, a more mid-range external focus, such as onto the movement of the dart, may have been more effective. Although this may be limiting when the end point is still accuracy, and thus the target still seems the most appropriate external focus. Therefore, it may be that this external focus is initially difficult for novices to use, but over time benefits would become more apparent when compared to the control condition. The control condition would eventually reach a limit, in that with no actual instructional direction, novices would find themselves needing direction as their skill progressed.

A limitation to the analysis of these findings is the simplistic nature of the scoring system. As suggested by Wulf et al. (2001) and also Reeve, Fischman, Christina, and Cauraugh (1994), this simple assessment may miss vital clues to performance differences. Only one numerical value was assigned to each scoring ring round the target, therefore variability in performance was only assessed in terms of distance from target centre and does not take into account that performance may vary in 360° around the target. In terms of sporting performance, where a dart fell within a scoring ring is of no concern. No extra points are awarded is a dart falls into the top half of a ring, so the concerns of Reeve et al. are limited only to understanding motor performance rather than functional motor performance where a specific outcome is required. However, findings from Study 1 did indicate that the differences between the Internal focus and External focus conditions was most pronounced in the vertical plane of finger and hand movement. If this is the case here we may hypothesise that the poorer accuracy of the Internal focus group may be reflected in darts falling lower down the target rather than wider of the mark to the left or right. Unfortunately, this data does not exist from the present study and so we cannot discuss how the accuracy was poorer, only that it was poor in relation to the other conditions. Future research should aim to address not only in which ring the dart fell, but also in which area of the target it fell (e.g., top left quarter, bottom right corner etc.).

Heart Rate Data

A significant difference was revealed between the different focus groups' heart rate profiles. The Internal focus group exhibited a slower HR during the 6 IBI prior to dart throw compared to the External and Control groups, which themselves did not differ. Although not supportive of previous theory, this HR pattern does reflect the performance data. Both the External and Control groups exhibited similar HR patterns as well as similar performance accuracy, whereas the Internal group showed different task accuracy and HR than the two other groups. This suggests that the instructions were able to induce similar physiological states in both the Control and External conditions, adding further evidence to the previous suggestion that the control condition was more similar to the external manipulation than the internal manipulation. No significant evidence of HR deceleration or acceleration was evident for each focus group prior to dart throws. This does not support the findings of Radlo et al. (2002).

This suggests that either (a), the attentional strategies did not effect HR acceleration/deceleration, or (b), HR deceleration/acceleration has already occurred before the 4 epochs and so the HR that was analysed represents the attentional state after strategy initialization.

Overall heart rate during the best and worst throws did not significantly differ, a finding not supporting Radlo et al.'s (2002) findings. The lack of difference may not be surprising as it involved combining data from each attentional instruction, which had been shown here to significantly influence HR and therefore would influence the HR profiles regardless of their accuracy. Therefore further analysis of the HR patterns of each focus group during the best and worst throws is appropriate. No significant differences were seen for the Internal and Control groups' best and worst throws. For the External group on the other hand, a significant relationship revealed that HR was significantly slower in the IBI epochs leading up to the most accurate throws when compared to the faster HR leading up to the least accurate throws.

It may well be that, in this case, the physical effort required of the novices to throw the dart masked any true effects that the attentional strategies had on HR. This would suggest a possible explanation as to why this data does not support Lacey's intake rejection hypothesis where HR would be seen to have decelerated during an external focus. Although the data does support Obrist et al.'s (1974) cardiac-coupling hypothesis, where HR decelerated during an internal focus, Obrist's further proposition that this reflects a quietened motor system associated with an internal focus is simply not evident here due to reduced accuracy. Therefore, Obrist's definition of an internal focus and how it affects motor performance may not be relevant here.

Heart Rate Variability offers an alternative avenue of investigation with regard to attentional focus states, and this study offers the first experimental assessment of differences in HRV associated with different attentional strategies. There was significantly more variation in the HR for the Internal group than in the External group. The Control group did not significantly differ in HRV from either the External or Internal groups. The difference in HRV between the Internal and External focus groups demonstrates a possible difference in attentional processing between the two groups. Specifically, HRV is suggested to decrease with increased attentional demands of the task (Vinvente, et al. 1987). The present Study's HRV data suggests that the External condition was more attentionally demanding than the Internal condition. This certainly seems acceptable, with the internal focus offering a more natural approach for novices who have not carried out the movement before and the external focus leaving these movements to be carried out automatically whilst trying to focus on the outcome. It may also be that the increased attentional demands of the External condition limited its success in this one-off trial, with further success being evident with further practice as attentional demands decrease. It is also interesting to note that the increased accuracy promoted by the external focus was achieved despite the increased attentional demands. However, an alternative interpretation could be that the increased accuracy was achieved *because* of the increased attentional demands of the task. Caution most be used in the interpretation of these results, as the present study used a simple method of calculating HRV during the epochs prior to each throw, namely the standard deviation of epochs. More sophisticated methods of measurement are available with increasingly accurate technology. However, with the technology available here, the present technique offers a valuable insight into HRV associated with different attentional focuses. Further psychological data to support this biological evidence is needed and data from the post-task questionnaire will shed further light on this issue.

Post-Task Questionnaire

In contrast to Study 1, the present study offers a comparison of participants' focus experience between groups. The control condition was rated as significantly easier to carry out than the internal focus, but not easier than the external focus. The external focus was not rated as easier to carry out than the Internal condition. No significant differences were revealed between groups' ratings of how difficult participants rated the instructions were to maintain. The control group rated their instructions as easier to maintain than both the External and Internal focus groups, which themselves were not significantly different. The External group rated their instructions as more successful than the Internal group. The control group was not rated as significantly more or less successful than either the Internal or External conditions. There were no significant differences in participants' estimations on how many throws they actually used their instructions on, with the External group estimating 77.14%, the Internal 77.73%, and the Control 83.33% of throws.

The levels of pre-test state anxiety were shown to influence the ratings of participants' experience of the different instruction groups. State anxiety had no influence on the participants' experience of the Control or Internal focus conditions. Nor did it affect participants' ratings of external focus on difficulty to carry out, difficulty to maintain, or the perceived success. However, those who were classified as highly state anxious before the task were more likely to rate the external focus as more mentally demanding than those who were low state anxious. This interesting finding suggests, similar to those findings in Study 1, that anxiety levels may influence the ability of individuals to use an external focus. Although this measure of mental demands is only basic, it still reflects participants' mental demand ratings of the instructions. More direct measures may be employed in the future to assess the mental demands of different attentional states in relation to anxiety levels, such as probe reaction times.

The differences in ratings of mental demands between the Control and External focus groups may go some way to explain their similar scores. Theoretically, and in previous research (e.g., Wulf, Hoss, & Prinz, 1998, Experiment 1), the external focus should offer benefits to motor performance over a control 'no-focus condition'. However, in the present study there were no differences. It is possible that the External group found the instructions beneficial, but too mentally demanding in this one-off instance. Therefore, it may be that an external focus becomes more pronounced in its benefits over time due to decrease in mental demands after practice. Adding further weight to this is the HRV findings discussed earlier. The HRV findings suggest that the External focus group was more attentionally demanding than the Internal group, although not the Control group. Taken together, the HRV and post-task questionnaire findings demonstrate that the two main focus conditions do place different demands upon the individual, and that this difference may account for the performance differences.

Application Implications

The present study demonstrates that attentional focusing strategies can have immediate effects upon novices' dart throwing accuracy. The positive findings of the control group can be discounted for application, as it is unlikely that individuals will appreciate being given no direction as an intervention. Similarly, the long term benefits of the control condition are not known from the present data. Therefore, an external focus of attention should be promoted as an intervention to promote efficient movement as opposed to an internal focus. Practitioners should be aware that the external focus does offer movement benefits, but is also more mentally demanding. Therefore, participant encouragement may be needed to ensure continued application of the external strategy over a longer term. This may be particularly relevant for individuals exhibiting high levels of anxiety. The application avenues include the obvious sports training and performance areas, such as coaching for motor skill execution. This would certainly seem, in light of the present study, particularly relevant for sports requiring accuracy. Other areas of application could also include the physical rehabilitation from injuries, where individuals have to re-learn movements. Physical therapists may find that clients benefit from directing their attention to outcomes or goals rather than on the movements themselves.

Conclusion

Previous research carried out by Wulf and colleagues has shown that directing a learners' attention toward an appropriate external focus can have almost immediate beneficial effects on performance (e.g., Wulf et al., 2000, experiment 2; Wulf, Hoss, & Prinz, 1998, Experiment 1; Wulf et al., 1999). Additionally, Radlo et al. demonstrated that the immediate effects on novices' performance is associated with corresponding affective psychophysiological states. The present study adds support to this area by showing that novices can effectively use an external strategy to improve their accuracy in a motor skill task when compared to an internal focus during a single one-off session.

Summary of Findings

1. Instructions emphasising an external focus of attention benefits novices accuracy in comparison to internal focus instructions, but not a control no-instruction condition.
2. Attentional focusing instructions significantly influence HR, with external and control focuses exhibiting faster HR than an internal focus, but were not different from each other.
3. An external focus was associated with lower HRV than both the internal and control conditions, which were not different from each other.
4. Participants differed in their experiences of the task depending on which instructions they were using and their level of state anxiety.

CHAPTER 4

THE EFFECTS OF ATTENTIONAL FOCUS DURING BALANCE AT REST AND IN FATIGUED STATES

A series of studies used dynamic balance tasks that required participants to balance on a stabilometer platform and to minimize deviations of the platform from the horizontal (e.g., McNevin et al. 2003; Shea & Wulf, 1999; Wulf et al., 1998, Experiment 2; Wulf, McNevin, & Shea, 2001). The studies consistently demonstrated that participants focusing on keeping markers attached to the platform horizontal (an *external* focus) produced more effective performance and learning than participants instructed to focus on keeping their feet horizontal (an *internal* focus). Furthermore, the advantages of using an external focus of attention was also found when compared to control "no focusing instruction" conditions (Wulf et al., 1998, Experiment 1; Wulf & McNevin, 2003). In light of these findings, and findings from Studies 1 and 2, it seems that research into the effectiveness of attentional focusing strategies upon motor performance and learning need now to incorporate naturally occurring factors. One such factor associated with motor skill execution in sporting and many other motor performance and occupational settings is physical fatigue.

Human posture is inherently unstable and must be maintained via small, very rapid (reflexive) patterns of muscular activation. Pertubations or loss of normal inputs to this relatively automatic system will result in degraded balance (McNevin et al., 2003). Fatigue is a multi-faceted phenomenon with the potential to influence performance and incidence of injury, and has been suggested to include both physiological and psychological aspects. Physical fatigue is an inevitable phenomenon for physical, professional or recreational activities (Vuillerme & Nougier, 2003). As a complex phenomenon, muscular fatigue can be defined as a reduction in the force-generating capacity regardless of task performed (Bigland-Richie & Woods, 1984). Fatigue is caused by a combination of different physiological mechanisms occurring at both the central and peripheral levels, leading to a decrease in motor control (Noakes, 2000). At the peripheral level, pre and postsynaptic mechanisms and sites are potentially implicated including a failure in the transmission of the neural signal or a failure of the muscle to respond to neural excitation (Bigland-Richie, & Woods). At the central level, fatigue may induce a failure of excitation of the motoneurons caused by changes in the nervous system (supraspinal, segmental, and sensory feedback) (Gandevia, Allen, Butler, & Taylor, 1996; Gandevia, Enoka, McComas, Stuart, & Thomas, 1995). It is interesting to note that very little research has examined the effect of fatiguing exercise on the performance of sports skills (McMorris, 2004). This is concerning, considering the potential detrimental effects fatigue can have on performance.

Fatigue and balance

As maintenance and control of posture and balance in a particular position, or during movement, is fundamental to physical activity, research has been drawn to factors which can affect it. Despite McMorris's (2004) claims, research is available on the effects of fatigue on postural control. It seems reasonable to hypothesise that fatigue will have an effect on postural control (Ageberg, Roberts, Holmstrom, & Friden, 2003), and in order to examine how fatigue affects balance and postural stability, researchers have focused upon two types of fatigue: generalised and localised. Generalised fatigue has been induced by a strenuous period of physical exercise, for example: Yaggie and Armstrong (2004) assessed the effects of Wingate test protocols on balance. The Wingate Anaerobic 30 cycle Test (WANT) has been the most popular anaerobic test to date. After a 10 minute warm up the participant begins pedalling as fast as possible without any resistance. Within 3 seconds, a fixed resistance is applied to the flywheel and the athlete continues to pedal "all out" for 30 seconds. The most commonly used test length has been thirty seconds, this is a time period for maximal efforts where the major fuel source is anaerobic.

Localised fatigue has been induced by specifically fatiguing muscle groups utilised in the balancing act, for example: Corbeil, Blouin, Begin, Nougier, and Teasdale (2003) induced muscular fatigue of ankle plantar-flexors with repeated plantar-flexion of both legs to examine how it degrades the regulation of bipedal quiet stance. Participants lifted a weighted bar placed on the distal extremity of their thighs by raising the heels. Participants performed 100 repetitions starting at 75% of their maximal workload with a reverse pyramid technique where load was diminished gradually whenever participants were unable to perform plantar-flexion.

Localised Muscular Fatigue and Balance

Caron (2003) found that localised fatigue of the lower limbs (in the soleus muscle) modified participants' postural control, expressed by an increase in centre of pressure mean velocity and standard deviation. These findings supported previous research by Nardone, Tarantola, Giordano, and Schieppati (1997) and Vuillerme, Nougier, and Prieur (2001). Recently, Gribble and Hertel (2004) demonstrated that isokinetic fatigue of the knee and hip flexors and extensors caused substantial postural control impairments in both the frontal and sagittal planes, whereas fatigue of the ankle plantar-flexors and dorsi-flexors only caused slight postural control impairments in the sagittal plane. After inducing localised bilateral muscular fatigue of the soleus and gastrocnemius Corbeil et al. (2003) found that, compared with a no-fatigue condition, fatigue places higher demands on the postural control system by increasing the frequency of actions needed to regulate the posture.

Although not its actual aim, one study poses a possible link between balance and fatigue research and attentional focus research. Vuillerme and Nougier (2003) assessed the effects of light finger touch on postural sway after lower-limb muscular fatigue. Participants were required to maintain standing balance with their eyes closed before and immediately after a localised fatiguing protocol of the calf muscles, whilst lightly touching a hanging sheet (offering no physical support) and whilst not lightly touching the sheet. Their findings suggest that light finger touch resulted in decreased postural sway in the no-fatigue and fatigue conditions. Interestingly, this stabilizing effect was more accentuated in the fatigue condition.

McNevin and Wulf (2002) draw parallels between balance studies using light touching supra-postural tasks (e.g., Riley, et al. 1999) and studies assessing the role of attentional focus on balance performance (e.g., Shae & Wulf, 1999). McNevin and Wulf suggest that in both lines of research, postural fluctuations were reduced, or balance was improved, when the participants' attention was directed away from the act of "standing still" and to an effect of this act on the environment (an external focus). In assessing this, McNevin and Wulf found that participants instructed to focus on the movements of the sheet (an *external* focus) exhibited greater postural frequency of responding than those instructed to focus on the movements of their finger (an *internal* focus). Similarly, Study 1 also demonstrated that an external focus of attention during a light-touch task promoted more efficient postural control than when an internal focus was used. What is clear from these parallels is that attentional focusing strategies may well have an effect during fatigued balance.

Generalised Muscular Fatigue and Balance

Yaggie and Armstrong (2004) expressed concern that use of selective joints in localised fatiguing protocols might not represent athletic activity, and as such more global fatigued states may more accurately reflect physiological conditions experienced by athletes during performance. In their study they concluded that fatigue induced through a Wingate test protocol adversely effected balance, and that recovery might occur within 10 minutes.

Ageberg et al. (2003) agree that fatigue induced by general exercise, such as cycling, running, or walking better resembles conditions in daily life and physical activities than localised fatigue. These authors assessed centre of pressure movements during single-legged balancing stance before and after the completion of short-duration, sub-maximal cycling. Increased values of average speed of centre of pressure movements and number of movements exceeding 10mm from the mean value in the frontal plane, and the amplitude of centre of pressure movements in the sagital plane following cycling indicate compensatory mechanisms aimed at maintaining balance in single-limb stance, or a decreased ability to maintain balance, in young healthy adults.

Assessing more prolonged exertion Pendergrass, Moore, and Gerber (2003) found that a two mile run produced a significant increase in postural sway as measured using the Biodex Stability System Overall Stability Index and Military Academy Stance Test. Representing a further extreme of generalised fatigued state, Nagy et al. (2004) found that participating in an Ironman triathlon significantly affects the ability of ironmen and non-iron men (trained individuals, but not ironmen competitors) to maintain balance.

Theoretical Implications of Fatigue and Balance Research

Ageberg et al. (2003) state that poor balance following exercise indicates compensatory mechanisms intended to maintain balance in single-legged stance, or a decreased ability to maintain balance. Similarly, Corbeil, Blouin, Begin, Nougier, and Teasdale (2003) proposed that compared with no-fatigue conditions, fatigue places higher demands on the postural system by increasing the frequency of actions needed to regulate the upright stance.

Ageberg, et al. (2003) suggest that changes in balance found after exercise may be explained by several factors. The activity of joint receptors, muscle spindles and Golgi tendon organs may be reduced by fatigue, resulting in proprioceptive deficit in muscle receptors and loss of muscle reflexes responsible for dynamic joint stability (Lattanzio & Petrella, 1998). As afferent (neural pathways carrying information from the receptors to the central nervous system) information is also important for the maintenance of postural control (Johanson, Sjolander, & Sojka, 1991), the decreased muscle response and muscle reaction may lead to a poorer ability to maintain balance. Gribble and Hertel (2004) further suggest that slowed conduction of afferent signal from the fatigue-altered state of the muscle may lead to a slowed propagation of efferent (nerve impulses from the CNS outward towards the periphery, motor neurons) signals to help maintain posture.

Current Research

What is clear is that both generalised fatigue and localised fatigue affect the ability to maintain postural control. In light of the findings regarding the benefits of an external focus of attention during balance performance, the current study will attempt to address any interactions between attentional focus and fatigue during balance. It is possible that, through utilisation of different attentional focusing strategies, balance may be improved during a fatigued state. This possibility is further strengthened by the identification of changes in control mechanisms needed to maintain balance whilst fatigued (e.g., Ageberg, et al., 2003). However, as research has yet to address this, which attentional focus would provide benefits is not clear.

Wulf and colleagues state that the benefits of an external focus during balance is that it utilizes more automatic control processes. Furthermore, participants using an external focus during dynamic balance tasks demonstrate a higher frequency of platform adjustments. McNevin et al. (2003) suggest that these higher frequency components seem to represent deterministic processes characterizing the incorporation and coordination of additional available degrees of freedom (see Thompson & Stewart, 1986). Furthermore, they indicate that superior performance using external focus instructions may reflect a system in which the coupling between agonist and antagonist muscles is assumed to be more effective due to coherence between sensory input and effector output (via the cerebellar system) (e.g., McAuley & Marsden, 2000).

Despite the benefits of an external focus recent researchers have addressed possible benefits of an internal attentional focus during motor performance. Research by Beilock et al. (2002) and Perkins-Ceccato et al., (2003) suggested that an internal focus may be beneficial to novices early in learning, whereas it is detrimental to expert performance later on in the learning process. Beilock et al. and Gray (2004) have proposed that attention to skill execution in experts may be crucial for breaking down, altering, and adapting proceduralized knowledge that the performer has judged to be unproductive.

Therefore two possibilities exist, firstly by allowing automatic motor control processes to function without conscious intervention, the motor system should effectively cope with a fatigued state. Or secondly, by the online control of fatigued motor systems through an internal focus, balance performance may be improved, or at least maintained whilst compromised physiological systems recover. Furthermore, the fatigue compromised motor system may not allow for full utilisation of an external focus due to disruption of automatic processes. Ultimately, the effects of attentional focusing strategies whilst fatigued is critical to our understanding of performance. This is made more apparent by Wegner (1994) who suggests that our concentration appears to drift away from its intended target mainly in situations where are cognitive resources are depleted through anxiety or fatigue.

Aims

The present study aims to assess the effects attentional focusing strategies have upon balance performance both at rest and during a fatigued state. Two experiments will assess performance on a weight-bearing single-legged balance task at rest and during a fatigued state. Studies assessing balance in single-legged stance are of importance since movement patterns of postural control are similar during the stance phase, and many injuries to the lower extremities occur during weight-bearing on one leg (Ageberg et al. 2003). In Experiment 1, a generalised fatigue state was induced in participants through completion of a Wingate test protocol on a stationary bicycle. In Experiment 2 localised muscular fatigue of the knee flexors and extensors was induced using an isokinetic dynamometer. It is logical to follow these two methods of generating fatigue as this is how the literature has developed, additionally it may well be that different attentional focusing strategies will be beneficial during different types of fatigued state.

Hypothesis

1. Fatigue will affect participants' ability to maintain balance on an unstable surface
2. Attentional focusing strategies will influence participants' ability to maintain balance on an unstable surface both at rest and when fatigued

Post task questionnaire

A post-task questionnaire was used to assess participants' experiences of the attentional focusing instructions that they were given for both of the following experiments. However, due to the size and scope of this chapter these findings have not been reported here.

Experiment 1: Generalised Fatigue

Methodology

Participants

Twenty-four healthy participants (11 male, 13 female) took part in the experiment. Mean age was 21.33, with a maximum of 38 and a minimum of 18. Mean height was 1.71m and weight 68.88kg. All participants were naive to the aim of the study, and none had participated in previous attentional focus experiments. All participants completed a general health questionnaire to assess suitability to participate in the fatigue session. None of the participants had a history of vestibular or central nervous system balancing problems or previous lower extremity injury history. The methodology was approved by the University of Hull Department of Psychology Research Committee.

Design

To avoid the problems with inter-individual variations in balance, this study was a within-subjects design. All participants performed under Natural, External and Internal conditions. As highlighted by McNevin et al. (2002), any effects of attentional focus would increase our confidence that this variable has an immediate influence on performance.

Apparatus and Task

Balance Task: Participants were required to carry out a 30-second single legged 'stork' balance task before (at rest) and after carrying out a fatigue session, under three different focusing conditions (see Figure 4.1). The task was carried out on a BioDex Balance System. The specific specifications of this system can be found in Appendix 5. The Biodex Balance System evaluates neuromuscular control by quantifying the ability to maintain dynamic postural stability on an unstable surface. The unstable surface consists of a circular platform (55cm diameter) on which participants stand and the degree of surface instability is controlled by a microprocessor-based actuator. The test records the participants' ability to control the platform's movement from a perfectly balanced position. A large degree of movement is indicative of poor postural control.

The BioDex balance system's platform stability can be adjusted, to give up to 20° of tilt. During the trials in this study, the stability was set to level 5. Difficulty levels range from 10 to 0, with 10 being the easiest. Level 5 represents a moderate (75%) level of stability that is equal to a 15%degree tilt (Biodex, 2002). Importantly, the feedback screen of the monitor was covered to stop participants using the visual aid during balance. Participants were instructed to keep the platform as stable and as level as possible for the duration of the 30s trial. For the purpose of attentional focus manipulation, four markers (dimensions) were attached to the platform. These were placed at each of the major directions of movement (Anterior/Posterior and Medial/ Lateral) at the outside edge of the platform (see Figure 4.2).

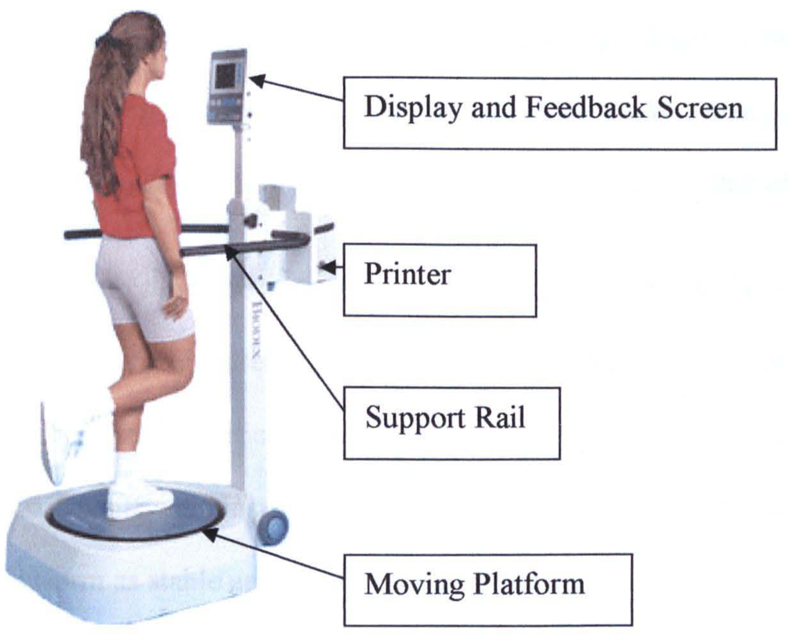


Figure 4.1: BioDex Balance System

Fatigue Task: participants carried out an adapted 30 second bicycle Wingate test to induce a generalised physically fatigued state, cycling at 60 rpm. Wingate workload was standardised between participants in relation to their body weight, and once the 60 rpm level had been achieved this load was applied and participants cycled with maximal effort for the period of 30 seconds, remaining seated throughout. Prior to the 30 second exertion task, participants warmed up for 5 minutes cycling at 100W with 10 second sprint burst every 20 seconds of the final minute. The bicycle was next to the BioDex balance system and participants completed the balance task immediately after completing the Wingate protocol, during which no physiological measures were taken.

Procedure

Participants were required to attend three days of testing, each lasting approximately 15 minutes, plus a familiarisation session. This session allowed participants to become familiar with both the Balance System and the equipment used in the fatigue protocol. This session would also reduce the initial learning effects of balancing on the equipment. Each participant completed a pre-exercise questionnaire assessing current level of health and fitness and screens for conditions that may be complicated by exercise (e.g., cardiovascular conditions). This was to assess participants' suitability for taking part in the fatiguing protocol. As a requirement of the study, participants were instructed not to engaged in demanding physical activity/exercise on the day of and day before each trial.

On each of the three testing days, participants carried the balancing task before (at rest) and immediately after the fatiguing protocol (fatigued). After completing the resting balancing trial, participants then immediately carried out the fatiguing protocol. All participants were instructed that the primary aim of the balance task was to keep the platform as stable and level as possible during each 30 second trial. Participants were required to stand on the platform with their dominant leg in the required position and wait for a start signal. In its pre-testing state, the BioDex platform is locked into a level and stable position. At the starting prompt, the experimenter began the balance task and the BioDex Balance system released the lock on the platform so that it became unstable.

Prior to the start of each balance trial, participants were required to stand in the balance position (single legged) whilst holding onto the support rails to each side. During this stage, and until the start of the trial, the platform is locked into a stable level position. The participant's free leg was bent at 90 degrees angle and held loosely at the side in order to prevent the subject acquiring a 'locked' position. Participants were required to place their foot (of their dominant leg) at the centre of the platform. The foot position was standardised in relation to foot size, and is clearly marked into the platform. When placed, co-ordinates are taken off the platform and inputted into the BioDex computer for accurate balance calculation. Five seconds prior to the task beginning participants were told to let go of the support rails and ready themselves for balance. Once released from the support rails, arms were held by participants' sides.

Participants carried out the Naturalistic condition first on the first day, followed by counterbalanced External and Internal on separate later days. The counterbalancing of the External and Internal, but not the Natural conditions is due to the nature of the instructions given. It was thought that the lack of instructions given in the natural condition would be most appropriate for a first session. It was felt that if participants carried out a focusing trial first followed by a natural trial, then there was a possibility that participants could try and use the focusing strategy during the natural trial.

The study did not aim to assess the influence of visual feedback provided by looking at the markers, and all participants were instructed to look straight ahead at the wall in front of them during the task. This was to emphasize that the purpose of the focusing trials was not to visually 'focus' onto either their foot or the markers, but that a mental focusing was required. It was important that participants understand this, and the experimenter observed for any participants who adopted a posture suggesting visual monitoring of their foot or the platform. Participants who asked about visual information were directed to focus straight ahead on the wall in front of them.

Attentional Focus Instruction Manipulations. Natural: participants were given no other instructions than to balance as well as they could for the duration of the trial. *External:* participants were instructed to keep the markers on the platform level for the duration of the trial. *Internal:* participants were instructed to keep their foot level and stable during the trial. Instructions were based on those used in previous studies (e.g., Wulf et al, 1998; Wulf, McNevin, & Shea, 2001), which were found to be effective in manipulating attentional focus and producing differences in balance performance (all instructions are presented in Appendix 8).

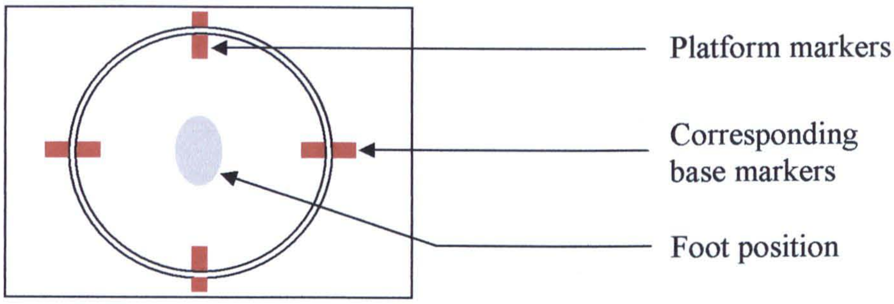


Figure 4.2: Balance platform external focus marker positions

Dependent Variables

The BioDex Balance system gives a Balance Assessment printout for each trial (for example printout, see Appendix 6), which contains all necessary data. This includes the overall balance index, anterior/posterior index, and medial/lateral index. A plot is also given to indicate the movement of centre of pressure around the midpoint. Overall balance index represents the participant's ability to control their balance in all directions. The overall stability index represents the variance of foot platform displacement in degrees, from level, in all motions during a test. A high number is indicative of a lot of movement during a test. The Anterior-Posterior Index represents the participant's ability to control their balance in the sagittal place. The Medial-Lateral Index represents the participant's ability to control their balance in the frontal plane. High values in each case represent the participant had difficulty balancing. The standard deviation (SD) represents repeatability in performance, the amount of variability in the statistical measure. A low SD indicates that the range of values, from which the mean was calculated were close together. The statistical procedures carried out by the BioDex system to calculate each value can be seen in Appendix 7.

Results

Overall balance performance will be analysed first with respect to mean balance index and standard deviation of balance index. The overall balance performance will then be broken down for movements in the medial-lateral and anterior-posterior directions.

Overall Balance Index

Table 4.1: Mean overall balance index values for each attentional strategy at rest and whilst generalised fatigued

Focus Strategy	Balance Index	Resting	Fatigued
Natural	**Mean**	4.25	4.70
	SD	(1.82)	(1.99)
Internal	**Mean**	3.95	4.19
	SD	(1.52)	(1.49)
External	**Mean**	4.22	5.35
	SD	(1.82)	(2.20)

A Focus (3) x Fatigue (2) repeated measures ANOVA was carried out. A significant main effect was observed for the effects of fatigue on balance index ($F_{(1,23)} = 16.23$, $p = 0.001$, $\eta_p^2 = 0.41$). Overall balance performance was significantly better before fatigue (mean = 4.14, SD = 1.72) than during a fatigued state (mean = 4.74, SD = 1.89). A significant main effect was observed for the effects of attentional focus on balance index ($F_{(2,46)} = 4.08$, $p = 0.02$, $\eta_p^2 = 0.15$). Least Significant Difference (LSD) post hoc analysis revealed that overall balance index in the Internal condition was significantly different from the External condition (p = 0.007, mean difference 0.712), but not the Control condition (p = 0.12, mean difference 0.40). The External and Control conditions were not significantly different (p = 0.24, mean difference 0.31). This value incorporates both pre-fatigue and fatigued state balance, and so care must be taken in its discussion. A significant interaction was identified between Fatigue State and Attentional Focus ($F_{(2,46)} = 4.07, p = 0.02, \eta_p^2 = 0.15$).

Pre-Fatigue - Fatigued State Paired Comparisons

Further analysis was carried out using paired sample t-tests, with pre-fatigue and fatigued state results compared for each focus condition. No significant difference was identified between pre-fatigue and fatigued state balance index in the Control condition (t = 1.69, df = 23, p = 0.105) or the Internal condition (t = 1.16, df = 23, p = 0.256), indicating that fatigue did not significantly influence postural control. The pre-fatigued mean balance indexes of 4.25 and 3.95 for the Control and Internal strategies respectively were not significantly different from their fatigued state balance indexes, 4.70 and 4.20 respectively. A significant difference was identified between pre-fatigue and fatigued balance using an External focus (t = 4.52, df = 23, p = 0.001), with balance index increasing (balance deteriorating) from 4.22 (1.82) to 5.35 (2.20). Figure 4.3 highlights this relationship.

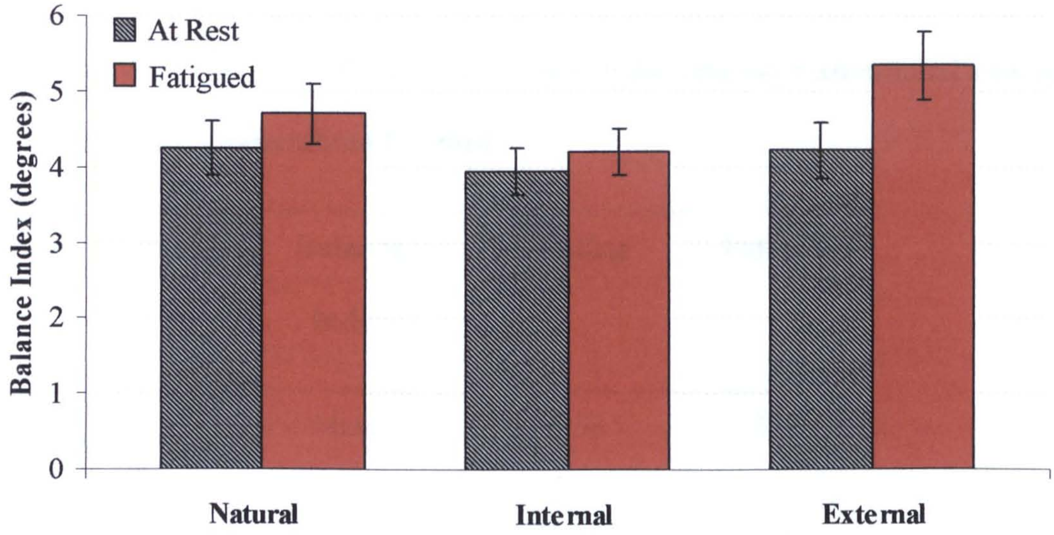


Figure 4.3: Mean overall balance index values for each attentional strategy at rest and whilst generalised fatigued (Lower values indicate superior postural control)

Analysis of Balance Index before Fatigue and During a Fatigued State

Two separate Focus (3) repeated measures ANOVAs were carried out to analyse balance index performance at rest and after fatigue. No significant differences were found between the 3 focus conditions' balance performance whilst at rest ($F_{(2, 46)} = 0.78$, $p = 0.47$, $\eta_p^2 = 0.03$). During a fatigued state a significant difference was identified in the main effect of focus on balance performance ($F_{(2, 46)} = 6.18$, $p = 0.004$, $\eta_p^2 = 0.21$). LSD post hoc analysis revealed that fatigued balance in the Internal Focus condition was significantly better than in the External Focus condition ($p = 0.002$, mean difference = 1.16), but not the control condition ($p = 0.10$, mean difference = 0.51). The External focus and Control condition did not significantly differ in fatigued balance quality ($p = 0.08$, mean difference = 0.65).

Balance Performance in the Anterior - Posterior Axis

One participant's data was not available for this axis, leaving 23 remaining data sets for analysis.

Mean Overall Balance Index

Table 4.2: Anterior – Posterior balance index values for each attentional strategy at rest and whilst generalised fatigued

Focus Strategy	Balance Index	Resting	Fatigued
Natural	**Mean**	3.53	3.67
	SD	(1.55)	(1.96)
Internal	**Mean**	3.11	3.48
	SD	(1.20)	(1.47)
External	**Mean**	3.22	3.87
	SD	(1.27)	(1.84)

A focus (3) x Fatigue (2) repeated measures ANOVA was carried out. A significant main effect was observed for the effects of fatigue on balance index ($F(1,22) = 6.58$, $p = 0.018$, $\eta_p^2 = 0.23$). Overall balance performance was significantly better at rest (mean = 3.28, SD = 1.34) than during a fatigued state (mean = 3.68, SD = 1.75). The main effect of attentional focus was not found to significantly affect balance index ($F_{(2,44)} = 0.80$, $p = 0.456$, $\eta_p^2 = 0.04$). This value incorporates both pre-fatigue and fatigued state balance, and so care must be taken in its discussion. No significant interaction was identified between Fatigue State and Attentional Focus ($F_{(2,44)} = 1.25$, $p = 0.30$, $\eta_p^2 = 0.05$).

Pre-Fatigue - Fatigued State Paired Comparisons

Further analysis of this interaction was carried out using paired sample t-tests, with pre-fatigue and fatigued state results compared for each focus condition. No significant difference was identified between pre fatigue and fatigued state balance index in the Control condition (t = 0.54, df = 22 p = 0.59) or the Internal condition (t = 1.82, df = 22, p = 0.08), indicting that fatigue had not influenced postural control significantly. The pre fatigued mean balance indexes of 3.53 and 3.11 for the Control and Internal strategies respectively were not significantly different from their fatigued state balance indexes, 3.67 and 3.48 respectively. A significant difference was identified between pre-fatigue and fatigued balance using an External focus (t = 1.82, df = 22, p = 0.02). Pre-fatigue mean balance index was 3.22, but this significantly rose (balance deteriorated) to 3.87 whilst balancing in a fatigued state. Figure 4.4 highlights this relationship.

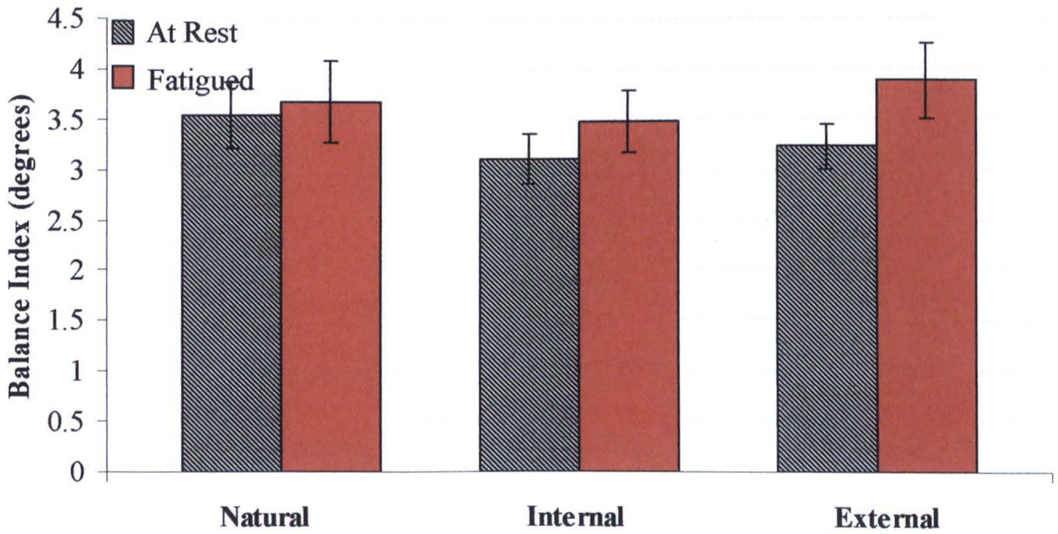


Figure 4.4: Anterior-Posterior balance index for each attentional strategy at rest and whilst generalised fatigued (Lower values indicate superior postural control)

Analysis of A-P Balance Index before and After Fatigue

Two separate Focus (3) repeated measures ANOVAs were carried out to analyse balance index performance at rest and after fatigue. Mauchley's Test of Sphericity was significant for Focus at rest (W = 0.57, p = 0.003), therefore Greenhouse Geisser values were used. No significant differences were found between the 3 focus conditions' balance performance whilst at rest ($F_{(2, 44)}$ = 1.82, p = 0.17, η_p^2 = 0.08). During a fatigued state no significant main effect of focus was identified ($F_{(2, 44)}$ = 0.57, p = 0.57, η_p^2 = 0.03).

Balance Performance in the Medial - Lateral Axis

One participant's data was not available for this axis, leaving 23 remaining data sets for analysis.

Mean Overall Balance Index

Table 4.3: Medial – Lateral balance index for each attentional strategy at rest and whilst generalised fatigued

Focus Strategy	Balance Index	Resting	Fatigued
Natural	**Mean**	2.50	2.99
	SD	(1.38)	(1.20)
Internal	**Mean**	2.59	2.63
	SD	(1.19)	(1.07)
External	**Mean**	2.87	1.64
	SD	(1.64)	(2.01)

A Focus (3) x Fatigue (2) repeated measures ANOVA was carried out. The main effect of fatigue on balance performance was significant ($F_{(1,22)} = 14.18, p = 0.001, \eta_p^2 = 0.39$). Overall balance performance was significantly better before fatigue (mean 2.65) than during a fatigued state (mean 3.09). Mauchly's Test of Sphericity was significant for the main factor of Focus (W = 0.74, $p = 0.04$), therefore Greenhouse-Geisser values were used. The main effect of Focus on balance performance was significant ($F_{(1.59,34.97)} = 4.65, p = 0.023, \eta_p^2 = 0.18$). LSD post hoc analysis revealed that balance index in the Internal condition (mean= 2.61) was significantly better than the External condition (mean = 3.27, p = 0.01, mean difference 0.65), but not the Control condition (mean = 2.75, p = 0.41, mean difference 0.14). The External and Control conditions were not significantly different (p = 0.07, mean difference 0.52). This value incorporates both pre-fatigue and fatigued state balance, and so care must be taken in its discussion. No significant interaction was identified between Fatigue State and Attentional Focus ($F_{(2,44)}$ = 2.86, p = 0.07, η_p^2 = 0.12).

Pre-Fatigue - Fatigued State Paired Comparisons

Further analysis was carried out using paired sample t-tests, with pre-fatigue and fatigued state results compared for each focus condition. A significant difference was identified between pre fatigue and fatigued state balance index in the Control condition (t = 2.08, df = 22, p = 0.05) and the external condition (t = 3.42, df = 22, p = 0.002). The pre fatigued mean balance indexes of 2.50 and 2.87 for the Control and Internal strategies respectively were significantly lower (balance was better) than their fatigued state balance indexes, 2.99 and 3.66 respectively. No significant difference was identified between pre-fatigue and fatigued balance using an Internal focus (t = 0.25, df = 22, p = 0.81). The pre-fatigue mean balance index of 2.59 was not significantly different from the mean balance index during the fatigued state of 2.63. Graph 4.5 highlights this relationship.

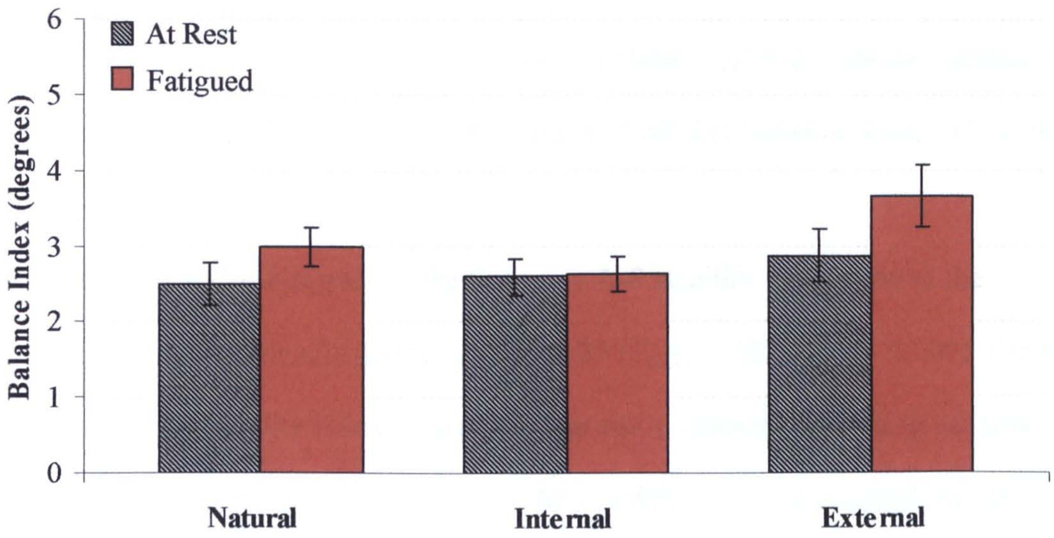


Figure 4.5: Medial – Lateral balance index values for each attentional strategy at rest and whilst generalised fatigued (Lower values indicate superior postural control)

Analysis of Balance Index Before and After Fatigue

Two separate Focus (3) repeated measures ANOVAs were carried out to analyse balance index performance at rest and after fatigue. No significant differences were identified between the 3 focus conditions' balance indexes whilst at rest ($F_{(2, 44)} = 1.29$, $p = 0.28$, $\eta_p^2 = 0.06$). Mauchley's Test of Sphericity was significant for Focus whilst fatigued (W = 0.76, $p = 0.05$), therefore Greenhouse Geisser values were used. During a fatigued state no significant main effect of focus was identified ($F_{(1.59, 35.06)} = 5.74$, $p = 0.01$, $\eta_p^2 = 0.21$). LSD post hoc analysis revealed that balance index in the Internal condition was significantly lower (balance was better) than in the External condition ($p = 0.004$, mean difference 1.03), but not the Control condition ($p = 0.81$, mean difference 0.67). The External and Control conditions were not significantly different ($p = 0.12$, mean difference 0.36).

A-P and M-L contributions to overall Stability Index

For each fatigue state and attentional strategy condition, stepwise multiple regressions were carried out using M-L stability index and A-P stability index to predict Overall Stability Index.

Control condition Pre-Fatigue: on the first step, A-P stability index entered the regression equation with adjusted R square = 0.85 ($F_{(1,21)}$ = 127.10, p = 0.000). On the second step, M-L stability index entered the regression equation producing adjusted r square = 1.0 ($F_{(2,20)}$ = 1982.67, p = 0.000). M-L stability index accounted for only an addition of 14% of overall stability variability.

Control condition Whilst Fatigued: on the first step, A-P stability index entered the regression equation with adjusted R square = 0.85 ($F_{(1,21)}$ = 126.68, p = 0.000). On the second step, M-L stability index entered the regression equation producing adjusted r square = 0.99 ($F_{(2,20)}$ = 1369.04, p = 0.000). M-L stability index accounted for only an addition of 14% of overall stability variability.

Internal condition Pre-Fatigue: on the first step, A-P stability index entered the regression equation with adjusted R square = 0.87 ($F_{(1,21)}$ = 148.33, p = 0.000). On the second step, M-L stability index entered the regression equation producing adjusted r square = 1.0 ($F_{(2,20)}$ = 1479.84, p = 0.000). M-L stability index accounted for only an addition of 12% of overall stability variability.

Internal condition Whilst Fatigued: on the first step, A-P stability index entered the regression equation with adjusted R square = 0.82 ($F_{(1,21)}$ = 96.39, p = 0.000). On the second step, M-L stability index entered the regression equation producing adjusted r square = 0.96 ($F_{(2,20)}$ = 96, p = 0.000). M-L stability index accounted for only an addition of 14% of overall stability variability.

External condition Pre-Fatigue: on the first step, A-P stability index entered the regression equation with adjusted R square = 0.80 ($F_{(1,17)}$ = 90.04, p = 0.000). On the second step, M-L stability index entered the regression equation producing adjusted r square = 0.99 ($F_{(2,20)}$ = 1669.54, p = 0.000). M-L stability index accounted for only an addition of 18% of overall stability variability.

External condition Whilst Fatigued: on the first step, A-P stability index entered the regression equation with adjusted R square = 0.58 ($F_{(1,21)}$ = 31.81, p = 0.000). On the second step, M-L stability index entered the regression equation producing adjusted r square = 0.98 ($F_{(2,20)}$ = 179.62, p = 0.000). M-L stability index accounted for an addition of 38% of overall stability variability.

Generalised Fatigue Discussion

Overall balance performance

The main aim of this study was to investigate the relationship between the effects of different attentional focusing strategies on postural control before and after a generalised fatiguing session. A significant interaction between Focusing Strategy and Fatigue State was revealed, and a large effect size indicated that the relationship warranted further investigation (>0.14, Cohen, 1992). Balance index values in all conditions exhibited a degrading of postural control after fatigue, supporting previous research showing that generalised fatigue degrades postural control (e.g. Yaggie & Armstrong, 2004). Interestingly, analysis revealed that both the Internal and Control conditions did not show significant decreases in balance performance, whereas the External condition demonstrated a significant worsening of balance performance after fatigue. This was further demonstrated by the finding that, whilst fatigued, participants' performance in the External condition was significantly worse than in the Internal condition, but not the Control condition. This demonstrates that the Internal focus exhibited superior balance performance in a fatigued state.

Whilst at rest though, postural control in the External condition was not significantly better than the Internal or Control condition, which themselves were not significantly different. This indicates no benefit of the external focus strategy whilst at rest. This does not support the previous findings showing benefits of an external focus when compared to an Internal focus and Control group (e.g., Wulf & McNevin, 2003; Wulf et al., 1998, Experiment 1; Wulf & McNevin, 2003; Wulf, Weigelt, Poulter, & McNevin, 2003) during the execution of motor tasks in non-fatigued states. This poses problems for discussion of the advantages of an internal focus when compared to the external focus whist fatigued. If an advantage cannot be demonstrated for the External focus whilst at rest, the significant degradation in postural control in the External condition may well be a reflection of this condition's poor performance. However, as the focus instructions were direct replications of Wulf et al.'s, it may be the case that the instructions were not appropriate for the situation. This, and other factors concerning methodology will be discussed later. Further research is needed to establish the effects of attentional focusing instructions at rest using this dynamic balance task.

Anterior-Posterior balance performance

No significant interaction was identified between Attentional Focusing Strategy and Fatigue State in the A-P direction. However, analysis did reveal that postural control did not significantly deteriorate in the Control or Internal conditions because of fatigue, but it did under the External condition. This suggests that in the A-P direction, the effects of fatigue degraded postural control in the External condition but not in the Internal condition. However, in between-condition comparisons, no significant differences were identified between the 3 conditions at rest or whilst fatigued. The A-P direction may be specifically vulnerable to the effects of generalised fatigue as well as the different influences of attentional focusing strategies. The benefits of an internal focus in the A-P direction are logical given the action of muscle groups. The movement and control of movement of the leg around the knee is most likely to occur in the A-P plane due to anatomical limits, therefore muscular control of the movement induced through an internal focus has been shown to be more effective in this direction whilst fatigued.

Medial-Lateral balance performance

Between-condition comparisons revealed no significant difference between the attentional focusing conditions at rest. Analysis of balance index before and after fatigue in the M-L plane for each condition revealed that postural control deteriorated in the External and Control conditions after fatigue but did not in the Internal condition. This suggests that the internal focus provides a beneficial effect on postural control over both the Control and External conditions in this plane. Furthermore, in between-condition comparisons in the fatigued state balance performance was poorer in the External condition when compared to the Internal, but not the Control condition. As with the A-P plane, anatomical factors can point us to the possible location of such effects. Movement in the M-L plane on the balance platform is specifically exhibited in the ankle. It is possible that an internal focus of attention afforded greater control of the ankle during a fatigued state, whereas the ankle became more unstable when an external focus was utilised. This seems plausible as instructions directed participants' attention towards their feet. This finding implies that whilst fatigued, the external focus left participant's at risk of ankle injury. Further research is needed to assess this claim.

Contributions to Overall Balance Index

At rest, the multiple regression indicated that the amount of Overall Balance index variability accounted for by the A-P balance index was 85% for the Control condition, 87% for the Internal condition, and 80% for the External condition. Whilst fatigued, these values changed to 85% for the Control condition, 82% for the Internal condition and 58% in the External condition. These results supported those of previous studies assessing balance using a Biodex Balance System (Arnold & Scmitz, 1998), who suggested that M-L values account for a very small proportion of overall balance index. However, one difference is the lower value for the External condition whilst fatigued. As this condition also experienced significantly poorer postural stability, it may be that a decrease in the stability in the M-L has increased its contribution to overall balance performance whilst fatigued. Furthermore, as this effect is not seen in the other focusing conditions, it suggests that the external focus promotes increased movement in the M-L direction during a fatigued state.

Conclusions

These results are the first evidence of the effects of attentional focusing strategies during a fatigued state. Previous research has been concerned with performance whilst at rest, findings from which are useful but not ecologically valid in the case of many performance and learning situations. The present results give preliminary evidence of the protective benefits of an internal focus on postural control in a fatigued state. Specifically, direct conscious control of movement reduced the effects of fatigue on balance, whereas an external goal-based focus of attention was more vulnerable to the degrading effects of fatigue. Analysis revealed that each of the main planes of movement exhibited this protective effect from fatigue. There is also evidence to suggest that, whilst fatigued, movement in the M-L direction is increased under an external focus of attention. Further research is needed to establish this.

A number of problems are present in the current experiment's findings, specifically, whether these findings are consistent with other forms of fatigue. Although the initial aim was to carry out the follow up study to assess the influence of attentional focus during balance perturbed by different forms of fatigue, another aim has become apparent. The generalised fatigue experiment was expected to induce a generalised fatigued state, and this was the case. However, due to the nature of the task it cannot be ruled out that a substantial proportion of localised fatigue of the leg was also induced. In Experiment 2 the current findings will be tested, but with the use of a localised fatigued state. This will test whether specifically fatiguing the leg muscles has the same effect as the overall fatiguing protocol used in the present experiment. It is proposed that if an internal focus of attention is beneficial during a fatigued state because of direct control of the fatigued movements being carried out, then this will be demonstrated under a localised fatigue state. Any differences in the observed relationship may be due to the absence of a generalised fatigued state.

Experiment 2: Localised Fatigue

Method

Participants

Nineteen healthy participants (11 males, 8 females) carried out the current study, with a mean age of 19.5 (max age = 22, min age = 18). 21 participants had been recruited but 1 participant became injured and was unable to continue, whereas another dropped out. Average height was 1.7m and weight 63.55kg. All participants were naive to the aim of the study, and none had participated in previous attentional focus experiments. All participants completed a general health questionnaire to ascertain suitability for taking part in the fatigue protocol. None of the participants had a history of vestibular or central nervous system balancing problems or previous lower extremity injury history. All participants were naïve as to the purpose of the study but were debriefed after completion. Participants were required to read an information sheet and fill out an informed consent form prior to taking part in the study. The methodology was approved by the University of Hull Department of Psychology Research Committee.

Design, Apparatus and Task

The design, balance task and Attentional Focusing Instructions were identical to that carried out in Experiment 1. Only the fatigue protocol used differed in that general fatigue was induced.

Fatiguing protocol: Localised muscular fatigue in the dominant (balancing) leg was induced using The Biodex System 3. This Isokinetic Dynamometer system allows for specific protocols to be programmed for standardised testing. In this case each participant carried out concentric leg extension / flexion to volitional failure, performed at 150 degrees per second, with a total range of movement being 81°. This specifically fatigued the balancing leg's quadriceps and hamstring muscles. Participants were seated and strapped into the equipment, and appropriate adjustments were made regarding leg dimensions. To ensure complete fatigue, participants were required to carry out 3 sets of a maximum of 20 repetitions of concentric and eccentric leg actions. Concentric contractions are the most familiar type of muscular contractions used in all lifting activities, with the muscle shortening as the fibres contract. In eccentric contractions the muscle lengthens as it develops tension, as for example, when slowly lowering a weight. The actin and myosin filaments within the fibre contract to produce the required force, but the fibres themselves slide alongside each other to create an overall lengthening of the muscle. Participants completed that fatigue protocol with their athletic shoes on, but performed the balance without shoes.

Results

Overall balance performance will be analysed first with respect to mean balance index and standard deviation of balance index. The overall balance performance will then be broken down for movements in the medial-lateral and anterior-posterior directions.

Overall Balance Index

Biodex stabilimoter produces an overall balance index, the higher this value, the poorer the balance performance.

Mean Overall Balance Index

Table 4.4: Overall balance index values for each attentional strategy at rest and whilst locally fatigued

Focus Strategy	Balance Index	Resting	Fatigued
Natural	Mean	3.19	3.87
	SD	(1.11)	(1.46)
Internal	Mean	2.83	2.87
	SD	(0.97)	(1.00)
External	Mean	2.69	3.10
	SD	(0.59)	(1.11)

A focus (3) x Fatigue (2) repeated measures ANOVA was carried out initially to assess the overall relationships within the data. A significant main effect was observed for the effects of fatigue on balance index ($F_{(1,18)} = 6.14$, $p = 0.02$, $\eta_p^2 = 0.25$). Overall balance performance was significantly better before fatigue (mean 2.90) than during a fatigued state (mean 3.28), indicating a deterioration in postural control whilst fatigued. However, this value incorporates all strategy conditions, and may well hide other relationships. A significant main effect was observed for the effects of attentional focus on balance ($F_{(2,36)} = 9.87$, $p = 0.00$, $\eta_p^2 = 0.35$). LSD post hoc analysis revealed that overall balance index in the Internal condition was significantly better than the Control condition ($p = 0.001$, mean difference = 0.68), but not the External condition ($p = 0.81$, mean difference = 0.004). Balance in the external condition was significantly better than in the Control condition ($p = 0.006$, mean difference = 0.64). Again, this value incorporates both pre-fatigue and fatigued state balance, and so care must be taken in its discussion. A significant interaction was identified between Fatigue State and Attentional Focus ($F_{(2,36)} = 3.90$, $p = 0.03$, $\eta_p^2 = 0.18$).

Pre-Fatigue - Fatigued State Paired Comparisons

Further analysis was carried out using paired sample t-tests, with pre-fatigue and fatigued state balance values compared for each focus condition. A significant difference was identified between pre-fatigue and fatigued state balance index in the Control condition (t = 2.80, df = 18, $p = 0.01$) and the External condition (t = 2.03, df = 18, $p = 0.05$). The pre fatigued mean balance indexes of 3.19 and 2.69 for the Control and External strategies respectively indicated that balance was significantly better than in a fatigued state, when balance indexes were 3.87 and 3.10 respectively. This indicates a deterioration in balance whilst fatigued in both conditions. No significant difference was identified between pre-fatigue and fatigued balance using an Internal focus (t = 0.24, df = 18, $p = 0.81$). The pre-fatigue mean balance index of 2.83 was not significantly lower than the mean balance index during the fatigued state of 2.87, indicating that fatigue did not significantly affect postural control in the Internal condition. Figure 4.6 highlights this relationship.

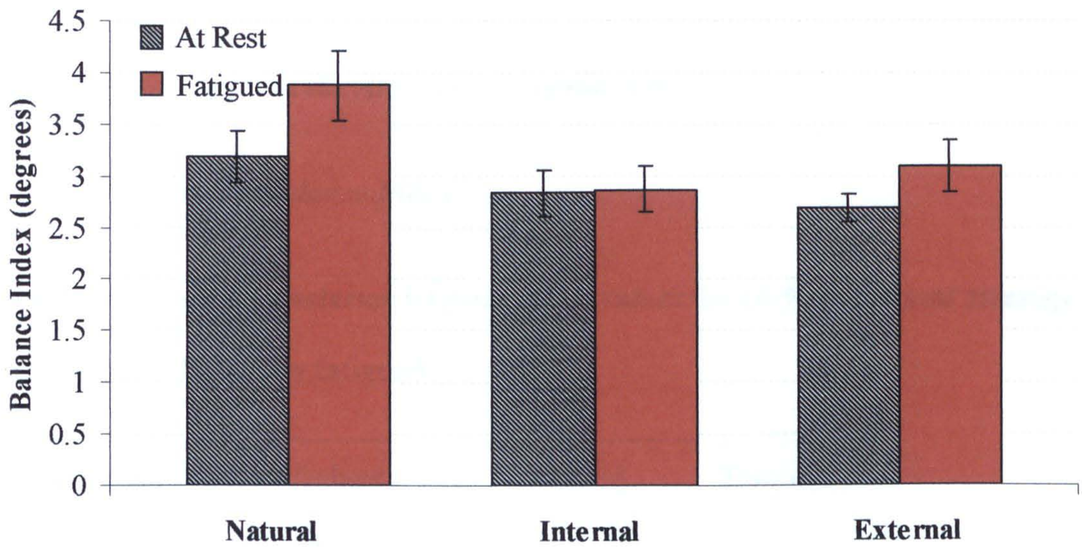


Figure 4.6: Overall balance index for each attentional strategy at rest and whilst locally fatigued (Lower values indicate superior postural control)

Analysis of Balance Index before Fatigue and During a Fatigued State

To assess the relationships between attentional focusing strategies at rest and whilst fatigued two separate Focus (3) repeated measures ANOVAs were carried out. A significant differences were found between the 3 focus conditions' balance performance whilst at rest ($F_{(2, 36)} = 4.49$, $p = 0.02$, $\eta_p^2 = 0.20$). LSD post hoc analysis revealed that balance in the Control condition was significantly worse than the Internal ($p = 0.01$, mean difference = 0.36) and External ($p = 0.02$, mean difference = 0.50) conditions. But the External and Internal conditions were not significantly different ($p = 0.47$, mean difference = 0.14). During a fatigued state a significant main effect of focus on balance was identified ($F_{(2, 36)} = 9.82$, $p = 0.001$, $\eta_p^2 = 0.35$). LSD post hoc analysis revealed that balance in the Control condition was significantly worse than in the Internal ($p = 0.000$, mean difference = 1.01) and External ($p = 0.01$, mean difference = 0.78) conditions. But the External and Internal conditions were not significantly different ($p = 0.30$, mean difference = 0.23).

Balance Performance in the Anterior - Posterior Axis

Mean Overall Balance Index

Table 4.5: Anterior – Posterior balance index values for each attentional strategy at rest and whilst locally fatigued

Focus Strategy	Balance Index	Resting	Fatigued
Natural	**Mean**	2.64	3.26
	SD	(1.17)	(1.17)
Internal	**Mean**	2.34	2.23
	SD	(0.84)	(0.80)
External	**Mean**	2.18	2.55
	SD	(0.67)	(1.34)

A focus (3) x Fatigue (2) repeated measures ANOVA was carried out. Mauchly's Test of Sphericity was significant for the Focus main effect (W = 0.66, p = 0.03) and the Focus x Fatigue interaction (W = 0.69, p = 0.04), Greenhouse Geisser values were used in these cases. No significant main effect was observed for the effects of fatigue on balance ($F_{(1,18)} = 3.01, p = 0.10, \eta_p^2 = 0.14$). Overall mean balance index before fatigue was 2.39 and during a fatigued state 2.68. A significant main effect of attentional focus was found ($F_{(1.49, 26.81)} = 5.68, p = 0.014, \eta_p^2 = 0.24$). This value incorporates both pre-fatigue and fatigued state balance, and so care must be taken in its discussion. LSD analysis revealed that balance in the Control condition was significantly poorer than in Internal (p = 0.005, mean difference = 0.67) and External (p = 0.04, mean difference = 0.58) conditions, which themselves were not significantly different (p = 0.60, mean difference = 0.08). No significant interaction was identified between Fatigue State and Attentional Focus ($F_{(1.52, 27.41)} = 3.18, p = 0.07, \eta_p^2 = 0.15$).

Pre-Fatigue - Fatigued State Paired Comparisons

Further analysis was carried out using paired sample t-tests, with pre-fatigue and fatigued state results compared for each focus condition. No significant difference was identified between pre-fatigue and fatigued state balance index in the Internal condition (t = 2.63, df = 18, p = 0.68) or the External condition (t = 1.71, df = 18, p = 0.11). The pre-fatigued mean balance indexes of 2.34 and 2.18 for the Internal and External strategies respectively were not significantly different from their fatigued state balance indexes, 2.23 and 2.55 respectively. This indicates no significant deterioration in balance performance when these strategies were used in a fatigued state. A significant difference was identified between pre-fatigue and fatigued balance in the Control condition (t = 0.42, df = 18, p = 0.02). The pre-fatigue mean balance index of 2.64 was significantly lower (balance was better) than the mean balance index during the fatigued state of 3.26, indicating a deterioration in postural control. Figure 4.7 highlights this relationship.

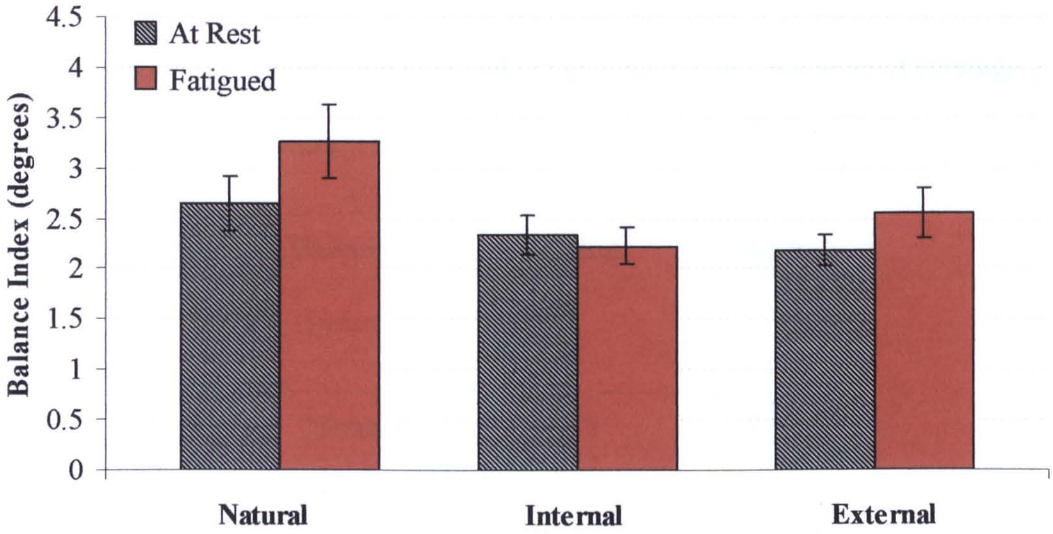


Figure 4.7: Anterior – Posterior balance index values for each attentional strategy at rest and whilst locally fatigued (Lower values indicate superior postural control)

Analysis of A-P Balance Index before and After Fatigue

Two separate Focus (3) repeated measures ANOVAs were carried out to analyse balance index performance at rest and after fatigue. Mauchly's Test of Sphericity was significant for the Focus at rest (W = 0.48, p = 0.002), so Greenhouse Geisser values were used. No significant difference was identified between the 3 focus conditions' balance performance whilst at rest ($F_{(1.32, 23.73)} = 2.81$, $p = 0.10$, $\eta_p^2 = 0.14$). During a fatigued state a significant main effect of focus on balance was identified ($F_{(2, 36)} = 5.67$, $p = 0.007$, $\eta_p^2 = 0.24$). LSD post hoc analysis revealed that balance in the Control condition was significantly poorer than in the Internal (p = 0.05, mean difference = 0.30) but not the External (p = 0,09, mean difference = 0.45) conditions. The Internal and External conditions were not significantly different (p = 0.38, mean difference = 0.15).

Balance Performance in the Medial - Lateral Axis

One participant's data was not available for this axis, leaving 23 remaining data sets for analysis.

Mean Overall Balance Index

Table 4.6: Medial – Lateral balance index values for each attentional strategy at rest and whilst locally fatigued

Focus Strategy	Balance Index	Resting	Fatigued
Natural	Mean	1.77	2.03
	SD	(0.72)	(0.57)
Internal	Mean	1.83	1.86
	SD	(0.69)	(0.97)
External	Mean	1.79	1.84
	SD	(0.52)	(0.73)

A focus (3) x Fatigue (2) repeated measures ANOVA was carried out. The main effect of fatigue on balance performance was not significant ($F_{(1,18)} = 1.06, p = 0.32, \eta_p^2 = 0.06$). Balance performance was not significantly better before fatigue (mean 1.80) than during a fatigued state (mean 1.91). Mauchly's Test of Sphericity was significant (W = 0.64, $p = 0.02$) for the main factor of Focus, therefore Greenhouse-Geisser corrections were used. The main effect of Focus on balance performance was not significant ($F_{(1.47, 26.40)} = 0.16, p = 0.86, \eta_p^2 = 0.01$). This value incorporates both pre-fatigue and fatigued state balance, and so care must be taken in its discussion. No significant interaction was identified between Fatigue State and Attentional Focus ($F_{(2,36)} = 75, p = 0.48, \eta_p^2 = 0.04$).

Pre-Fatigue - Fatigued State Paired Comparisons

Further analysis was carried out using paired sample t-tests, with pre-fatigue and fatigued state results compared for each focus condition. No significant differences were identified between pre-fatigue and fatigued state balance index in the Control (t = 1.40, df = 18, p = 0.18), External (t = 0.31, df = 18, p = 0.76) or Internal (t = 0.21, df = 18, p = 0.84) conditions. Graph 4.8 highlights this relationship.

Analysis of M-L Balance Index before and After Fatigue

Two separate Focus (3) repeated measures ANOVAs were carried out to analyse balance index performance at rest and after fatigue. No significant difference was identified between the 3 focus condition's balance performance whilst at rest ($F_{(2, 36)}$ = 0.05, p = 0.95, η_p^2 = 0.03). During a fatigued state no significant main effect of focus on balance was identified ($F_{(2, 36)}$ = 0.61, p = 0.55, η_p^2 = 0.03).

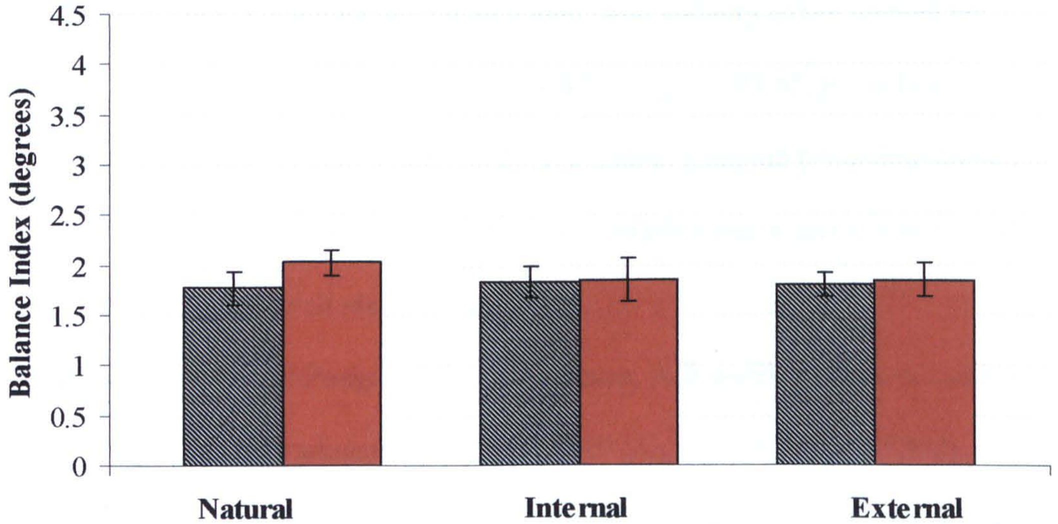


Figure 4.8: Medial – Lateral balance index values for each attentional strategy at rest and whilst locally fatigued (Lower values indicate superior postural control)

A-P and M-L contributions to overall Stability Index

For each fatigue state and attentional strategy condition, stepwise multiple regressions were carried out using M-L stability index and A-P stability index to predict Overall

Stability Index. The purpose of this analysis was to assess the relative contributions of balance in each major movement plane to overall stability, and to investigate whether this changed as a function of fatigue and focus.

Control condition Pre-Fatigue: on the first step, A-P stability index entered the regression equation with adjusted R square = 0.85 ($F_{(1,17)}$ = 99.47, p = 0.000). On the second step, M-L stability index entered the regression equation producing adjusted r square = 0.99 ($F_{(2,16)}$ = 546.59, p = 0.000). M-L stability index accounted for only an addition of 13% of overall stability variability.

Control condition Whilst Fatigued: on the first step, A-P stability index entered the regression equation with adjusted R square = 0.92 ($F_{(1,17)}$ = 220.97, p = 0.000). On the second step, M-L stability index entered the regression equation producing adjusted r square = 0.99 ($F_{(2,16)}$ = 1086.33, p = 0.000). M-L stability index accounted for only an addition of 6% of overall stability variability.

Internal condition Pre-Fatigue: on the first step, A-P stability index entered the regression equation with adjusted R square = 0.85 ($F_{(1,17)}$ = 97.65, p = 0.000). On the second step, M-L stability index entered the regression equation producing adjusted r square = 0.98 ($F_{(2,16)}$ = 506.61, p = 0.000). M-L stability index accounted for only an addition of 13.3% of overall stability variability.

Internal condition Whilst Fatigued: on the first step, A-P stability index entered the regression equation with adjusted R square = 0.49 ($F_{(1,17)}$ = 18.56, p = 0.000). On the second step, M-L stability index entered the regression equation producing adjusted r square = 0.94 ($F_{(2,16)}$ = 118.75, p = 0.000). M-L stability index accounted for an addition of 41.5% of overall stability variability.

External condition Pre-Fatigue: on the first step, A-P stability index entered the regression equation with adjusted R square = 0.65 ($F_{(1,17)}$ = 34.29, p = 0.000). On the second step, M-L stability index entered the regression equation producing adjusted r square = 0.84 ($F_{(2,16)}$ = 48.54, p = 0.000). M-L stability index accounted for only an addition of 19% of overall stability variability.

External condition Whilst Fatigued: on the first step, A-P stability index entered the regression equation with adjusted R square = 0.86 ($F_{(1,17)}$ = 114.21, p = 0.000). On the second step, M-L stability index entered the regression equation producing adjusted r square = 0.97 ($F_{(2,16)}$ = 293.75, p = 0.000). M-L stability index accounted for only an addition of 10.3% of overall stability variability.

Localised Fatigue Discussion

Overall balance performance

The main aim of this study was to investigate the relationship between the effects of different attentional focusing strategies on postural control before and after a localised fatiguing session. A significant interaction between fatigue state and focusing strategy supported the findings of Experiment 1, indicating that the effects of attentional focus both at rest and whilst fatigued warranted further investigation. The large effect size for this interaction (>0.14, Cohen, 1992) also supported further analysis.

Analysis of the effects of each focus condition at rest and whilst fatigued indicated that the Internal and External focus conditions did not significantly differ from each other, but did differ from the Control condition in both states. Large effect sizes for these effects indicated that the strategy group accounted for a large amount of balance variation, with the Control group exhibiting poorer postural control in both states. This finding does not support the results of Experiment 1, where no differences were identified between all conditions at rest, and an External focus promoted poorer performance than the internal but not the Control condition whilst fatigued. Additionally, this finding does not support the previous findings of Wulf et al. in their balance studies (e.g., McNevin, Shea, & Wulf, 2003), who have consistently demonstrated superior balance performance using an external focus whilst at rest. Analysis of the change in postural control in each focus condition due to fatigue revealed some interesting findings. Balance in the External and Control conditions deteriorated with fatigue, indicating and supporting previous research showing similarly that localised fatigue interferes with the motor system's ability to maintain postural stability (e.g., Caron, 2003). This supports the results of Experiment 1, and suggests that despite the no differences between Internal and External attentional focusing strategies at rest and whilst fatigued, the internal focus seems to be offering some protection from the detrimental effects of fatigue on postural control. The external focus on the other hand has promoted a significant deterioration in balance performance whilst fatigued.

Anterior-Posterior balance performance

The investigation was broken down to include balance values in each of the main directions to shed light on this relationship. Values indicated a deterioration in postural control whilst fatigued under Control and External conditions, but a slight improvement in balance performance under Internal conditions whilst fatigued. However, analysis of the balance index in the anterior-posterior direction revealed that fatigue did not significantly change balance under Internal and External conditions, but did under Control conditions. There was no evidence showing any differences between the two attentional focus strategies in each fatigue state. This suggests that, in the anterior-posterior direction, each focusing strategy provided protection against the effects of fatigue on balance compared to the control condition. This finding does not support those of Experiment 1, and may reflect a difference in the effects of the two types of fatigue upon balance and the subsequent effects of attentional focus.

Medial-lateral balance performance

Values suggest that there were only small differences between balance performance in each condition under the different fatigue states, with the only apparent change being a deterioration in balance whilst fatigued under the Control condition. However, similar to the anterior-posterior direction, overall balance index values in the medial-lateral direction demonstrated no significant differences either before or after fatigue. This suggests that the influence of attentional strategies on balance was not evident in the medial-lateral plane. Again, this does not support the findings of Experiment 1 and may reflect the lack of influence localised fatigue had on postural control in the medial-lateral direction.

Directional contributions to overall balance index values

At rest, the multiple regression indicated that the amount of Overall Balance index variability accounted for by the A-P balance index was 85% for the Control condition, 85% for the Internal condition, and 65% for the External condition. Whilst fatigued, these values changed to 92% for the Control condition, 49% for the Internal condition and 86% in the External condition. Apart from the value for the Internal condition at rest, these results supported those of previous studies assessing balance using a Biodex Balance System (Arnold & Schmitz, 1998), who suggested that M-L values account for a very small proportion of overall balance index. This relationship does not support the findings of Experiment 1, where a decrease in the contribution of the A-P direction with fatigue was observed in the External condition with fatigue. The opposite is the case here. It is suggested that with fatigue, the Internal condition has increased the stability in the A-P direction. This increase in stability would therefore decrease the contribution of the A-P values to overall balance index values, and increase the contribution from the M-L direction. The improved stability in the A-P direction would be exhibited through increased control of leg and foot movements in the A-P plane. This different relationship may well reflect differences in the nature of the fatigue induced in the current experiment compared with Experiment 1.

Conclusions

The current experiment assessed the effects of localised fatigue of the standing leg during balance, and offers a new condition under which attentional focusing effects can be tested. The present study has demonstrated that at an internal focus of attention may provide some protection from the effects of fatigue on postural control. Furthermore, an external focus demonstrated a significant worsening in postural control whilst fatigued suggesting limitations to the benefits of an external focus of attention. This finding is in opposition to the suggestions of Wulf et al., who propose that an external focus of attention should be beneficial for all tasks, but they do not take into account the influence of fatigue on the motor system.

A problem with the present experiment is that, at rest, the results do not support the findings of Wulf et al.'s previous balance studies, which show benefits of an external focus of attention. When the analysis was broke-down into the two main planes of movement, no evidence was shown to suggest that the influence of each attentional focus was isolated to a single direction. As movement was possible in the full 360° range it is likely that splitting the values into the two directions does not add further insight. The finding that the medial-lateral direction demonstrated no differences in balance either before or whilst fatigued may not be problematic. Previous research, (e.g. Arnold & Schmitz, 1998) has shown that the medial-lateral stability index accounts for only a small proportion of the overall balance index as measured by the Biodex balance system. Indeed, the present results indicated that the percentage of overall postural control accounted for by the M-L plane was: during the Control condition 13% and 6% whilst fatigued; during the Internal condition, 13.3% at rest and 41% whilst fatigued; and during the External condition 19% at rest and 10.3% whilst fatigued. One issue here is the increase in overall postural control variability accounted for by the M-L in the internal fatigue condition. As this condition exhibited a protection against the effects of fatigue, it is proposed that this result indicates a decrease in A-L movement whilst using an internal focus of attention during a fatigued state.

However, if fatigue was to be induced that would specifically effect the ability to balance in a specific plane than the effects of focus may have been clearer. For example, Gribble and Hertel (2004) demonstrated that fatiguing the ankle plantarflexors and dorsiflexors specifically impaired postural control in the sagittal plane. Using different attentional focusing strategies under such specifically localised fatigue conditions would shed light on the possible protective nature of an internal focus.

Possible implications for these findings relate to situations which exhibit localised fatigue. One such example is weights training. With the repetitive execution of movements, localised fatigue is induced in the muscles which are being trained. Chen (2000) has shown that lifting strategies change as a function of arm fatigue. These changes also increased lower back loading, and increased risk of injury. Furthermore, Resnick (1996) suggested that even after training in correct movement technique in industrial lifting, fatigued workers may use biomechanically non-optimal postures. Therefore, the use of appropriate cognitive strategies during lifting may help maintain efficient technique and reduce the risk of injury. The present results advocate the direct control of movements using an internal strategy whilst in a fatigued state.

General Discussion

One particular issue with both sets of result was the lack of evidence showing the benefits of an external focus over an internal focus during this dynamic balance task, something consistently demonstrated by Wulf et al. (e.g. McNevin, Shea, & Wulf, 2003). Several issues have come to light regarding this.

Firstly, comparing the task used in these experiments with those used by Wulf et al. may not be as simple as thought. Wulf et al. use a simple dynamic balance task that is unstable in the medial-lateral direction (e.g. Wulf, Shea and Park, 2001), and therefore only requires participants to control their movement in this plane. The current experiments used a more dynamic balance task that was unstable in all directions simultaneously, making it a much harder task. The strength of previous findings suggests that the benefits of an external focus should follow on to this task, but this has not been the case. Due to the difficulty of the task, it may be that the benefits of an external focus are not as apparent initially. As this task only required participants to attend a single familiarisation session, it may be that participants' ability to utilise an external focus is limited. Future research may need to assess the influence of attentional focus during a fatigued balance task which has been well learned. However, Wulf et al. have shown consistently that the beneficial effects of externally focused instructions can be seen very early in learning (e.g. Totsika & Wulf, 2003; Wulf, HoB, & Prinz, 1998; Wulf et al., 1999, 2002), suggesting that the performer's attentional focus can have a strong and almost immediate effect on performance.

Regarding measurement, other differences are apparent between the current research and the previous studies on attentional focus and balance by Wulf and colleagues. Specifically, the dependent measures are different. In Wulf et al.'s studies using stabilometers moving in the sagittal plane, degrees out of balance is collected (e.g., McNevin et al., 2003) and from this data root-mean-square errors (RMSE) in degrees is used as the dependent measure. In addition, spectral frequency analysis reveals subtle frequency differences in performance between groups that provides important information related to the maintenance of postural control. In the present study the Biodex stability index, represents the variance of foot platform displacement in degrees, from level, in all directions. This objective assessment measure assesses neuromuscular control by quantifying the ability to maintain dynamic bilateral and unilateral postural stability on an unstable surface, and has shown to be influenced by fatigue (e.g. Pendergrass, et al. 2003).

Arnold and Schmitz (1998) demonstrated that AP stability index was larger than ML stability index, a finding demonstrated here. However, previous research (e.g. Era & Heikkinen, 1985; Goldie, Bach, & Evans, 1989) using COP measures during single-leg stance demonstrated AP and ML sway to be approximately equal. The reduced sway in the ML direction compared to the AP direction has two, not mutually exclusive, explanations. Arnold and Schmitz suggest that firstly, increased movement at the A-P plane is due to greater gravitational moment around that axis and increased muscular stability around the ML axis. Secondly, anatomically, there is a greater degree of movement available in the ankle's AP plane then in its ML plane.

Another problem with the comparison between the present findings and Wulf et al.'s findings is due to the instructions used. Firstly, as with the point above, the tasks were different, but the instructions used in the present study were developed from those used in Wulf et al.'s tasks. It may be possible that instructions needed a different emphasis for them to be successful whilst at rest. However, a more plausible explanation, which also has implications for the findings regarding the reduced effectiveness of the external focus whilst fatigued, is that of distance of external focus. Wulf and colleagues have proposed that there is an ideal distance of an external focus, which is a compromise between increased distance from the movements but not too far as to be completely unrelated (see Wulf and Prinz, 2001). It is a possibility that the external focus used in this study was too close to or too far away from the participants to be fully effective at rest. Furthermore, it is suggested here that fatigue may alter the location of the ideal distance of external focus in that it is increased. Due to the demands placed on the motor system by physical fatigue, external focuses close to the body may become more closely related to an internal focus and performers may need to focus further away for benefits to be apparent. On the other hand, markers further away from the participants may become more difficult to focus upon effectively as a results of fatigue. However, there are physical limitations in the present task imposed by the dimensions of the balance platform. A review of the distances of external focuses used in Wulf et al.'s balance studies is needed, and is presented below in table 4.7.

Table 4.7: Marker distances in Wulf et al. balance and attentional focus studies

Authors (year)	Distance of External Focus Markers from:	
	Participants' Feet	Platform Midline
Present Study	27.5cm	27.5cm
Wulf, et al. (1998)	Touching tip of feet	20.4cm
Shea & Wulf (1999)	Touching tip of feet	14cm
Wulf, et al. (2001)	Touching tip of feet	25cm
McNevin, et al. (2003)	*Far inside*: 23cm	
	Near: Touching the tip of feet	23cm
	Far outside: 26cm	49cm

In each of the studies reviewed in Table 4.7, an external focus was found to be beneficial to performance and learning of a balance task on a stabilometer unstable in the medial-lateral direction. Consistently, an external focus of attention was induced by instructing participants to direct their attention to markers placed directly in front of their feet. The distance of the markers used in the present study are considerably further away from the markers used in studies where the markers were touching the tip of participants' feet. This may suggest that the markers in the present study were too far away from the participants' feet to be effectively used. However, McNevin et al. (2003) used greater distances and found that whilst all external focus instructions produced improved performance in relation to an internal focus of attention, both the far outside and far inside focuses produced further performance benefits. This suggests that the distances used in the present study would produce further benefits if compared to markers that were placed directly next to the participants' feet. However, the markers used in the present study are an additional 1.5cm from the participant's foot than those in McNevin et al.'s (2003) far-outside condition. Although only a small distance, this may present a limit at which an external focus becomes less effective in this task. Indeed, Wulf et al. (2000, Experiment 2) demonstrated that focusing on more remote effects is not always more beneficial. This prompted Wulf and Prinz (2001) to suggest that an optimal mid-point exists for an effective external focus, one which is easily distinguishable from the body movements but also a distance which is still related to the movement technique.

What isn't clear is the relationship the distances of markers have if they are only in relation to a single foot, as in this study, or to two feet, as in all the reviewed balance papers. Single legged balance may restrict the effective distance at which an external focus is beneficial, and markers placed nearer to the feet may have produced performance benefits at rest. Future research is needed to establish this.

Regardless of the issues surrounding the external focus used in the present study, the results indicate the possibility that an internal focus may offer protection from the effects of fatigue. Why this should be the case goes against the proposals of researchers such as Wulf et al., (e.g. 1999) or Singer et al. (e.g., 1994) who demonstrate consistent benefits of an external focus and degraded performance whilst using an internal focus in a number of motor performance and learning situations. However, as these researchers did not take into account such naturally occurring factors such as fatigue, their claims do not cover movement in a fatigued state. But as fatigue is naturally associated with movement, the proposal that using an internal focus to gain online control of a movement needs clarifying with future research.

One study which has taken into account naturally occurring factors during performance was Gray (2004), who investigated the influence of changes in attentional focus during performance and periodic slumps in performance. Gray suggested that when a performer experiences a slump in performance, they utilise an internal focus of attention to take control of the skill, identify problems with its execution, and return it to optimal performance where an internal focus of attention is reduced. In a similar vein, the present studies' findings demonstrate a slump in performance, albeit one that has been produced by the effects of fatigue rather than a natural decrease in movement efficiency.

It may also be that the 'slumps' in performance experienced by the batters in Gray's (2004) study may well have been due to physical fatigue caused by the task. In Gray's study (Experiment 1), participants carried out a total of 100 bat swings with 20s between each swing. Therefore, it is plausible that physical fatigue was induced at times during the task, specifically of a localised nature in the arms and shoulders. However, no measure of physical fatigue or perceived exertion was obtained as this was not the primary aim of Gray's study. Therefore, in light of the suggestions of Gray (2004), the benefits of an internal focus of attention in the present study for offsetting the effects of fatigue on balance may be due to the online step-by-step control of movement emphasised, exactly the type of focus that Wulf et al. suggest to degrade performance. Fatigue has been suggested to place higher demands on the postural system by increasing the frequency of actions needed to regulate upright stance, and by taking control of the movements involved in balance, participants may have been able to reduce the frequency of movements. Additionally, due to the slowing of propagation of efferent signals due to fatigue, the movements being executed are no longer fully automatic. By consciously attending to the movements, a certain degree of control is gained for the movements, and it may be that the internal focus is a more natural focus to attain during the fatigued state.

Furthermore, previous research has demonstrated that focusing upon a movement being carried out promotes greater awareness of the movement (e.g. Smid et al. 2004). This greater proprioceptive awareness of movement promoted by the internal condition would provide more direct feedback regarding the nature of the leg and foot's position in a fatigued state. This information would be useful for the maintenance of balance, whereas an external focus would not provide such information, leaving automatic processes free to run off movements that have been compromised by fatigue. The greater awareness of movement promoted by an internal focus would provide self-regulatory mechanisms with information regarding movements that had now become compromised by fatigue. Beilock et al. (2002) and subsequently Gray (2004) have proposed that the benefits of an internal focus of attention are linked to self-regulatory mechanisms. Although online attention is detrimental to performance during a non-compromised system, without the feedback to self-regulatory systems performance deteriorated with the use of an external focus whilst fatigued. Self-regulatory mechanisms would be able to identify, adjust and control aspects of movement which had been compromised. From the current findings, aspects of postural control would therefore be identified as non-productive and altered through online awareness.

Another explanation, not separate from the previous explanation, covers the influence of physiological feedback. Physical fatigue increases the bodily sensations experienced by performers due to increased amounts of information being available regarding the state of different physiological systems. Indeed, in endurance events where such sensations are increased, athletes use different attentional techniques to either focus away from these increased sensations or focus upon them. The increased sensations of fatigue in both of the experiments here may have been distracting and may have increased the difficulty of focusing externally. Whereas an internal focus of attention will have become a more natural focus to use during movement.

The "constrained action hypothesis" (Wulf, McNevin, & Shea, 2001; Wulf, Shea & Park, 2001; see also, Wulf and Prinz, 2001), previously used to explain deterioration in performance due to an internal focus, provides further indication to the possible benefits of an internal focus during fatigued movement. Postural control on unstable surfaces involves a delicate interplay between a number of central processes and peripheral reflexes. An internal focus promotes the active intervention in these automatic processes, and has been shown to degrade postural control in other studies (e.g., McNevin et al., 2003) but not the present study. However, due to these automatic processes being compromised due to fatigue, active intervention provides protection against deterioration for exactly the same reasons it would degrade performance at rest. By actively controlling movements, the participant is aware of the current state of balance and can adjust to maintain it.

A potential downside to the positive effects of an internal focus reported here regards performance on secondary tasks. Although, as others have stated (Beilock et al., 2002 and Gray, 2004), an internal focus is beneficial in specific situations which require online control, what is not clear is how this online control impacts on other tasks. Wulf et al. (2001) demonstrated, at rest, poorer probe reaction times under internal relative to external focus conditions during unstable balance performance. Therefore, in this case, although an internal focus provided protection against fatigue, this may have come at the expense of available attentional resources due to online cognitive effort. Future research needs to investigate the attentional demands of each attentional focus during fatigued balance.

Implications

Sporting and everyday activity can induce fatigue in the motor system, and is therefore an important factor to consider when suggesting appropriate attentional strategies to improve performance. Wulf et al. have proposed that an external focus of attention be promoted for all motor performance situations. However, this may now be an inflexible approach. If applied psychology is to have an effect upon peoples' performance, then a consideration of changing circumstances is necessary for appropriate strategies. Single strategy approaches will prove to be ineffective if they cannot be flexibly applied to changing circumstances. In the present study, fatigue has been shown to change the effectiveness of different attentional strategies during performance. Therefore, the sports psychologist should be aware of the different focuses that can be promoted in a fatigued state. Gray (2002) has stated that elite athletes may continuously cycle between different attentional focuses, and that it may be important for athletes to learn strategies to move quickly and effectively between them to perform effectively. This more flexible approach seems appropriate in light of the present findings. An athlete may need to use an internal focus of attention to maintain efficient performance whilst in a fatigue state, and when fatigue has subsided, move back to a more externally focus of attention. Indeed, Nardone, Tarantula, Giordano, and Schieppati (1997) indicated that the detrimental effects of fatigue on balance wear off after approximately 15 minutes. Future research needs to establish this with a more longitudinal study assessing the role of attentional focusing strategies as fatigue is induced, and as it subsides. Additionally, this study suggests that future research should assess the influence of greater fatigued states than those imposed here. Both fatiguing protocols used here were of a short duration, whereas other studies have assessed balance after more long-term fatiguing protocols such as load lifting for two hours (Resnick, 1996) or a 2 mile run (Pendergrass, et al. 2003). Such protocols may further exaggerate the protective effects of an internal focus, or this protection may subsequently disappear under greater fatigue demands.

The current findings do not fully explain the influence different attentional strategies can have during fatigue. Although the results demonstrate a protective effect of fatigue under an internal focus and deterioration under an external focus, no data is available to show how balance changed. Future research should establish how the different attentional focuses affected overall balance strategies. One such approach could be the use of kinematic analysis to assess the effects upon different body parts. It may be that the external focus promoted ineffective use of the upper body during balance, which led to poorer balance whilst fatigued. Other analysis may assess the effects of attentional focusing strategies on muscular activity during movements executed whilst fatigued. This seems a logical line of enquiry as Vance et al. (2004) have demonstrated changes in EMG activity during movements executed with different attentional focuses.

Such EMG research would provide a valuable insight into the mechanisms associated with specific strategies, namely why an internal focus may be beneficial during a fatigued state. In research addressing muscular activity during landing actions, quadriceps muscle activity is thought to affect a knee extension movement to prevent the stance limb from "collapsing" under body weight (Steele & Brown, 1999). It may be that whilst fatigued, an internal focus facilitates the activation of such muscular units to prevent instability around the knee. By actively taking control of the movements the effects of fatigue can be mediated. It should be noted that balance during a fatigued state should not show benefits comparable to that of an external focus at rest. However, the inconclusive evidence here for an advantage of the external focus whilst at rest does not provide support for this view.

A link has been suggested between changes in postural sway and injury incidence (e.g. Tropp, Ekstrand, & Gillquist, 1984). Furthermore, Gribble et al. (2004) stated that fatigue-induced exchanges in postural control place the individual at a greater risk for musculoskeletal injury, and that steps should be taken during conditioning and rehabilitation of athletes to help prevent muscular fatigue. One such physical method would be to increase the physiological systems' ability to cope with fatigue. However, cognitive strategies may prove to be useful when fatigue has set in. Controlling the body's ability to maintain postural control whilst fatigued by using an internal focus of attention may help an athlete to avoid possible injuries. However, as proposed by Wulf and Prinz (2001), an internal focus of attention can leave an individual vulnerable to injury. Therefore, the athlete must be trained regarding the appropriate situations to apply specific focusing strategies. In this case, it is suggested that an athlete should be aware of how to shift between an internal and external focus of attention when fatigue sets in and dissipates. Although these are the first findings suggesting a different role of attentional focuses during a fatigued state and future research must substantiate these claims, they support other research demonstrating potentially beneficial effects of an internal focus (e.g., Beilock et al., 2002; Gray, 2004). This adds further weight to Masters' (1992) claim that skill-focused attention, particularity in experts, should no longer be considered a negative trait that must be avoided at all costs.

CHAPTER 5

EFFECTS OF ATTENTIONAL FOCUSING STRATEGIES DURING PRACTICE AND PERFORMANCE OF A MOTOR SKILL

Study 2 demonstrated the benefits of an external focus for novice darts throwers during a one-off performance session. This follow up study aims to assess the possible development of such advantages over time; particularly how the attentional focusing strategy used during practice may influence later accuracy during a performance session. Study 2 was a replication and extension of the study carried out by Radlo et al. (2002), whose findings showed a benefit of using an external strategy during a one-off performance session involving novices. However, Radlo et al. do claim that an internal focus may be beneficial to learners (p.215), but future research is needed to assess this. Additionally, Study 2 found that a control (no-instruction) strategy was more beneficial than an internal strategy, and just as effective as an external strategy. In light of this, the effects of an internal focus on later performance is of interest, particularly if the movement inefficiency promoted by this focus is carried over into subsequent performance sessions.

The aim of a practice session is to run through and become accustomed to the movements of a skill, and may pose a situation where different effects of attentional focusing strategies are observed. Indeed, Beilock et al. (2002) suggest that during a practice situation where the goal is not to maximise performance outcomes, a skill-focused strategy is beneficial due to its online awareness of movement. Being aware of movement at this stage, although detrimental to performance at that time (as observed in Study 2), provides the learner with valuable information regarding technique. Such information can be corrected and adjusted in line with performance aims. Using such refinement may provide benefits during later performance sessions where an internal focus of attention would be detrimental. On the other hand, Wulf and colleagues suggest that an external focus of attention should be utilised throughout practice and performance. Any skill focused attention would leave the learner held back in their development of a skill. Indeed, Wulf, et al. (2002) stress that instructions directing a learner's attention towards the coordination of their bodily movements is typically done during the teaching of motor skills, and that such an approach is counterproductive. Furthermore, researchers has demonstrated that an internal focus of attention which directs attention to explicit information about a skill during learning leaves a performer vulnerable to the choking effects of stress and anxiety during performance (e.g., Masters, 1992; Masters et al., 1993; Hardy et al., 1996; Mullen & Hardy, 2000).

The present study also aims to build on the findings and methodology of Study 2 through the addition of different areas of analysis. One area which will be assessed in the present study will be the location of darts lading on the board. Wulf et al. (2001) suggests that future research should avoid simple 2 dimensional scoring systems. In line with the suggestions and those of Reeve et al. (1994) and Hancock, Butler and Fischman (1995) a more detailed scoring system will be used in the present study. By only considering the score in relation to the centre of the target, valuable differences in the performances may be missed. For example, Study 1 indicated that during a supra-postural task, an external focus of attention promoted improved movement efficiency in the vertical plane when compared to an internal strategy. If such an effect is apparent in a dart throwing task, we may observe an increased number of darts hitting the target on the lower half of the board during for those using an internal strategy compared to those using an external strategy.

Studies 1 and 2 demonstrated that participants may have different experiences regarding the different attentional focusing strategies. Specifically, Study 1 demonstrated that participants using an attentional strategies during a supra-postural task rated the internal strategy as being less successful as the external strategy. Furthermore, those participants who preferred the internal strategy rated the external strategy as significantly harder to maintain. Study 2 also showed that participants using the external strategy rated it more successful than participants using the internal strategy during a dart-throwing task. What the present study aims to assess is the possible changes in experiences of attentional focusing strategies over time. During a repetitive task, a performer's attentional focus may fluctuate from different areas. Such changes have been suggested to be present in expert performers attentional direction by Gray (2004). Gray suggested that expert performers may actively move their attentional focus along a continuum from internal to external as the situation dictated. Other researchers, such as Liao and Masters (2002) have shown that attentional focuses can change due to stress or anxiety. Therefore, this study will assess possible changes in attentional focuses over the course of a repetitive task with attentional focusing instructions provided. This will be achieved by presenting experience questions to participants throughout the task, rather than after the task has finished. By assessing participants' experiences *during* a task, a more accurate picture will emerge which may add valuable data to the discussion of the effects of different attentional focusing strategies. Additionally this approach also avoids the problems associated with retrospective accounts of participants' experiences.

Other areas of interest are the subjective experiences of participants regarding the attentional focusing strategy they are currently using. Studies 1 and 2 assessed participants experiences of difficulty and success using a post-task questionnaire. However, subtle changes may be apparent during tasks, and researchers such as Gray (2004) would suggest this to be the case. Assessing changes in the experiences of each attentional focusing strategy may provide valuable data in explaining the observed effects. Indeed, Wulf et al. suggest the use of manipulation checks such as post-task questionnaires or interviews to assess this, but do not go as far as suggesting during tasks assessment. The repeated block nature of many motor learning studies provide an opportunity to assess these during task fluctuations, by administrating simple questions between blocks.

EXPERIMENT 1: single focus strategy practice and performance: accuracy and during task experience data

The purpose of Experiment 4.1 was to determine the effects of using a single attentional strategy during a practice session, on subsequent performance one week later. Additionally, the possible advantages of practicing and performing using different attentional strategies was assessed by forming separate groups reflecting the different attentional instructions combinations that were possible. One group practiced using the internal strategy and performed using the internal strategy; one group practiced using the internal strategy and performed using the external strategy; one group practiced using the external strategy and performed using the external strategy; and one group practiced using the external strategy and performed using the internal strategy. All participants practiced throwing darts at a target using their allocated strategy with less emphasis on accuracy, and one week later performed the same dart throwing task with their allocated strategy with emphasis on performing as accurately as possible.

Hypothesis

1. Practice with an attentional focus will influence later accuracy during a performance session
2. Attentional focusing strategies will influence accuracy during both practice and performance.
3. Participants' experiences of each attentional strategy will differ

Methodology

Participants

Participants were undergraduate students who earned course credit for their participation and university employees. All participants were all novice darts throwers, meeting the same requirements as Study 2. The University of Hull Department of Psychology Research Committee approved the protocol used in this study. Sixty nine participants (25 males, 44 females) carried out the study, with a mean age of 21.28 (max = 55, min = 18, sd=6.77). When split into practice groups, 34 (15 males, 19 females) participants practiced using an external strategy and 35 (10 males, 25 females) used an internal strategy. For the performance session, 35 (17 males, 18 females) participants performed using the external strategy whilst 34 (8 males, 26 females) used an internal strategy.

Apparatus and Task

Darts and Target

The darts target and dart will be the same dimensions as the one used in the dart throwing task in Study 2. Also identical is the layout of the experimental area, with distances being exactly the same. Further analysis made for the location of the darts landing on the target. Figure 5.1 indicates the separation of the target into separate areas for analysis, and the code given for each section was as follows: 1: top left; 2: top right; 3: bottom left; 4: bottom right. As with Study 2, darts which hit the centre ring (a bull's-eye) scored 0, and the outer ring scored 9. Shots that fell outside the outer ring also scored a 9.

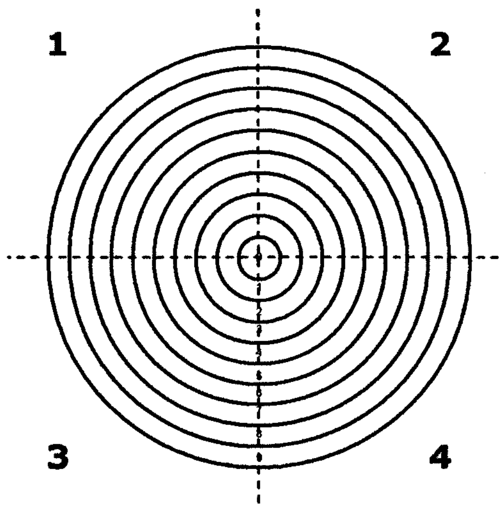


Figure 5.1: Target scoring organization

During Task Questionnaire

Throughout the task, participants completed a short questionnaire to assess the experiences of using the instructions they had been given during the last 8 throws they had completed. A short pilot study found that directing participants to complete the questionnaire after every block was too disruptive to the main darts task. The questionnaire was carried out after block 2, 4, 6, 8, and 10 resulting in 5 separate time points. The questionnaire was presented using the computer program SuperlabPro, with participant responding using the number-pad. This allowed for questions to be randomly presented to participants, and reduce order effects in the hope of obtaining representation of participants' feelings at that time point. Questions were answered by pressing the appropriate number button response from the likert scale of 1 (none at all) to 7 (a great deal). Three groups of questions were given, Internal Questions, External Questions and General Experience Questions, and these are presented below in Table 5.1.

Table 5.1: During Task Subjective Experience Questions

Question Type	During the last 8 throws:
Internal	How much attention was directed towards your hand?
	How much attention was directed towards your arm?
External	How much attention did you direct towards the target?
	How much attention did you direct towards the dart?
	How much attention did you direct towards the speed of the dart?
General Experience	How difficult was it to follow the instructions you were given?
	How often did you use the instructions you were given?
	How physically demanding was the task?
	How much effort was needed?

Procedure

The procedure used in the present experiment is identical to that used in Study 2. The difference is that, whereas in Study 2 participants attended a one-off session, participants in the present study attend two separate sessions one week apart. These two sessions were identical in procedure, in that they both required participants to throw 10 warm-up throws followed by 10 blocks of 4 test throws resulting in a total of 50 dart throws. The two sessions' aims differed. The first session was the practice session and the second session was the performance session. On arrival at the practice session, participants were informed that the aim of this session was to give them chance to practice and become accustomed to the task and movements that it requires, using the instructions given, and there was less emphasis on performing as accurately as possible. The performance session was organised one week later, and participants were informed that the aim was to perform as accurately as possible using the instructions given, and their experience from the practice session, and that this session was their last chance to perform well.

The instructions used were adapted from those found to successfully induce appropriate attentional states in Study 2 and Radlo et al. (2002) demonstrated their effectiveness at inducing appropriate physiological. Individuals in the internal focus group were instructed to focus onto the movements that they were carrying out during each throw and use the instruction they were given to do this. Specifically: 1) feel the weight of the dart in their hand; 2) think about drawing the dart back to the ear; 3) feel the bend in the elbow; and 4) feel the dart as it left the finger tips. Individuals in the external focus groups were directed to focus on the outcome of the task and use the instructions given to help achieve this. Specifically: 1) focus on the centre of the dart board; 2) slowly begin to expand upon perspectives of the dart board; 3) then refocus to the centre of the dart board, expanding the centre and, making it as large as possible; and 4) toss the dart when so focused.

Once completed, participants were debriefed both orally and in writing as to the aims of the experiment. Any questions were answered, and contract details were made available so that future questions could be addressed. A short report based on the results of the study was made available to all participants in the study, all of whom were contacted via email.

Experiment 4.1 Results

Practice

The performance of participants in each focus group was assessed during the practice session, where the emphasis was on practice rather than performance. Performance is based a score for where the dart landed within a 10 ring target. A bull's-eye scores 0 and the outer ring scores 9, therefore the higher the score the less accurate the throw. Table 5.2 presents the mean accuracy values of each block for each strategy.

Table 5.2: Practice accuracy values for external and internal strategy groups

	Focus Strategy		
Block	External (34)	Internal (35)	Total (69)
	Mean (SD)	Mean (SD)	Mean (SD)
1	3.76 (1.75)	4.21 (1.92)	3.99 (1.84)
2	3.45 (1.72)	4.13 (1.82)	3.79 (1.79)
3	3.96 (1.77)	4.33 (1.65)	4.14 (1.71)
4	3.89 (1.96)	4.39 (1.79)	4.14 (1.88)
5	3.94 (2.17)	4.31 (1.69)	4.13 (1.94)
6	3.41 (1.47)	3.90 (1.38)	3.66 (1.43)
7	3.71 (1.82)	4.14 (1.66)	3.95 (1.75)
8	3.45 (1.91)	4.01 (1.51)	3.73 (1.73)
9	3.67 (2.01)	4.06 (1.53)	3.87 (1.78)
10	3.44 (1.91)	3.79 (1.69)	3.62 (1.80)
Total	3.67 (1.85)	4.13 (1.66)	

An Attentional Strategy (2) x Block (10) ANOVA indicated no significant difference between internal and external attentional strategy groups' practice accuracy ($F_{(1,67)}$ = 1.89, p = 17, $\eta_p^2 = 0.03$), with mean scores of 4.13 and 3.67 respectively. A small effect size indicates that the groups did not account for a large amount in darts accuracy during the practice trial. Figures 5.2 and 5.3 highlight this relationship. A significant effect of block was identified ($F_{(9,603)} = 2.16$, $p = 0.023$, $\eta_p^2 = 0.03$), but no interaction was revealed between Block and Attentional Focus Strategy ($F_{(9,603)} = 0.14$, $p = 1.0$, $\eta_p^2 = 0.002$).

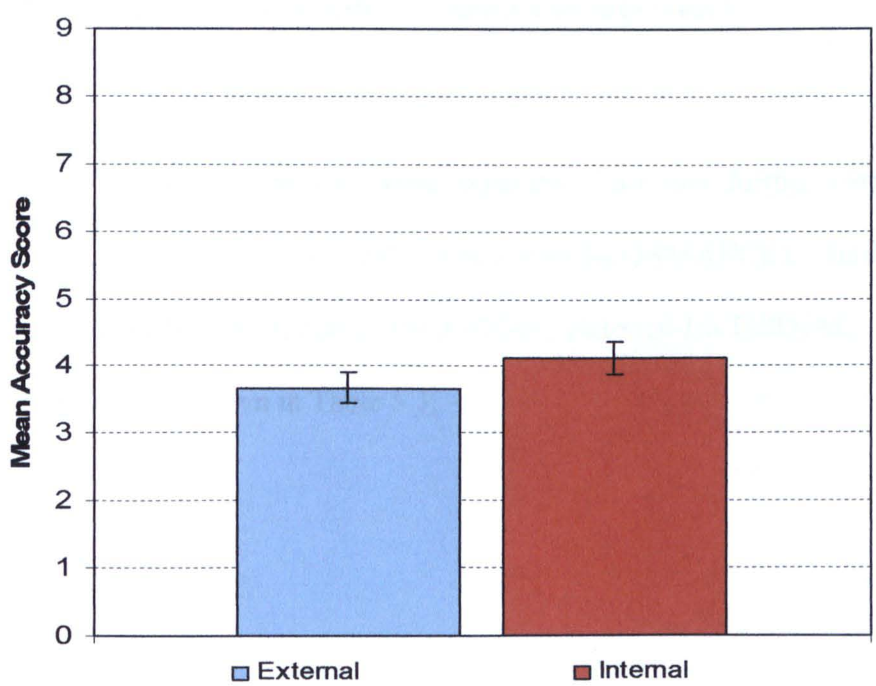


Figure 5.2: Internal and External Strategy Group Practice Accuracy (Lower value indicates more accurate score)

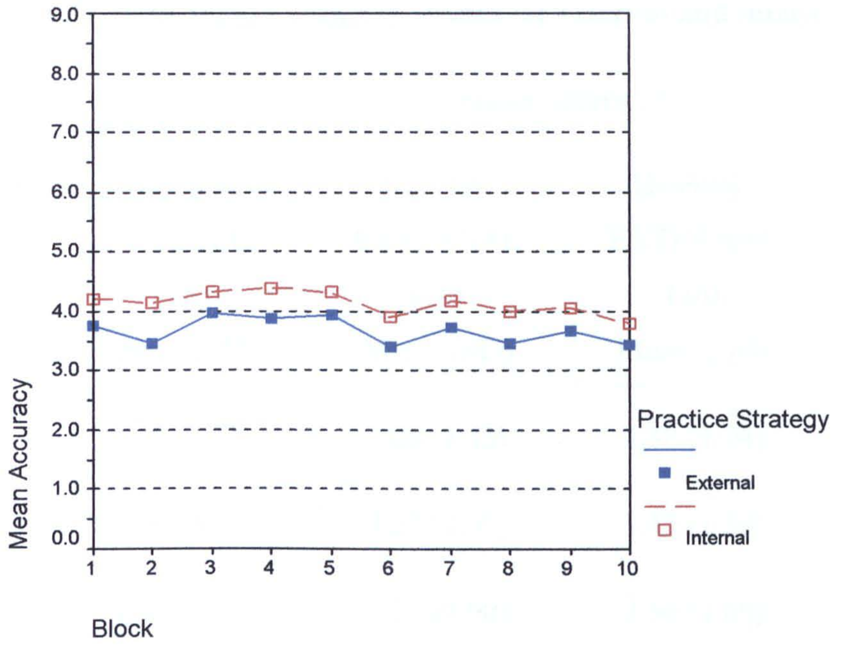


Figure 5.3: Internal and External Strategy Group Practice Accuracy Throughout the Session (Lower value indicates more accurate score)

Performance

Each of the practice groups were separated into two further performance groups, making four groups in total (practice-PERFORMANCE): Internal-INTERNAL, Internal-EXTERNAL, External-INTERNAL, External-EXTERNAL. The performance of each group is shown in Table 5.3.

Table 5.3: Performance accuracy values for external and internal strategy groups

	Focus Strategy *			
Block	Internal-INTERNAL (16) Mean (SD)	Internal-EXTERNAL (19) Mean (SD)	External-EXTERNAL (16) Mean (SD)	External-INTERNAL (18) Mean (SD)
1	3.72 (1.23)	3.24 (1.42)	3.38 (1.94)	4.53 (2.51)
2	4.06 (1.91)	3.22 (1.69)	3.13 (1.50)	4.31 (2.26)
3	4.50 (1.77)	3.71 (1.90)	3.56 (1.69)	4.33 (1.79)
4	4.09 (1.60)	3.41 (1.42)	3.11 (1.25)	4.17 (2.19)
5	4.61 (1.52)	3.13 (1.21)	3.05 (1.69)	4.25 (1.57)
6	4.00 (1.81)	3.41 (1.36)	2.97 (1.56)	3.92 (1.54)
7	4.31 (1.56)	3.45 (1.54)	3.22 (1.90)	4.49 (1.91)
8	4.09 (1.84)	3.39 (1.15)	3.17 (1.25)	3.81 (1.58)
9	4.30 (1.67)	3.21 (1.45)	3.41 (1.80)	3.83 (1.76)
10	4.22 (1.71)	3.14 (1.22)	2.83 (1.35)	4.25 (1.50)
Total	4.19 (1.66)	3.33 (1.44)	3.18 (1.59)	4.19 (1.86)

* Note: Focus Strategy order = Practice-PERFORMANCE

Analysis of the four different Practice-Performance group's accuracy in the performance session using a Group (4) x Block (10) ANOVA indicated a significant main effect for group ($F_{(3,65)} = 3.21$, $p = 0.03$, $\eta_p^2 = 0.13$). LSD Post Hoc analysis revealed that both Internal-EXTERNAL and External-EXTERNAL groups performed significantly more accurately than the Internal-INTERNAL ($p = 0.05$ and $p = 0.04$ respectively) and External-INTERNAL ($p = 0.03$ and $p = 0.02$ respectively) focus groups, which in each case did not significantly differ from each other (p = 0.72). Figures 5.5 and 5.6 highlight this relationship. Partial Eta Squared indicates that the effect size for this relationship is medium to large, with group membership accounting for 13% of the variation in darts accuracy. No significant main effect for block ($F_{(27,585)}$ = 0.94, p = 0.49, η_p^2 = 0.01) or Block x Attentional Focus Strategy interaction ($F_{(27,585)}$ = 0.59, p = 0.95, η_p^2 = 0.03) was identified. Figures 5.4 and 5.5 highlight this.

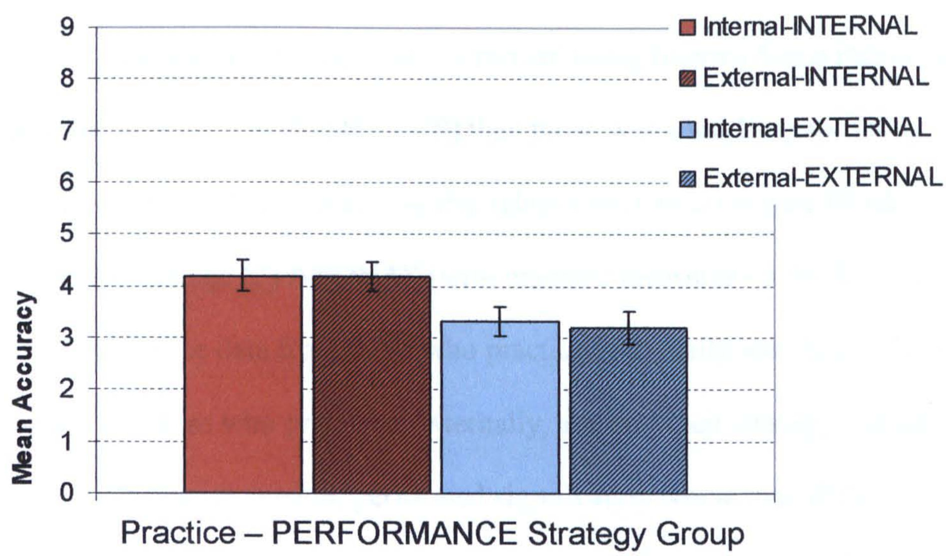


Figure 5.4: Overall Accuracy for Each Performance Group during Performance (Lower value indicates more accurate score)

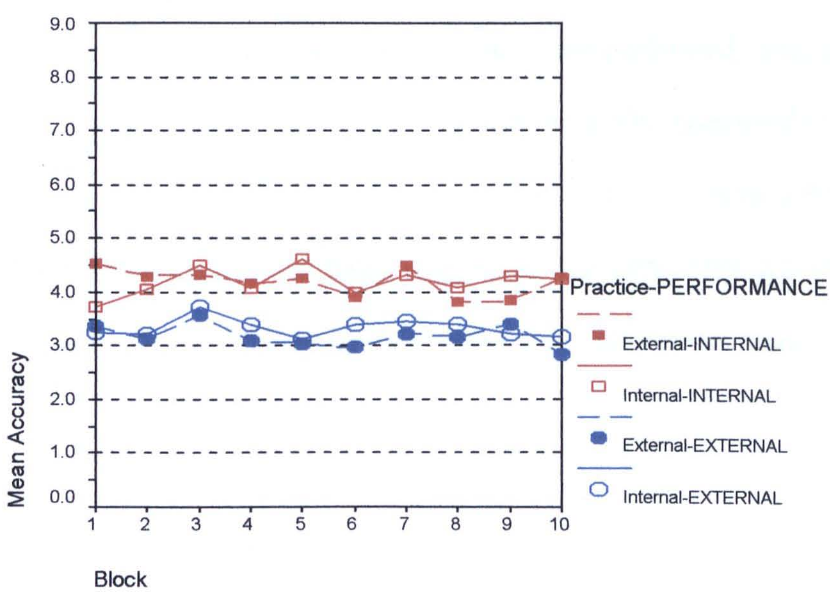


Figure 5.5: Accuracy during the performance session for each strategy group (Lower value indicates more accurate score)

Further analysis was carried out to assess whether changing participants' attentional focusing style from practice would affect accuracy during performance in the follow-up performance session. A Practice Attentional Strategy (2) x Focus Change/No Change (2) ANOVA revealed a significant practice strategy and Focus Change interaction ($F_{(1,65)} = 9.57, p = 0.003, \eta_p^2 = 0.13$). For the Internal-Practice group, those who performed using external instructions threw more accurately (M = 3.33, SE = 0.29) than those who performed using internal instructions (M = 4.19, SE = 0.31). For the External-Practice group those who performed using Internal focus instructions threw less accurately (M = 4.19, SE = 0.29) than those who used External focus instructions (M = 3.18, SE = 0.31). Expanding this relationship, two separate Block (10) x Change/No Change (2) ANOVAS (with repeated measures on the first factor) were carried out on the data from those who practiced internally and those who practiced externally. Those who practiced Externally, and had their strategy changed to internal for the performance session, performed significantly worse than those who continued to use the external strategy ($F_{(1,32)} = 4.15, p = 0.05, \eta_p^2 = 0.12$). Partial eta squared indicates that the effect size for this relationship was medium to large, suggesting that 12% of the accuracy variance was accounted for by the Change factor. Oppositely, those who practiced using the Internal strategy but performed using an External strategy performed significantly more accurately than those who continued to use the Internal strategy ($F_{(1,33)} = 6.00, p = 0.02, \eta_p^2 = 0.15$). Partial eta squared indicates that the effect size for this relationship was large, suggesting that 15% of the accuracy variance was accounted for by the Change factor. Figure 5.6 indicates this relationship.

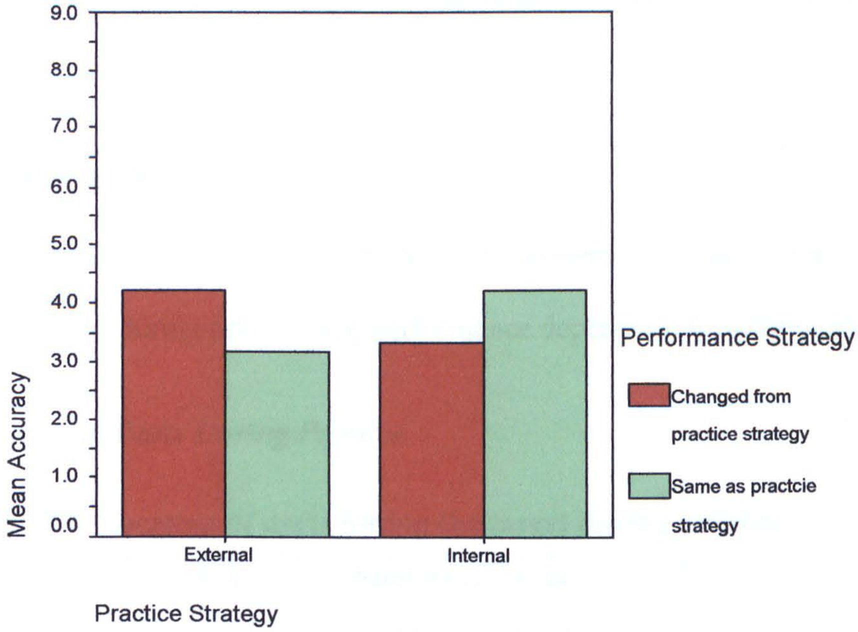


Figure 5.6: Performance accuracy depending on strategy used during practice and whether the strategy was changed for performance (Lower value indicates more accurate score)

Perfect "bull's-eye" shots

The number of bull's-eyes scored during the practice and performance sessions were noted and analysed using one-way ANOVAs.

Bull's-eyes during practice: Analysis revealed that the External group scored significantly more bull's-eye's than the Internal group ($F_{(1,67)} = 7.34, p = 0.01$). Participants in the Internal practice group scored a mean of 1.63 (1.70) bull's-eyes compared to the External practice group who scored a mean of 3.00 (2.45) bull's-eyes.

Bull's-eyes during performance: No significant difference was identified between the four performance groups ($F_{(1,67)} = 7.34, p = 0.01$). Participants in the Internal-INTERNAL group scored a mean of 1.81 (1.97), the External-INTERNAL scored 1.61 (1.65), the Internal-EXTERNAL scored 2.74 (1.05), and the External-EXTERNAL scored 3.06 (2.89). However, when grouped together to form two focus groups, Internal and External, a significant difference was identified ($F_{(1,67)} = 5.25, p = 0.03$). Participants using an external strategy during performance scored more bulls-eye's than those using the internal strategy, scoring means of 2.89 (2.43) and 1.71 (1.78) respectively.

Location of Darts

One way ANOVAs were used to assess the differences in the number of darts landing in each quarter during practice and performance depending upon the strategy used.

Location of Darts During Practice

Table 5.4: Location of darts hitting the target during practice

Location	Strategy	Number of Darts	(SD)
1	Internal	4.41	(3.69)
	External	4.66	(4.18)
2	Internal	4.35	(3.76)
	External	3.17	(2.77)
3	Internal	13.97	(5.36)
	External	15.69	(6.16)
4	Internal	17.27	(5.52)
	External	16.49	(6.70)

Between each focus strategy, no significant difference was found for the darts falling in location 1 ($F_{(1,68)} = 0.07, p = 0.80$), 2 ($F_{(1,68)} = 2.20, p = 0.14$), 3 ($F_{(1,68)} = 1.52, p = 0.22$), and 4 ($F_{(1,68)} = 0.28, p = 0.60$).

Location of Darts During Performance

Table 5.5: Location of darts hitting the target during performance

Target Location	Focus Strategy	Number of Darts	(SD)
1	Internal	3.59	(2.75)
	External	4.71	(3.06)
2	Internal	3.62	(2.67)
	External	5.49	(3.58)
3	Internal	16.56	(5.68)
	External	15.31	(5.90)
4	Internal	16.24	(4.99)
	External	14.49	(5.08)

Between each focus strategy, no significant difference was found for the darts falling in location 1 ($F_{(1,68)} = 2.57, p = 0.11$), 3 ($F_{(1,68)} = 0.80, p = 0.38$), and 4 ($F_{(1,68)} = 2.08, p = 0.15$). A significant difference was revealed between darts falling in location 2 depending upon the focusing strategy used ($F_{(1,68)} = 6.01, p = 0.02$). Participants using the External strategy landed significantly more darts in location 2 than those using an Internal strategy, with means of 5.49 (3.58) and 3.62 (2.67) respectively.

The significant difference for location 2 indicated that further analysis of location may reveal further differences. The locations were simplified to either the top half or the bottom half of the target and analysed using two one-way ANOVAS. The External group hit the target significantly more often than the Internal group in the top half ($F_{(1, 68)} = 6.95, p = 0.01$), with means of 5.10 (SD = 2.55) and 3.60 (SD = 2.14) respectively. Those using an internal strategy hit the target more often in the lower half than those using an external strategy ($F_{(1, 68)} = 6.95, p = 0.01$), with means of 16.40 (SD = 2.14) and 14.90 (SD = 2.55) respectively.

Participants Experience of Attentional Focusing Instructions During Practice

External Questions

Table 5.6: During task questionnaire responses to external questions

Question	Time Point	Focusing Strategy Group	
		Internal (34)	External (33)
		Mean (SD)	Mean (SD)
Attention Directed to Dart	1	5.23 (1.30)	4.29 (1.55)
	2	5.18 (1.45)	4.38 (1.87)
	3	5.09 (1.16)	4.29 (1.82)
	4	5.18 (1.09)	5.03 (1.45)
	5	5.24 (1.33)	4.91 (1.73)
Speed of the Dart	1	3.18 (1.82)	2.97 (1.51)
	2	3.35 (1.69)	3.88 (1.55)
	3	3.91 (1.52)	4.06 (1.63)
	4	3.85 (1.65)	4.74 (1.73)
	5	4.29 (1.85)	4.32 (1.82)
Attention Directed to the Target	1	5.44 (1.73)	6.56 (0.66)
	2	5.21 (1.71)	6.44 (0.96)
	3	5.21 (1.51)	6.41 (0.82)
	4	5.18 (1.47)	6.41 (0.82)
	5	5.50 (4.54)	6.53 (0.66)

Mauchleys test of Sphericity was significant for the factor Time for each question, therefore Greenhouse-Geisser values were used.

How Much Attention Was Directed to the Dart: No significant effect of Time ($F_{(3.44, 226.81)} = 2.23$, $p = 0.08$, $\eta_p^2 = 0.03$), or interaction between Time and Focus strategy ($F_{(3.44, 226.81)} = 1.80$, $p = 0.13$, $\eta_p^2 = 0.03$). A significant effect was identified for Strategy Group ($F_{(1, 66)} = 4.55$, $p = 0.04$, $\eta_p^2 = 0.06$). With the Internal strategy group reporting directing more attention to the dart than the External group with mean scores of 5.18 (SE = 0.20) and 4.58 (SE = 0.20) respectively.

How Much Attention Was Directed to the Speed of the Dart: A significant effect of Time ($F_{(3.03, 200.25)} = 14.14, p = 0.001, \eta_p^2 = 0.18$) was revealed. LSD post hoc analysis revealed that reported attention directed to the speed of the dart at time point 1 was significantly lower than at time points 2, 3, 4, 5. Attention to dart speed at time point 2 was significantly lower than time points 3, 4, 5. Attention to dart speed at time point 3 was significantly lower than at time point 5, and time points 4 and 5 were not significantly different. This trend indicates a gradual increase in the amount of attention directed towards the speed of the dart, regardless of focus strategy, which reached a peak at time points 4 and 5. This is highlighted in Figure 5.7. No significant interaction between Time and Focus strategy ($F_{(3.03, 200.25)} = 1.72, p = 0.07, \eta_p^2 = 0.04$) main effect of Strategy Group ($F_{(1, 66)} = 0.73, p = 0.40, \eta_p^2 = 0.01$) were revealed.

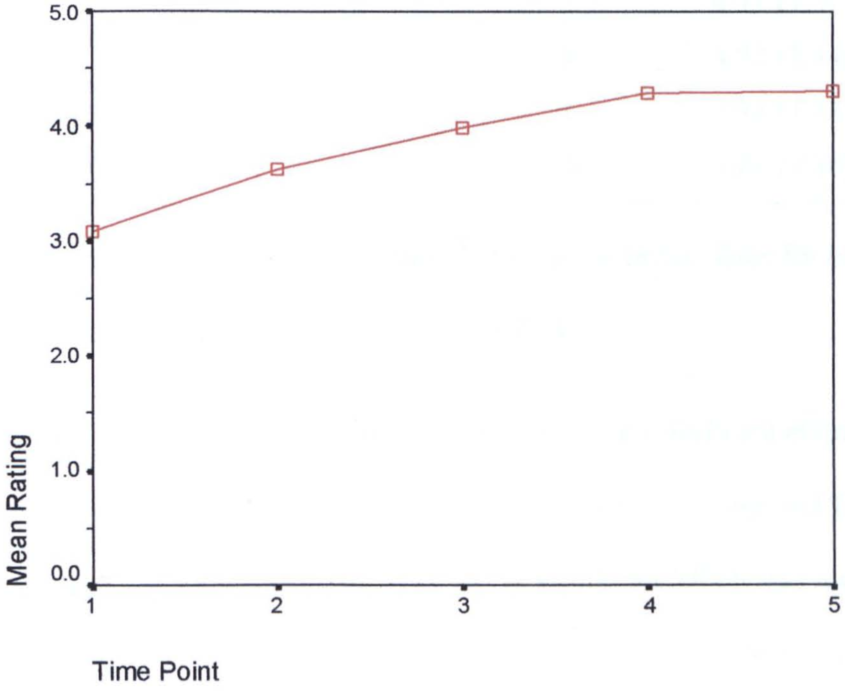


Figure 5.7: Attention Directed to Speed of Dart over Time During Practice

How Much Attention Was Directed to the Target: No significant effect of Time ($F_{(3.29, 216.87)} = 1.34, p = 0.27, \eta_p^2 = 0.02$) or interaction between Time and Focus strategy ($F_{(3.29, 216.87)} = 0.17, p = 0.90, \eta_p^2 = 0.003$) were revealed. A significant main effect of Strategy Group ($F_{(1, 66)} = 0.73, p = 0.40, \eta_p^2 = 0.01$) was identified. The External group reported directing more attention to the target than the Internal group, with means of 6.47 (SE = 0.18) and 5.31 (SE = 0.18) respectively.

Internal Focus Questions

Table 5.7: During task questionnaire responses to internal questions

		Focusing Strategy Group	
Question	Time Point	Internal (34)	External (33)
		Mean (SD)	Mean (SD)
Attention Directed to Arm	1	5.65 (0.78)	3.58 (1.70)
	2	5.09 (1.29)	3.84 (1.64)
	3	5.15 (1.43)	4.00 (1.84)
	4	5.26 (1.31)	4.12 (1.87)
	5	5.24 (1.42)	4.21 (2.19)
Attention Directed to the Hand	1	4.76 (1.46)	3.29 (1.71)
	2	4.71 (1.06)	3.59 (1.54)
	3	4.82 (1.34)	3.56 (1.78)
	4	4.74 (1.38)	3.82 (1.68)
	5	4.88 (1.32)	3.82 (1.87)

Mauchleys test of Sphericity was significant for the factor Time for each question, therefore Greenhouse-Geisser values were used.

How Much Attention was Directed to Your Arm: No significant effect of Time ($F_{(3.46, 224.67)} = 0.52, p = 0.70, \eta_p^2 = 0.01$), or interaction between Time and Focus strategy ($F_{(3.46, 224.67)} = 2.26, p = 0.07, \eta_p^2 = 0.03$). A significant effect was identified for Strategy Group ($F_{(1, 65)} = 20.31, p = 0.01, \eta_p^2 = 0.24$). The Internal strategy group reported directing more attention to their arm during each throw than the External group with mean scores of 5.28 (SE = 0.21) and 3.95 (SE = 0.21) respectively.

How Much Attention was Directed to Your Hand: No significant effect of Time ($F_{(3.29, 217.11)} = 0.78, p = 0.54, \eta_p^2 = 0.01$), or interaction between Time and Focus strategy ($F_{(3.29, 217.11)} = 0.57, p = 0.68, \eta_p^2 = 0.01$) was identified. A significant effect was identified for Strategy Group ($F_{(1, 66)} = 18.11, p = 0.01, \eta_p^2 = 0.22$), the Internal strategy group reported directing more attention to their hands during each throw than the External group with mean scores of 4.78 (SE = 0.19) and 3.62 (SE = 0.19) respectively.

General Experience Questions

Table 5.8: During task questionnaire responses to general experience questions

Question	Time Point	Group Internal (34) Mean (SD)	 External (33) Mean (SD)
Effort Needed	1	5.03 (0.97)	4.62 (1.26)
	2	4.82 (1.19)	1.74 (1.11)
	3	4.47 (1.28)	5.06 (1.07)
	4	4.62 (1.35)	4.91 (1.48)
	5	4.56 (1.58)	5.03 (1.31)
Difficulty to Follow Instructions	1	2.38 (1.35)	2.53 (1.40)
	2	2.53 (1.44)	2.59 (1.62)
	3	2.56 (1.19)	2.62 (1.46)
	4	2.56 (1.28)	2.88 (1.67)
	5	2.41 (1.48)	2.71 (1.62)
Physical Demands	1	2.70 (1.45)	2.45 (1.30)
	2	3.00 (1.39)	3.09 (1.70)
	3	3.09 (1.23)	3..36 (1.90)
	4	3.24 (1.56)	3.42 (1.68)
	5	3.18 (151)	3.90 (1.93)
How Often Did You Use the Instructions?	1	6.19 (0.68)	6.07 (0.88)
	2	6.30 (0.78)	6.07 (0.96)
	3	6.00 (1.24)	6.07 (1.00)
	4	6.04 (1.22)	5.90 (1.47)
	5	5.93 (1.52)	6.17 (0.93)

Mauchleys test of Sphericity was significant for the factor Time for the questions on Effort, Physical Demands, and how often the instructions were used, therefore Greenhouse-Geisser values were used.

How Much Effort was Needed During the Last 4 Throws: No significant effect of Time ($F_{(2.98, 196.70)} = 0.05$, $p = 0.99$, $\eta_p^2 = 0.001$) or main effect of Strategy Group ($F_{(1, 66)} = 0.52$, $p = 0.47$, $\eta_p^2 = 0.01$) were identified. A significant interaction between Time and Focus strategy ($F_{(2.98, 196.70)} = 3.46$, $p = 0.02$, $\eta_p^2 = 0.05$) was revealed, which is demonstrated in Figure 5.8.

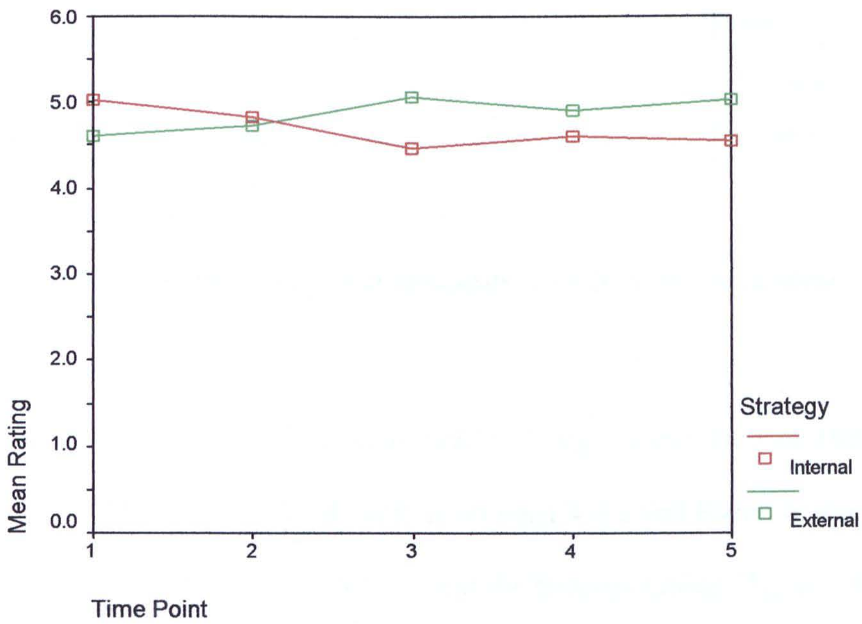


Figure 5.8: Changes in Effort Needed over Time for Each Strategy Group

How Difficult was it to Follow the Instructions: No significant effect of Time ($F_{(4, 264)} = 0.60$, $p = 0.66$, $\eta_p^2 = 0.01$), interaction between Time and Focus strategy ($F_{(4, 264)} = 0.267$, $p = 0.90$, $\eta_p^2 = 0.004$) or main effect for Strategy Group ($F_{(1, 66)} = 0.40$, $p = 0.53$, $\eta_p^2 = 0.01$) was identified for reported difficulty of instructions.

How Physically Demanding was the Task: A significant effect of Time ($F_{(3.13, 200.25)} = 11.85$, $p = 0.001$, $\eta_p^2 = 0.16$), and interaction between Time and Focus strategy ($F_{(3.13, 202.19)} = 2.71$, $p = 0.04$, $\eta_p^2 = 0.04$) was revealed indicating a gradual increase in physical demands as the task progressed, highlighted by Figure 5.9. But no significant main effect for Strategy Group was identified ($F_{(1, 64)} = 0.35$, $p = 0.55$, $\eta_p^2 = 0.01$).

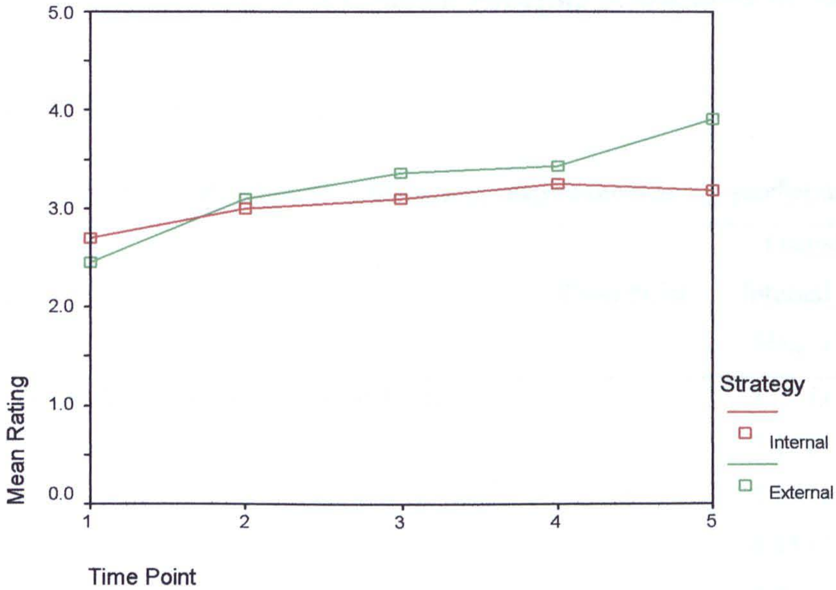


Figure 5.9: Changes in physical demands over time for each strategy group

How Often Did You Use the Instructions?: No significant effect of Time ($F_{(3.31, 178.58)}$ = 0.58, p = 0.68, η_p^2 = 0.01), interaction between Time and Focus strategy ($F_{(3.31, 178.58)}$ = 0.74, p = 0.54, η_p^2 = 0.01) or main effect for Strategy Group ($F_{(1, 54)}$ = 0.02, p = 0.88, η_p^2 = 0.000) was identified for differences in the reported use of instructions.

Participants Experience of Attentional Focusing Instructions During Performance

External Questions

Table 5.9: External subjective question responses during performance

Question	Time Point	Focusing Strategy Group Internal (34) Mean (SD)	External (33) Mean (SD)
How Much Attention Was Directed To The Dart	1	5.12 (1.27)	4.46 (1.80)
	2	5.12 (1.14)	4.63 (2.00)
	3	5.15 (1.35)	4.51 (2.09)
	4	5.48 (1.33)	4.86 (1.90)
	5	5.24 (1.39)	4.63 (1.91)
How Much Attention was Directed to the Speed of the Dart	1	3.72 (1.94)	3.89 (1.47)
	2	4.13 (1.56)	4.14 (1.83)
	3	4.22 (1.54)	4.29 (1.53)
	4	4.47 (1.70)	4.26 (1.70)
	5	4.63 (1.66)	4.31 (1.76)
How Much Attention Was Directed to the Target	1	5.18 (1.22)	6.63 (0.60)
	2	5.47 (1.29)	6.49 (0.82)
	3	5.66 (1.31)	6.60 (0.65)
	4	5.63 (1.43)	6.37 (0.81)
	5	5.63 (1.39)	6.60 (0.69)

Mauchleys test of Sphericity was significant for the factor Time for each question, therefore Greenhouse-Geisser values were used.

How Much Attention was Directed to the Dart: No significant effect of Time ($F_{(3.24, 213.78)} = 1.93, p = 0.11, \eta_p^2 = 0.03$), or interaction between Time and Focus strategy ($F_{(3.24, 213.78)} = 0.10, p = 0.98, \eta_p^2 = 0.01$). A significant effect was identified for Strategy Group ($F_{(1, 66)} = 2.94, p = 0.09, \eta_p^2 = 0.04$), with the Internal strategy group reporting directing more attention to the dart than the External group with mean scores of 5.22 (SE = 0.25) and 4.62 (SE = 0.24) respectively.

How Much Attention was Directed to the Speed of the Dart: A significant effect of Time ($F_{(2.90, 188.17)} = 3.73$, $p = 0.01$, $\eta_p^2 = 0.05$) was revealed. LSD post hoc analysis revealed that attention to dart speed at time point 1 was significantly lower than time points 3, 4, 5. This trend indicates an increase in the amount of attention directed towards the speed of the dart after the first 2 blocks of four throws, regardless of focus strategy and is shown in Figure 5.10. No significant interaction between Time and Focus strategy ($F_{(2.90, 188.17)} = 0.56$, $p = 0.69$, $\eta_p^2 = 0.01$) main effect of Strategy Group ($F_{(1, 66)} = 0.03$, $p = 0.87$, $\eta_p^2 = 0.001$) were revealed for reported attention directed to the dart's speed.

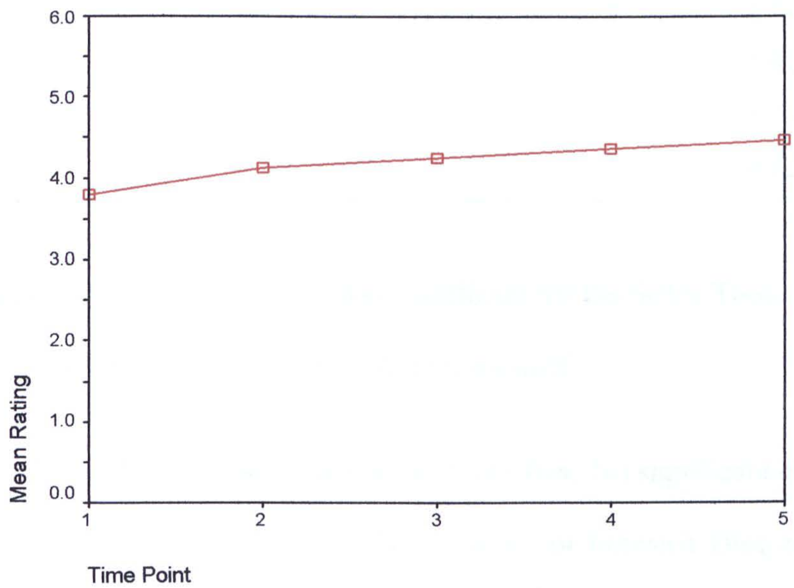


Figure 5.10: Changes in ratings of attention directed to speed of dart over time

How Much Attention Was Directed to the Target: No significant effect of Time ($F_{(3.23, 209.98)} = 0.98$, $p = 0.42$, $\eta_p^2 = 0.02$) or interaction between Time and Focus strategy ($F_{(3.23, 209.98)} = 1.80$, $p = 0.13$, $\eta_p^2 = 0.03$) were revealed. A significant main effect of Strategy Group ($F_{(1, 66)} = 22.12$, $p = 0.001$, $\eta_p^2 = 0.25$) was identified. The External group reported directing more attention to dart speed than the Internal group, with means of 6.54 (SE = 0.15) and 5.53 (SE = 0.16) respectively.

Internal Questions

Table 5.10: Internal subjective question responses during performance

Question	Time Point	Focusing Strategy Group Internal (34) Mean (SD)	External (33) Mean (SD)
How Much Attention Was Directed to Your Arm	1	5.24 (1.23)	3.69 (1.49)
	2	5.21 (1.22)	3.66 (1.66)
	3	5.27 (1.48)	3.80 (1.94)
	4	5.09 (1.57)	3.83 (1.95)
	5	5.18 (1.45)	4.09 (1.82)
How Much Attention Was Directed to Your Hand	1	4.73 (1.64)	3.11 (1.62)
	2	4.79 (1.43)	3.63 (1.68)
	3	4.91 (1.38)	3.40 (1.80)
	4	4.73 (1.55)	3.60 (1.83)
	5	4.73 (1.48)	3.60 (1.87)

Mauchleys test of Sphericity was significant for the factor Time for both questions, therefore Greenhouse-Geisser values were used.

How Much Attention was Directed to Your Arm: No significant effect of Time ($F_{(3.55, 234.21)} = 0.54$, $p = 0.70$, $\eta_p^2 = 0.01$), or interaction between Time and Focus strategy ($F_{(3.55, 234.21)} = 0.85$, $p = 0.50$, $\eta_p^2 = 0.01$) was identified. A significant effect was revealed for Strategy Group ($F_{(1, 66)} = 17.09$, $p = 0.001$, $\eta_p^2 = 0.21$). The Internal strategy group reported directing more attention to their arm than the External group with mean scores of 5.20 (SE = 0.24) and 3.81 (SE = 0.23) respectively.

How Much Attention was Directed to Your Hand: No significant effect of Time ($F_{(3.23, 213.47)} = 0.92$, $p = 0.50$, $\eta_p^2 = 0.01$), or interaction between Time and Focus strategy ($F_{(3.23, 213.47)} = 0.97$, $p = 0.43$, $\eta_p^2 = 0.01$) was revealed. The Internal strategy group reported directing significantly more attention to their hand than the External group ($F_{(1,66)} = 15.15$, $p = 0.001$, $\eta_p^2 = 0.19$) with means of 4.78 (SE = 0.24) and 3.47 (SE = 0.23).

Instruction General Experience Questions

Table 5.11: General Subjective Experience Question Responses During Performance

		Focusing Strategy Group	
Question	Time Point	Internal (34)	External (33)
		Mean (SD)	Mean (SD)
How Much Effort Was Needed	1	4.82 (1.26)	4.59 (1.54)
	2	4.79 (1.29)	4.74 (1.39)
	3	5.03 (1.40)	4.56 (1.82)
	4	5.09 (1.28)	4.65 (1.55)
	5	5.09 (1.49)	5.09 (1.31)
How Difficult was it to Follow Instructions	1	2.67 (1.59)	2.89 (1.79)
	2	2.72 (1.53)	3.43 (1.95)
	3	2.61 (1.64)	3.26 (1.88)
	4	2.58 (1.64)	3.00 (1.57)
	5	2.55 (1.79)	2.91 (1.77)
How Physically Demanding was the Task	1	2.87 (1.52)	2.69 (1.43)
	2	3.16 (1.53)	3.14 (1.59)
	3	3.58 (1.91)	3.40 (1.72)
	4	3.77 (1.87)	3.43 (1.65)
	5	4.03 (2.01)	3.46 (1.77)
How Often Did You Use the Instructions	1	6.38 (0.82)	6.18 (0.92)
	2	5.97 (1.09)	6.15 (1.06)
	3	5.97 (1.23)	5.85 (1.25)
	4	6.00 (1.16)	5.73 (1.35)
	5	6.07 (1.36)	6.00 (1.12)

Mauchleys test of Sphericity was significant for the factor Time for each question, therefore Greenhouse-Geisser values were used.

How Much Effort Was Needed During the Last 4 Throws: No significant effects of Time ($F_{(3.43, 222.65)} = 1.95, p = 0.11, \eta_p^2 = 0.03$), interaction between Time and Focus strategy ($F_{(3.43, 222.65)} = 1.01, p = 0.40, \eta_p^2 = 0.02$), or main effect of Strategy Group ($F_{(1, 65)} = 0.70, p = 0.41, \eta_p^2 = 0.01$) were identified for how much effort was needed.

How Difficult was it to Follow the Instructions: No significant effect of Time ($F_{(3.44, 226.75)} = 1.10$, $p = 0.36$, $\eta_p^2 = 0.02$), interaction between Time and Focus strategy ($F_{(3.44, 226.75)} = 0.55$, $p = 0.70$, $\eta_p^2 = 0.01$) or main effect for Strategy Group ($F_{(1, 66)} = 1.62$, $p = 0.21$, $\eta_p^2 = 0.02$) was identified for difficulty to follow instructions.

How Physically Demanding was the Task: A significant effect of Time ($F_{(3.20, 205.09)} = 12.0$, $p = 0.001$, $\eta_p^2 = 0.16$) was identified. LSD post hoc analysis revealed that ratings of the physical demands during the task at time point 1 were significantly lower than time points 2, 3, 4, 5. Physical demands at time point 2 was significantly lower from 3, 4, 5. Time points 3, 4 and 5 were not significantly different from each other. This relationship indicates a gradual increase in the ratings of perceived physical demands as the task progressed, with the ratings levelling out from time point 3 onwards, and is highlighted by Figure 5.11. No significant interaction between Time and Focus strategy ($F_{(3.20, 2.05.09)} = 0.88$, $p = 0.46$, $\eta_p^2 = 0.01$) or main effect for Strategy Group was identified ($F_{(1, 64)} = 0.50$, $p = 0.48$, $\eta_p^2 = 0.01$).

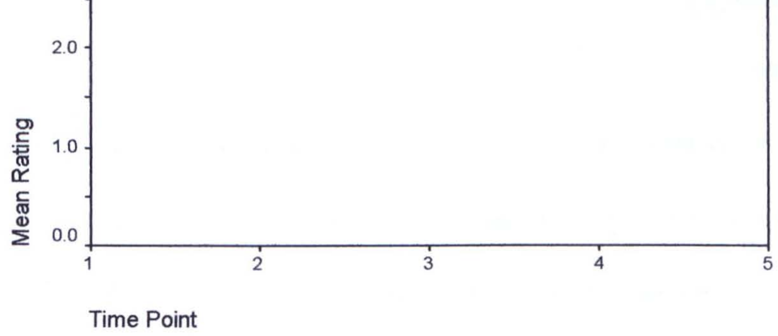


Figure 5.11: Changes in rating of physical demands over time

How Often Did You Use the Instructions: A significant effect of Time ($F_{(3.50, 209.89)} = 0.3.03$, $p = 0.02$, $\eta_p^2 = 0.05$), but no significant interaction between Time and Focus strategy ($F_{(3.50, 209.89)} = 0.87, p = 0.0.48, \eta_p^2 = 0.01$) or main effect for Strategy Group ($F_{(1, 60)} = 0.15, p = 0.70, \eta_p^2 = 0.003$) was identified. LSD post hoc analysis revealed participants reported to use their instructions more often at time point 1 than time points 3 and 4. This relationship indicates a decrease in instruction use, regardless of strategy group, at time points 3 and 4 compared to the start of the task, see Figure 5.12.

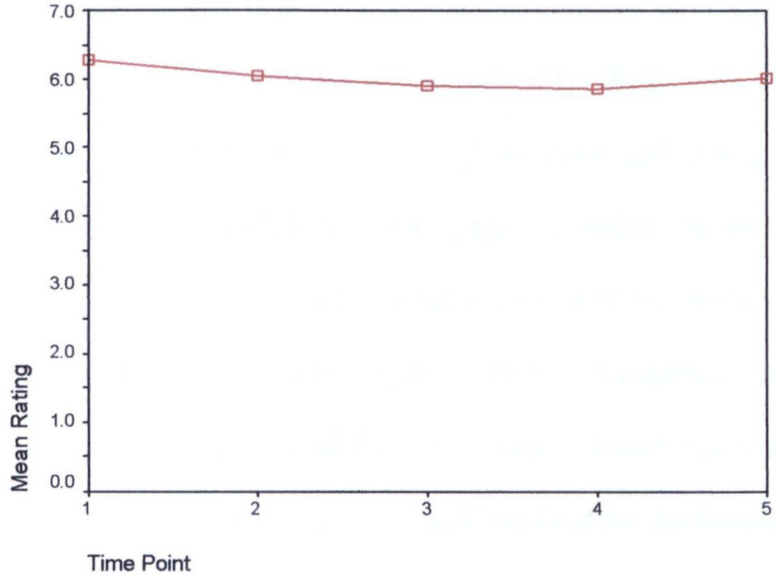


Figure 5.12: Instruction use during the task

Changes in experience due to instruction changes

Changes in the ratings of questions over the two sessions was assessed using 2 (session) x 5 (Time Point) repeated measures ANOVAs for each attentional focusing group (4). The results of which are presented in Tables 5.12 and 5.13. Results indicate whether changing strategy from practice (e.g., Internal-EXTERNAL or External-INTERNAL) or keeping the strategy used the same throughout (e.g., Internal-INTERNAL or External-EXTERNAL) affected novice participants' experiences of using the instructions during the dart throwing task.

External Questions

No significant changes in the reported amount of attention directed towards the dart was observed for either the Internal-Internal, Internal-External, or External-External groups. A significant increase was demonstrated in the reported amount of attention directed towards the dart in the External-Internal group, changing to the internal strategy for performance increased the amount of attention reported to be directed to the dart for that group. No significant changes were observed for the amount of attention directed to the speed of the dart in the Internal-External and External-External groups. A significant increase in the reported amount of attention directed to the speed of the dart was observed for both the Internal-Internal and External-Internal groups. No significant changes were observed for the reported amount of attention directed to the target for the Internal-Internal and External-External groups. A significant increase in attention reported to be directed to the target was observed for the Internal-External group, and a significant decrease was observed for the External-Internal group in relation to the changes in strategy used.

Table 5.12: Changes in Ratings of Internal and External Questions Between Practice and Performance Session

Question		Group	ANOVA (*significant)	Session 1	Session 2
External Questions	How Much Attention Was Directed to the Dart	Internal-Internal	(F(1, 14)= 0.52, p=0.48 , eta squared = 0.04)	5.17 (1.39)	5.33 (1.24)
		Internal-External	F(1, 18)= 3.83, p=0.07 , eta squared = 0.18)	5.19 (1.16)	4.6 (1.83)
		External-External	(F(1, 14)= 0.001, p=0.97 , eta squared = 0.000)	4.65 (1.76)	4.64 (2.12)
		External-Internal	(F(1, 17)= 7.23, p=0.02 , eta squared = 0.30) *	4.52 (1.64)	5.13 (1.32)
	How Much Attention Was Directed to the Dart's Speed	Internal-Internal	(F(1, 13)= 7.13, p=0.02 , eta squared = 0.35). *	3.69 (1.70)	4.21 (1.79)
		Internal-External	(F(1, 18)= 0.25, p=0.63, eta squared = 0.01)	3.74 (1.75)	3.91 (1.71)
		External-External	(F(1, 15)= 0.41, p=0.53 , eta squared = 0.03)	4.34 (1.47)	4.50 (1.56)
		External-Internal	(F(1, 17)= 4.79, p=0.04 , eta squared = 0.22) *	3.69 (1.73)	4.22 (1.62)
	How Much Attention Was Directed to the Target	Internal-Internal	(F(1, 13)= 3.42, p=0.09 , eta squared = 0.21)	5.51 (1.67)	6.12 (0.87)
		Internal-External	(F(1, 18)= 3.11, p=0.00, eta squared = 0.63) *	5.15 (1.53)	6.56 (0.72)
		External-External	(F(1, 15)= 3.38, p=0.09 , eta squared = 0.18)	6.64 (0.72)	6.51 (0.70)
		External-Internal	(F(1, 17)= 13.23, p=0.002, eta squared = 0.44) *	6.32 (0.81)	5.10 (1.47)
Internal Questions	How Much Attention was Directed to Your Arm	Internal-Internal	(F(1, 14)= 1.31, p=0.27 , eta squared = 0.09)	5.05 (1.14)	4.77 (1.51)
		Internal-External	(F(1, 18)= 40.18, p=0.000 , eta squared = 0.69) *	5.45 (1.32)	3.34 (1.65)
		External-External	(F(1, 14)= 0.59, p=0.46 , eta squared = 0.04)	4.18 (1.93)	4.38 (1.82)
		External-Internal	(F(1, 17)= 25.62, p=0.000 , eta squared = 0.60) *	3.78 (1.78)	5.56 (1.14)
	How Much Attention was Directed to Your Hand	Internal-Internal	(F(1, 14)= 0.33, p=0.57 , eta squared = 0.02)	4.80 (1.11)	4.59 (1.56)
		Internal-External	(F(1, 18)= 15.10, p=0.001 , eta squared = 0.46) *	4.77 (1.45)	3.11 (1.65)
		External-External	(F(1, 15)= 0.91, p=0.36 , eta squared = 0.06)	3.65 (1.84)	3.90 (1.82)
		External-Internal	(F(1, 17)= 18.65, p=0.000 , eta squared = 0.52) *	3.59 (1.62)	4.93 (1.44)

* Significant Differences at p = 0.05

Table 5.13: Changes in General Experience Questions Between Practice and Performance Sessions

Question	Group	ANOVA (*significant)	Session 1	Session 2
How Much Effort Was Needed	Internal-Internal	(F(1, 14)= 1.36, *p*=0.26 , eta squared = 0.09)	4.85 (1.24)	5.19 (1.26)
	Internal-External	(F(1, 18)= 0.22, *p*=0.65 , eta squared = 0.01)	4.58 (1.31)	4.77 (1.55)
	External-External	(F(1, 15)= 0.64, *p*=0.44 , eta squared = 0.04)	4.64 (1.47)	4.79 (1.42)
	External-Internal	(F(1, 17)= 1.16, *p*=0.30 , eta squared = 0.06)	5.08 (1.00)	4.78 (1.38)
How Difficult Was it to Follow the Instructions	Internal-Internal	(F(1, 14)= 0.00, *p*=1.0 , eta squared = 0.00)	2.60 (1.47)	2.60 (1.74)
	Internal-External	(F(1, 18)= 3.93, *p*=0.06 , eta squared = 0.18)	2.40 (1.26)	3.13 (1.79)
	External-External	(F(1, 15)= 8.92, *p*=0.01 , eta squared = 0.37) *	2.56 (1.58)	3.03 (1.80)
	External-Internal	(F(1, 17)= 0.28, *p*=0.60 , eta squared = 0.02)	2.78 (1.54)	2.64 (1.59)
How Physically Demanding Was the Task	Internal-Internal	(F(1, 13)= 1.20, *p*=0.29 , eta squared = 0.08)	3.33 (1.40)	3.61 (1.75)
	Internal-External	(F(1, 18)= 1.89, *p*=0.19 , eta squared = 0.10).	2.83 (1.42)	3.12 (1.74)
	External-External	(F(1, 15)= 1.47, *p*=0.24 , eta squared = 0.09)	3.01 (1.78)	3.35 (1.52)
	External-Internal	(F(1, 15)= 02, *p*=0.90 , eta squared = 0.001)	3.48 (1.61)	3.55 (1.86)
How Often Did You Use Instructions	Internal-Internal	(F(1, 11)= 4.54, *p*=0.057 , eta squared = 0.29) *	6.10 (0.87)	5.75 (1.23)
	Internal-External	(F(1, 14)= 0.10, *p*=0.75, eta squared = 0.01)	6.08 (1.25)	6.09 (1.11)
	External-External	(F(1, 12)= 0.03, *p*=0.87 , eta squared = 0.002)	6.03 (1.11)	5.90 (1.18)
	External-Internal	(F(1, 14)= 0.76, *p*=0.40 , eta squared = 0.05)	6.13 (0.93)	6.21 (1.08)

* Significant Differences at $p = 0.05$

Internal Questions

No significant changes were observed in the amount of attention reported to be directed to the arm for the Internal-Internal and External-External groups. A significant increase was observed in the External-Internal and a significant decrease in the Internal-External groups. Similarly, no significant changes were observed in the Internal-Internal and External-External groups in the ratings of the amount of attention directed to their hands. But a significant increase in attention reported to be directed to their hands in the External-Internal group, and a significant decrease in the Internal-External group.

General Experience Questions

No significant changes were observed for any group in their ratings of how much effort was needed during the task, how physically demanding the task was or whether participants verbalised instructions. No significant differences were identified for participants' ratings of how difficult it was to follow the instructions in the Internal-Internal, Internal-External, and External-Internal conditions. A significant increase in the ratings of the difficulty of instructions was observed in the External-External group. No significant differences were observed for differences in ratings of how often participants used the instructions given in the Internal-External, External-External, and External-Internal groups. A significant decrease in the use of instructions was observed for the Internal-Internal group.

Experiment 1 Discussion

The primary aim of this study was to assess the effects of practice on subsequent performance of a darts task by novice darts throwers. Previous research has generally used groups confined to single attentional focus strategies and observed their learning over time. This study offers the chance to observe the accuracy of learners carrying out a dart throwing task who have been given the chance to use different attentional strategies during performance from practice, and compare them to those who have used the same strategy during both practice and performance.

Practice

Participants using the external strategy during practice were more accurate than those using the internal strategy; however, this was not significant. This finding is not in line with the findings of Study 2, where external focus instructions were shown to be beneficial in a one-off performance session. However, the change in task priority must be taken into account. In line with the suggestions of Beilock et al. (2004), the practice session's aim in the present study was to provide an opportunity to practice the task and become familiar with the task being carried out. More emphasis was placed upon practice, and less was placed on performing as accurately as possible during this session. Whereas Study 2 emphasised accurate performance throughout the one-off session. Therefore, it is likely that participants approached this first session in the present study with less need to perform accurately, knowing that the follow-up session would require more accurate performance. In light of previous research by Wulf et al. who have used long term learning studies these findings are important. They suggest that when the aim of the practice session does not emphasise maximal performance, as suggested by Beilock et al. (2004), efficiency does not significantly differ between the attentional strategies. What is left to be assessed is whether this effect influences later performance, which will be discussed later on. One observation that can be made from this finding is that all groups were evenly matched at this stage of the task, with no advantage being held by any group for the subsequent performance session.

Although no significant differences were seen in the overall accuracy of each strategy group during practice, those using an external strategy scored significantly more bull's-eyes during the practice session than those using an internal strategy. Although this result is seems to be in conflict with the previous finding that there was no significant difference between the two strategy groups during practice, it is compatible. It demonstrates that although overall performance was not affected, the external strategy did offer some benefit to accuracy. It also suggests that the external focus is primarily suited to producing accurate performance. Analysis of the location of where darts hit the target was hoped to provide information regarding differences in motor patterns in addition to overall accuracy. Nevertheless, no differences were identified between the attentional strategies for the locations that the darts hit the target. This suggested that, as with overall practice accuracy, the attention strategy used by participants did not effect the location of where darts hit the target and therefore did not significantly effect movement execution.

Performance

The four groups demonstrated significantly different accuracy scores during the performance session. Specifically, those using an external strategy performed more accurately than those who used an internal strategy, regardless of the practice strategy they used. This finding suggests that an internal focus during practice was not detrimental to subsequent performance using an external focus. Similarly, using an external focus during practice did not lead to subsequent performance benefits for those using an internal strategy during the performance session. What seems to be the critical factor is the actual strategy being used during the performance session, when emphasis was placed on performing as accurately as possible.

This is further emphasised by the finding that, those who practiced using an internal strategy but performed using an external strategy significantly improved their accuracy. Whereas those who practiced using an external strategy, but performed using an internal strategy, experienced a significant degrading of their accuracy during the performance session. In comparison, those who practiced and performed using the same strategy neither significantly increased or decreased accuracy during the performance session.

Contrary to the findings of perfect bull's-eye scores during practice, there was no significant difference between the four performance groups number of bull's-eye scores during performance regardless of the significant difference in accuracy between the groups. This finding may reflect that, during performance situations, those using an internal strategy were able to score a number of bull's-eyes similar to those using an external strategy, but that the overall performance was degraded. The External strategy group on the other hand improved overall performance accuracy. Analysis of where darts hit the target during the performance session revealed that participants using an external strategy landed significantly more darts in the top right quarter (location 2) of the target than participants using an internal strategy. No other significant differences were identified. After combining locations to produce a simple top half – bottom half location analysis, results suggested that using external strategy resulted in more darts hitting the target in the top half than in the bottom half of the target when compared to the Internal condition. This suggests that an external focus produced an arm throw pattern that was not only more accurate, but also more likely to hit the target in the upper half, specifically in the upper right quarter of the target, when compared to the internal strategy. These findings are complimentary in that an arm movement which is more likely to throw darts to hit the top half of the target is also more likely to be the most accurate. By producing throws that are less likely to hit the top half of the target, the internal strategy is also increasing the chances of less accurate throws. By promoting darts to hit the lower half, the chance of hitting an accurate area is much reduced for the internal strategy.

Participants' experience of Attentional Focusing Instructions

The during task questionnaire asked a number of questions regarding participants' experiences of the instructions they had been given. These questions fell into 3 categories: external focus, internal focus, and general task experience questions.

External questions

During the practice session, participants using an internal strategy reported directing significantly more attention to the dart than those in the External group during dart throws. No significant differences between the groups were reported for the amount of attention directed towards the speed of the dart, although a significant effect of time suggested a gradual increase in the amount of attention directed to speed during the practice session. The External group reported directing more attention to the target than the internal strategy group during dart throws.

During the performance session, no significant differences were identified between each groups' ratings of how much attention they directed to the dart or the speed of the dart during dart throws. This may reflect the fact that these questions, although initially thought to reflect an external focus of attention, in actual fact are too closely related to each of the focus conditions to demonstrate significant group differences. For instance, focusing upon the dart during the movement may promote similar awareness of the hand and visa versa. Participants using an external strategy reported that they directed more attention to the target than participants using the internal strategy. As a clearly external focus point, this difference offers a clearer insight into the reported different attention processing of each group. The external focus instructions emphasised focusing upon the target, and without this emphasis the internal strategy group have reported directing less attention towards the target. In light of the performance differences observed, this difference in information processing indicates one way in which the two groups differed. Wulf et al. (e.g., 2001, 1999) research demonstrated that an external focus of attention promotes more effective motor performance, and that the focus should be on the intended outcome of the movement, and in this case the target is the desired outcome of the movement.

Some changes in experiences of participants over the course of the two trials were observed. Participants practicing using an external strategy and performing using an internal strategy (External-INTERNAL) demonstrated a significant increase in the reported amount of attention directed to wards the dart, but not the other groups. In this case, the change to using the internal instructions during the performance session increased the amount of attention directed to the dart during throw movements from when external instructions were used during practice. No significant changes were observed for attention directed to the speed of the dart for either the Internal-EXTERNAL or External-EXTERNAL groups. However, both the Internal-Internal and External-Internal groups significantly increased their reported attention towards the speed of the dart during their performance session. This finding suggests that the internal strategy used during the performance session promoted a large emphasis on focusing upon the speed of the dart and that information regarding the speed of the dart is related to the movements emphasised by internal focus instructions.

Indicating the changes in emphasis of each strategy group, both groups that changes strategy for the performance session (Internal-EXTERNAL and External-INTERANAL) demonstrated significant changes in the attention they reported to direct towards the target. The Internal-EXTERNAL group significantly increased the amount of attention reported to be directed towards the target in the performance session, whilst the External-INTERNAL group significantly reduced the amount of attention paid to the target. If these reports reflect the information processing of participants during performance, then it demonstrates that participants did change their attentional style in relation to external information processing during performance depending on strategy group.

Internal Questions

During practice, the participants using the internal focus strategy reported directing more attention to both their arm and hand than the external strategy group. This finding reflects the desired attentional focus hoped to be achieved by the internal instructions, by directing attention to the movements being carried out. Although no differences were observed in accuracy between the two strategy groups during practice, that the Internal group reported directing more attention towards their arm and hand during the movements indicates difference in information processing. Specifically, participants reported being more aware of their arm movements during practice when using an internal focus.

The larger amount of attention reported to be directed to the arm and hand by the Internal group, compared to the External group, may explain the larger amount of attention also reported to be directed towards the dart. For the whole of the movement, the dart is in the hand of the participant and so any attention directed to the hand will also include attention directed to the dart. Therefore, the previously suggested externally based question of attention directed to the dart may in fact be more closely related to an internal focus question due to the task. In fact, as Wulf et al. have noted (See Wulf & Prinz 2001 for a review) an external focus which is too close to the body is difficult to differentiate from bodily movements and an internal focus.

As during practice, the Internal strategy group reported directing more attention towards their arm and hand during performance session. Although in the practice session no accuracy differences were observed, the Internal group were less accurate during the performance session. Research by those such as Wulf (e.g., 1998, 2003) and Singer (e.g., 1993) would suggest that this is because of an increase amount of attention paid to skill execution, and these self-reported measures demonstrate this.

Reflecting the effects of changing strategy for the performance session, the Internal-EXTERNAL strategy group demonstrated a significant decrease in the attention reported to be directed to the arm and hand whilst the External-INTERNAL reported significant increases. In line with the previous finding that these groups demonstrated opposite changes regarding the attention paid to the target, these findings demonstrate the shift between the two attentional strategy instructions. The two groups who did not change strategy also did not change the reported levels of attention directed to their arm or hand. This indicates that participation in the two sessions did not influence these reports, rather change in instructional strategy played an important role.

General Experience Questions

No significant differences were observed for how much effort was needed during the task for each strategy group during practice. A significant interaction, however, suggests that the internal strategy began with a larger amount of effort needed than the external strategy group and decreased throughout the task so that it ended up needed less effort than the external strategy. Whereas then external strategy began with needing less effort than the internal strategy but this increased so that at the end of the task it required more effort than the internal strategy. No significant effect of strategy group was identified for ratings of how difficult it was to follow the instructions. This is an important finding as it indicates that any differences in performance should not be due to differences in difficulty of the instructions given to the participants. No significant effect of strategy group was identified for ratings of the physical demands of the task, but a significant interaction between time and strategy group indicates a possible difference over time. At the start of the task, participants in the External strategy group rated the task as less physically demanding than the Internal group, but by the end of the task their ratings had increased to higher then the Internal strategy groups ratings of physical demand. This finding goes against the proposal that an external focus should take attention away from the physical demands of a task, a finding demonstrated in exertion research (e.g., Gill & Strom, 1985). However, the greater awareness of movement emphasised by the internal focus does not necessarily lead to increased physical demands.

No significant difference was identified between strategy groups for their ratings of how often instructions were used. Both strategy groups indicated that they used the instructions given in the majority of throws. However, it is interesting to note that the instructions were not reported to have been used during all throws throughout the task. It seems possible that, at times, participants will resort to their own strategy rather than use the instructions given. This may well be related to the difficulty of instructions being used, or simply boredom of continually using the same instructional set throughout a task.

No significant differences were observed between the attention strategy groups' ratings of the general experience questions during the performance session. This indicates that the difference in performance which were observed may not be due to differences in any differences in effort, physical demands, instruction difficulty, or how often the instructions were used.

The External-EXTERNAL group demonstrated a significant increase in the difficulty in following the instructions over the two sessions, a finding not evident in the reports of the other groups. Interestingly, this may reflect an issue with the constant use of external focus instructions. Without variation in instruction or emphasis of the external focus, the ability to maintain a focus on one external outcome (e.g., the target) may become more difficult. Boredom in the face of the repetitive nature of the task may play an important role in the present finding, with the groups who switched focus not experiencing such feelings. Although the Internal-INTERNAL group did not report similar increases in difficulty, they did demonstrate a significant decrease in the reported use of instructions given, a finding not evident for the other groups. Again, this may reflect boredom in the use of the same instructions again during the task. Similarly, this may also reflect a frustration towards the limitations that an internal focus places on performance, and a propensity to revert to a personal focus of attention during the task which the participant may regard as more productive.

Methodological Issues With During Task Questionnaire Analyses

Although research into the experiences of participants whilst using different attention strategies is needed, it is a difficult concept to assess. This study's use of a during-task questionnaire, rather than a simple end-of-task questionnaire, offers valuable insight. However, even the data gained through this methodology is limited. There is still a strong likelihood that participants are simply answering questions in line with the instructions they are given, and this may be hard to avoid. However, ratings of general experience questions suggest that participants were willing to differentiate between different factors and strategies. It is hoped that these findings might provide a platform for further research into this area.

EXPERIMENT 2: combined focus strategy practice and single focus performance: accuracy and during task experience data

Experiment 4.2 will attempt further investigation into the effects of prior practice upon later performance using attentional focusing instructions. By allowing all participants to practice using both strategies for the same amount of time, there is also an opportunity to assess the effects preference for specific instruction types can have on performance accuracy. Preference for specific types of attentional instruction, if found, may interfere with the effectiveness of a strategy being used if it is conflict with this preference. In Study 1 no significant preference was shown when participants were given the chance to experience both internal and external strategies. Significant difference in reported experiences of each attentional strategy did suggest that participants in both Studies 1 and 2 rated the external strategy as more successful for performing the task at hand. In previous research, preferences for an external focus has not been consistently reported. For example, in Experiment 1 of Wulf, Shea and Park (2001) when participants were given one day of practice to experience the different attentional instructions and then a choice of which attention instruction they prefer, no clear preference was identified. However, in Experiment 2, when participants were given two days, significantly more participants chose an external focus of attention. In both of these studies, small sample sizes limit the analysis of preference differences (Of the 17 participants in Experiment 4.1, 10 participants chose an internal focus while 7 chose an external focus. Of the 20 participants in Experiment 2, 16 chose an external focus and only 4 chose an internal focus). The present study will use larger sample sizes to offset the problem of participant choice creating small groups for analysis. Furthermore, in Wulf et al. (2001) participants were encouraged to switch their attentional focus several times during practice trials. But if, as Wulf et al. go on to conclude, time is a critical factor in the ability of participants to make an accurate preference decision, then the amount of time a participant spends using a specific strategy should be controlled. Therefore, rather than leaving participants to switch between focus strategies at will, the present study aims to control the amount of time participants spend using each strategy by providing specific instructions for specific periods of practice. Without control of the amount of time participants use each strategy for, participants may well end up relying upon one strategy for the majority of the time as it feels the easiest. With control over the time spent in each strategy, regardless of how easy or hard a strategy is perceived to be, participants may develop more accurate preferences depending upon performance or experience.

Hypothesis

1. Attentional strategies will influence the accuracy of dart throws during practice and performance
2. Given equal exposure to attentional strategies during practice, participants will demonstrate clear preferences for a specific strategy
3. Preference for a particular strategy will influence the effectiveness of attentional strategies during performance
4. Participants will in each strategy group show clear differences in their experiences of using attentional instructions

Methodology

Participants

Seventy-two participants (32 males, 40 females) took part in the present study. The mean age was 19.82 (3.78), minimum age was 18 and maximum age was 40. All participants were students or members of staff at the University of Hull, and received either course credit or payment for full participation in the experiment. Participants were all novice darts players, defined along the guidelines used in Study 2.

Apparatus and Task

The dart throwing task was identical to that used in Experiment 4.1. The during task questionnaire was identical, but an additional question was added to the General Experience questions: *How distracted were you during the last 8 throws?* This question was added due to feedback from participants in Experiment 4.1, who mentioned distraction as a problem with using the instructions they were given.

Procedure

As with Experiment 4.1, participants attended two separate sessions, one week apart. Each session was identical with regards to the task being carried out, consisting of 10 warm-up throws followed by 40 test throws split into 10 blocks of 4 throws. The aims of the practice and performance sessions were the same as those in Experiment 4.1. Where Experiment 4.2 differs however, is the set-up of the practice session. During the practice session, instead of using a single attentional focusing strategy, participants used both internal and external strategies to allow for experience of both strategies during practice. Participants used one set of instructions for the warm-up throws and the first five blocks of four throws, and then used the remaining strategy for the last 5 blocks of 4 throws. Counterbalancing resulted in two practice focus groups; those who used internal instructions first and external second (Internal-External) and those who used external instructions first and internal second (External-Internal). Participants were instructed that they would be receiving two sets of instructions during the task, but that they would only receive the second set after completion of the first half of the session. It was stressed that participants should use the instructions given only for the throws they were instructed to use them with, and that they should be used regularly as possible. Participants were given the instructions for the first half of the practice session at the beginning of the session; this was in both written and verbal form from the experimenter and they were repeated before every block of throws. The second set of attentional instructions was only given after the completion of the first half of the session. At this half-way point, participants were again given written verbal instructions regarding their new strategy, and would then proceed to hear the instructions before every block of remaining throws. The instructions used were the same as those used in Experiment 4.1, and emphasised either an internal focus onto the movements being carried out or an external focus onto the intended outcome (the target). For the practice session, participants were randomly assigned to either the Internal-External (N=37, 13 males and 24 females) or External-Internal (N=35, 19 males and 16 females) practice group. At the completion of the practice session, participants were asked to indicate which of the two instruction sets they preferred.

The performance session was identical to that in Experiment 4.1, with the aim being to perform as accurately as possible using the instructions given and the experience gained from the practice session. Participants were only given one set of instructions to use throughout the performance session, with written instructions given first followed by verbal instruction before every other warm-up throw and every block. For the performance session, participants were randomly assigned to either Internal (n=32, 7 males, 25 females) or External (n=40, 25 males, 15 females) strategy groups.

Results for Experiment 4.2

Accuracy During Practice

Table 5.14: Practice accuracy during each block for each strategy group

Practice Order Group	Block	Practice Strategy	Accuracy Mean	(SD)
External-Internal	1	External	3.79	(2.08)
Internal-External		Internal	4.76	(2.41)
External-Internal	2	External	3.91	(2.33)
Internal-External		Internal	4.58	(2.08)
External-Internal	3	External	4.04	(2.29)
Internal-External		Internal	4.77	(2.04)
External-Internal	4	External	3.67	(2.18)
Internal-External		Internal	4.39	(2.27)
External-Internal	5	External	3.91	(1.92)
Internal-External		Internal	4.60	(2.17)
External-Internal	6	Internal	4.80	(2.26)
Internal-External		External	4.11	(2.04)
External-Internal	7	Internal	5.09	(2.57)
Internal-External		External	4.11	(1.81)
External-Internal	8	Internal	4.54	(2.42)
Internal-External		External	4.09	(1.78)
External-Internal	9	Internal	4.66	(2.54)
Internal-External		External	4.09	(2.18)
External-Internal	10	Internal	4.20	(2.58)
Internal-External		External	3.92	(2.21)

Two 2 (Practice Strategy) x 5 (Block) ANOVAs with repeated measures on the last factor were carried out for the first five blocks and last five blocks of throws to assess differences in accuracy. No significant difference was identified between participants using internal and external strategies for either the first ($F_{(1, 70)} = 2.63, p = 0.11, \eta_p^2 = 0.04$) or second ($F_{(1, 70)} = 1.52, p = 0.22, \eta_p^2 = 0.02$) five blocks. Analysis was carried out using a 2 (Practice Strategy Group) x 10 (Block) ANOVA, with repeated measures on the last factor. No significant main effect of strategy group was identified ($F_{(1, 70)} =$

0.03, $p = 0.86$, $\eta_p^2 = 0.000$), indicating no overall difference in accuracy between the groups at practice regardless of the change in strategy. Mauchley's Test of Sphericity was significant for the factor Block, therefore Greenhouse-Geisser correction values were used. No significant effect of Block was revealed ($F_{(6.19, 433.44)} = 1.59$, $p = 0.15$, $\eta_p^2 = 0.02$). A significant Practice Group x Block interaction ($F_{(6.19, 433.44)} = 7.33$, $p = 0.000$, $\eta_p^2 = 0.10$) indicates that, although no significant difference was observed between groups, when using the external focus instructions, participants were more accurate than when they use the internal strategy. See Figure 5.13.

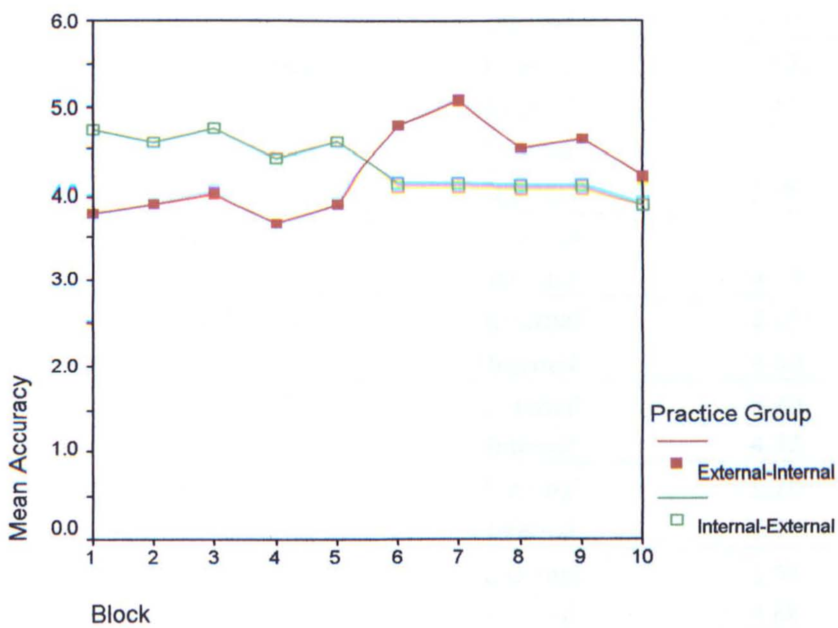


Figure 5.13: Accuracy of each strategy combination group during practice (Lower value indicates more accurate score)

Accuracy During Performance

Analysis of instruction preference revealed that significantly more participants preferred the external than the internal strategy ($X^2 = 9.39$, df = 1, $p = 0.002$), with groups of 49 and 23 respectively. After random allocation to performance groups; of those in the Internal group, 19 preferred the external and 13 preferred the internal strategy. Of those in the External group, 30 preferred the external and 10 preferred the internal strategy. Table 5.14 indicates the accuracy scores of each performance session strategy and Table 5.15, breaks down performance groups into preferred styles.

Figure 5.14: Performance Accuracy of Each Strategy Combination Group

Block	Practice Group	Performance Strategy	Accuracy Mean	(SD)
1	Internal-External	External	3.23	(1.71)
		Internal	5.19	(2.24)
	External-Internal	External	2.31	(1.07)
		Internal	6.00	(2.39)
2	Internal-External	External	3.35	(1.99)
		Internal	4.90	(1.40)
	External-Internal	External	2.16	(1.01)
		Internal	6.37	(2.26)
3	Internal-External	External	3.55	(1.92)
		Internal	5.32	(1.88)
	External-Internal	External	2.50	(1.13)
		Internal	5.67	(2.43)
4	Internal-External	External	3.08	(1.94)
		Internal	4.65	(1.80)
	External-Internal	External	2.39	(1.13)
		Internal	5.90	(2.35)
5	Internal-External	External	3.50	(2.25)
		Internal	4.50	(1.44)
	External-Internal	External	2.25	(0.95)
		Internal	6.00	(2.38)
6	Internal-External	External	3.40	(1.78)
		Internal	4.32	(1.76)
	External-Internal	External	2.24	(0.99)
		Internal	5.70	(2.80)
7	Internal-External	External	3.55	(2.01)
		Internal	4.88	(1.90)
	External-Internal	External	2.43	(1.24)
		Internal	5.30	(2.52)
8	Internal-External	External	3.00	(1.81)
		Internal	5.07	(2.14)
	External-Internal	External	2.55	(1.15)
		Internal	5.10	(2.36)
9	Internal-External	External	3.20	(2.02)
		Internal	5.06	(2.00)
	External-Internal	External	2.36	(0.99)
		Internal	6.15	(2.23)
10	Internal-External	External	3.61	(2.02)
		Internal	4.09	(2.26)
	External-Internal	External	2.48	(1.51)
		Internal	5.30	(2.52)

Table 5.15: Accuracy of Each Strategy Group During Performance and Preference

Block	Performance Strategy	Accuracy Mean	(SD)	Preferred Strategy	Accuracy Mean	(SD)
1	External	2.82	(1.50)	External	2.64	(1.20)
				Internal	3.39	(2.23)
	Internal	5.57	(2.31)	External	6.18	(2.20)
				Internal	4.67	(2.25)
2	External	2.78	(1.71)	External	2.38	(1.18)
				Internal	4.08	(2.47)
	Internal	5.59	(1.97)	External	5.74	(2.08)
				Internal	5.37	(1.86)
3	External	3.03	(1.63)	External	2.66	(1.17)
				Internal	4.22	(2.32)
	Internal	5.48	(2.13)	External	5.82	(2.17)
				Internal	5.00	(2.05)
4	External	2.76	(1.64)	External	2.45	(1.26)
				Internal	3.75	(2.34)
	Internal	5.23	(2.14)	External	5.67	(1.88)
				Internal	4.60	(2.41)
5	External	2.91	(1.86)	External	2.53	(1.38)
				Internal	4.14	(2.67)
	Internal	5.20	(2.05)	External	5.51	(2.13)
				Internal	4.75	(1.92)
6	External	2.80	(1.56)	External	2.47	(1.11)
				Internal	3.89	(2.27)
	Internal	4.97	(2.37)	External	5.29	(2.43)
				Internal	4.50	(2.31)
7	External	3.03	(1.78)	External	2.69	(1.40)
				Internal	4.11	(2.47)
	Internal	5.08	(2.18)	External	5.34	(2.17)
				Internal	4.69	(2.23)
8	External	2.79	(1.55)	External	2.37	(1.00)
				Internal	4.14	(2.23)
	Internal	5.09	(2.21)	External	5.39	(2.14)
				Internal	4.63	(2.32)
9	External	2.76	(1.67)	External	2.42	(1.12)
				Internal	3.86	(2.58)
	Internal	5.57	(2.15)	External	6.20	(1.84)
				Internal	4.65	(2.30)
10	External	3.09	(1.89)	External	2.77	(1.69)
				Internal	4.14	(2.22)
	Internal	4.66	(2.43)	External	4.76	(2.09)
				Internal	4.50	(2.94)

A 2 (Focus Strategy Used) x 2 (Preferred Focus Strategy) x 10 (Block) repeated measures ANOVA (with repeated measures on the last factor) indicated a significant main effect of Focus Strategy Used ($F_{(1, 68)} = 20.33$, $p = 0.0001$, $\eta_p^2 = 0.23$). Participants using the external strategy were significantly more accurate than those using the internal strategy, with means of 3.25 and 5.16 respectively (see Figure 5.15).

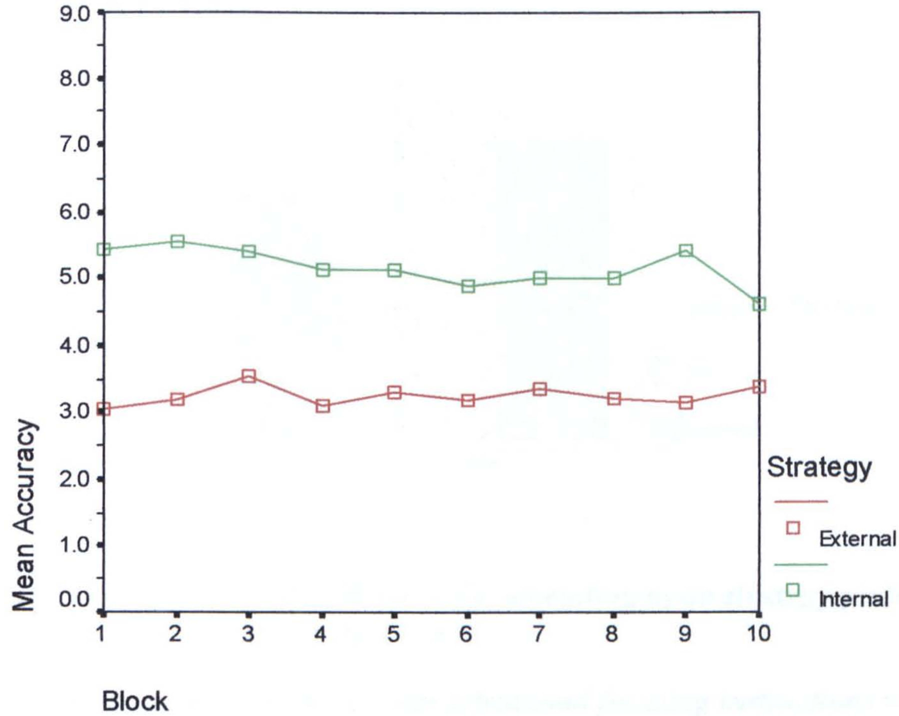


Figure 5.15: Accuracy of each strategy group during the performance session (Lower value indicates more accurate score)

No significant main effect was established for Preferred Focus Strategy ($F_{(1, 68)} = 0.12$, $p = 0.73$, $\eta_p^2 = 0.002$). A significant interaction between Preferred Focus Strategy and Performance Strategy Used ($F_{(1, 68)} = 5.56$, $p = 0.02$, $\eta_p^2 = 0.08$) was revealed. Separate one-way ANOVAS for each performance strategy group assessed the differences in accuracy between participants with different instructional preferences. In the External strategy performance group, participants who preferred the external strategy performed significantly more accurately than those who preferred the internal strategy ($F_{(1, 38)} = 4.43$, $p = 0.04$, $\eta_p^2 = 0.10$), with means of 2.68 and 3.83 respectively. Whilst using the internal strategy during performance, accuracy of participants who preferred the external strategy was not significantly different the accuracy of those who preferred the internal strategy ($F_{(1, 30)} = 1.66$, $p = 0.21$, $\eta_p^2 = 0.05$), with means of 5.59 and 4.73 respectively. Figure 5.16 indicates this relationship.

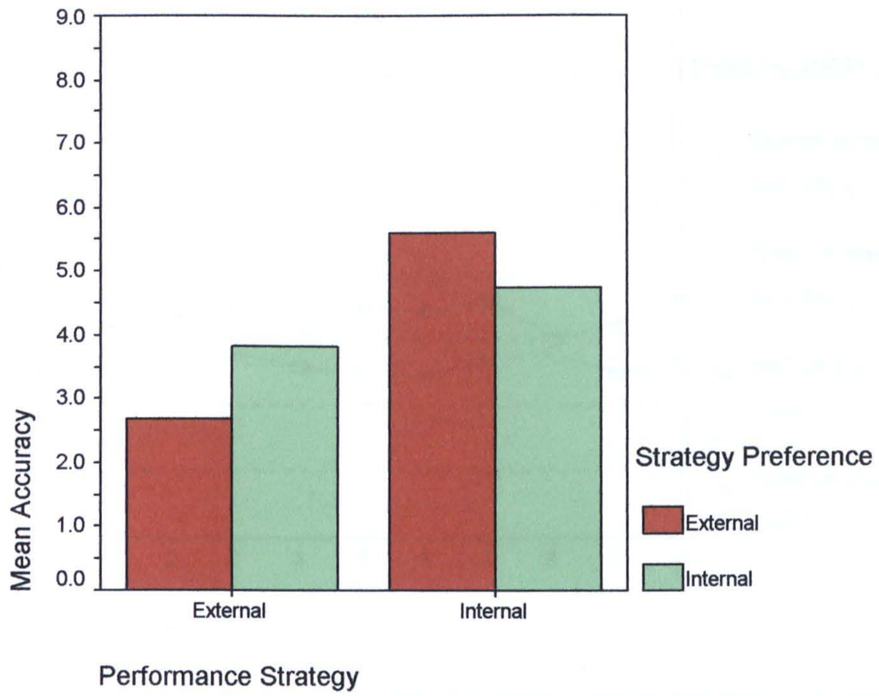


Figure 5.16: Accuracy of each strategy depending upon strategy preference (Lower value indicates more accurate score)

Performance in relation to the order attentional focusing instructions were administered during practice.

Table 5.14 indicates the scores participants obtained during performance in relation to the strategy they used and the strategy order they used in practice. A 4 (Practice-Performance Group) x 10 (Block) ANOVA with repeated measures on the last factor revealed a significant main effect for Practice-Performance group ($F_{(3, 68)} = 12.65$, $p = 0.001$, $\eta_p^2 = 0.35$). LSD post hoc analysis revealed that the Internal-External-EXTERNAL and External-Internal-EXTERNAL groups did not differ from each other (p=0.15), but performed significantly more accurately than the Internal-External-INTERNAL (p = 0.01 and p = 0.000 respectively) and External-Internal-INTERNAL (p = 0.000, p = 0.000 respectively) groups. The External-Internal-INTERNAL and

Internal-External-INTERNAL did not significantly differ from each other ($p = 0.11$).

Figures 5.17 and 5,18 highlight this relationship.

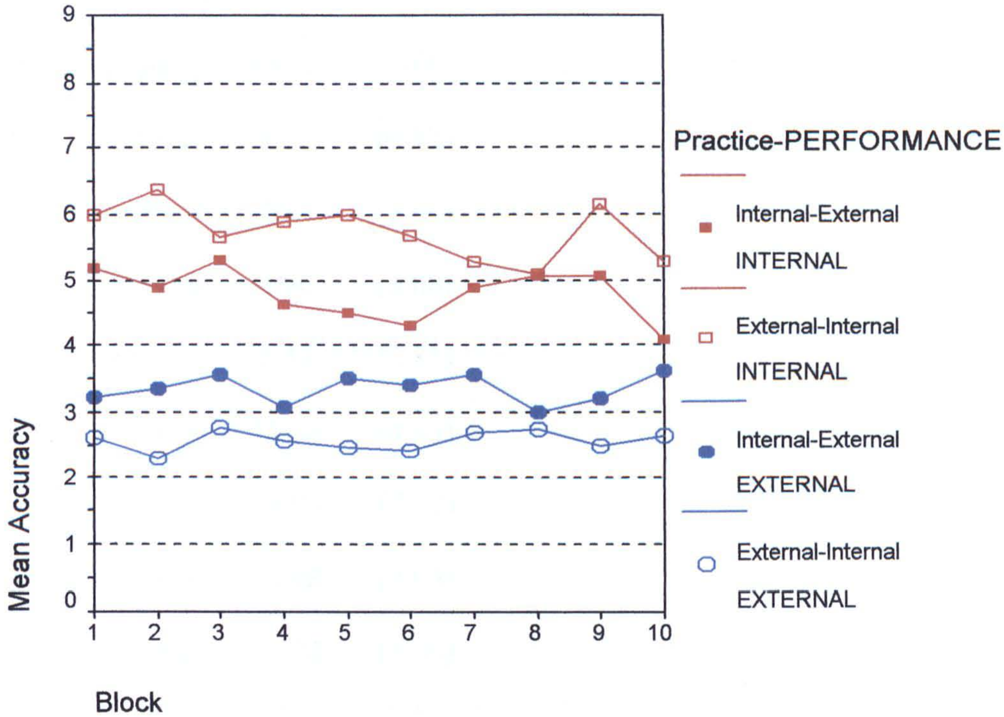


Figure 5.17: Performance accuracy for each attentional strategy practice-performance group (Lower value indicates more accurate score)

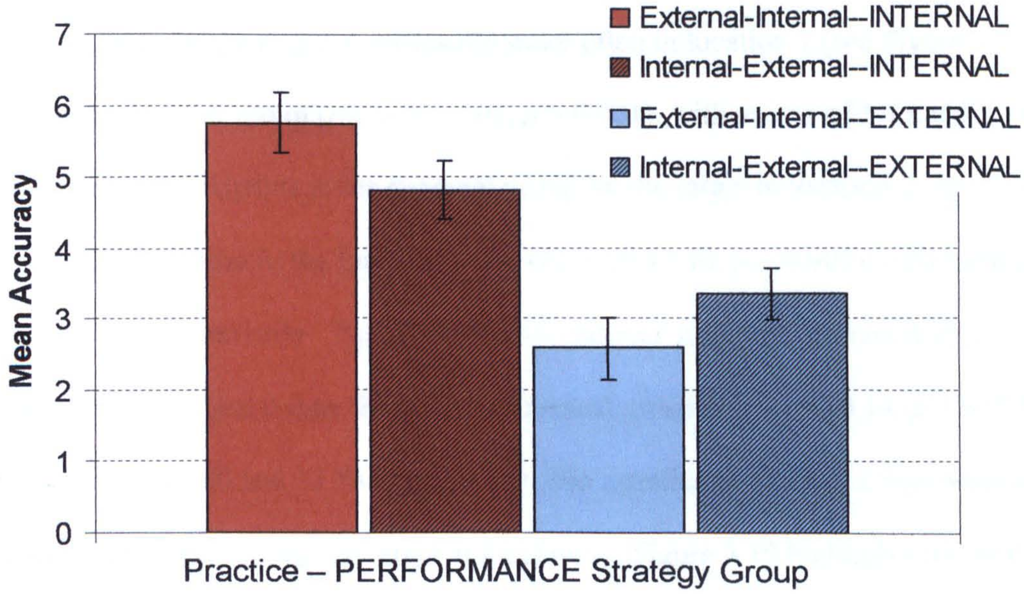


Figure 5.18: Overall accuracy during performance for each attentional strategy group

Location of darts during performance

Table 5.16: Mean numbers of darts hitting the target in each location during the performance session

Location	Strategy	Mean	(SD)
1	External	5.75	(4.12)
	Internal	2.34	(2.44)
2	External	4.90	(3.08)
	Internal	2.44	(2.86)
3	External	13.88	(4.43)
	Internal	19.00	(7.07)
4	External	15.48	(4.64)
	Internal	16.22	(5.46)

Four separate one-way ANOVAS analysed any difference in the number of darts hitting the target at the four locations for each focus strategy group. Participants in the External group hit the target significantly more often in location 1 (see Figure 5.1) than those in the Internal group ($F_{(1, 71)} = 17.03$, $p = 0.001$), with means of 5.75 and 2.34 respectively. Participants in the External group hit the target in location 2 significantly more often than those in the Internal group ($F_{(1, 71)} = 12.10$, $p = 0.001$), with means of 4.90 and 2.44 respectively. Participants in the Internal group hit the target significantly more often in location 3 than those in the External group ($F_{(1, 71)} = 14.14$, $p = 0.001$), with means of 19.00 and 13.88 respectively. No significant difference was observed in the number of darts hitting the target at location 4. Figure 5.19 highlights this pattern.

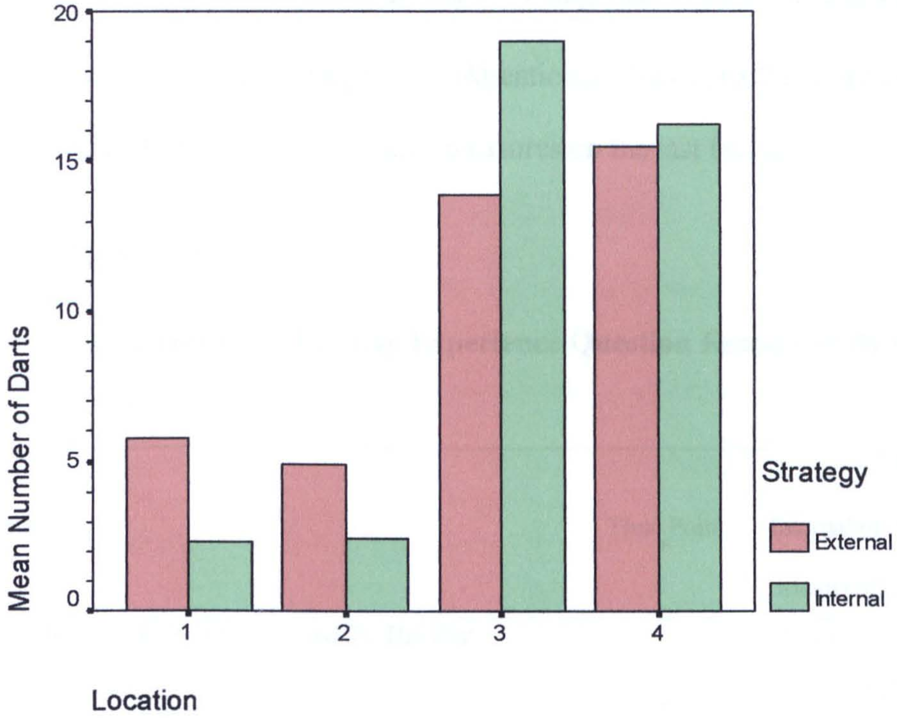


Figure 5.19: Location of darts hitting the target during performance for each strategy group

Number of "Bull's-eyes" scored in the performance session

Table 5.17: Mean number of bull's-eyes scored by each attentional strategy group

Strategy	Mean	(SD)
External	4.40	(3.81)
Internal	1.09	(1.65)

Analysis using a one-way ANOVA revealed that participants in the External group scored significantly more bull's-eyes than those in the Internal group ($F_{(1,70)} = 20.92$, $p = 0.001$), with means of 4.40 (3.81) and 1.09 (1.65) respectively.

Participants Experience of Attentional Focusing Instructions During Performance

Each question was analysed using a 2 (Attentional Strategy) x 2 (Preferred Strategy) x 5 (Time Point) ANOVA, with repeated measures on the last factor.

External Questions

Figure 5.20: External Subjective Experience Question Responses During Performance

		Group	
Question	Time Point	Internal (41)	External (31)
		Mean (SD)	Mean (SD)
How Much Attention Was Directed To The Dart	1	4.10 (1.62)	4.12 (1.52)
	2	4.35 (1.33)	4.44 (1.60)
	3	4.19 (1.62)	4.20 (1.58)
	4	4.13 (1.86)	4.34 (1.44)
	5	4.35 (1.82)	4.63 (1.53)
How Much Attention was Directed to the Speed of the Dart	1	3.23 (1.59)	3.37 (1.56)
	2	3.42 (1.80)	3.59 (1.56)
	3	3.55 (1.79)	3.63 (1.53)
	4	3.68 (1.66)	3.73 (1.67)
	5	3.68 (1.90)	3.49 (1.58)
How Much Attention Was Directed to the Target	1	4.58 (1.63)	6.15 (0.94)
	2	4.39 (1.89)	6.07 (1.23)
	3	4.45 (1.89)	6.00 (1.05)
	4	4.58 (1.95)	6.20 (0.81)
	5	4.52 (1.95)	6.02 (0.96)

How Much Attention was Directed to the Dart: No significant effect of Performance Strategy ($F_{(1, 68)} = 0.02, p = 0.89, \eta_p^2 = 0.00$), Preferred Focus Strategy ($F_{(1, 68)} = 0.08, p = 0.78, \eta_p^2 = 0.00$), or Performance Strategy x Preferred Focus Strategy interaction ($F_{(1, 68)} = 0.55, p = 0.46, \eta_p^2 = 0.01$) was identified for reported attention directed to the dart.

How Much Attention was Directed to the Speed of the Dart: No significant effect of Performance Strategy ($F_{(1, 68)} = 0.04, p = 0.83, \eta_p^2 = 0.00$), Preferred Focus Strategy ($F_{(1, 68)} = 0.35, p = 0.56, \eta_p^2 = 0.01$), or Performance Strategy x Preferred Focus Strategy interaction ($F_{(1, 68)} = 1.64, p = 0.21, \eta_p^2 = 0.02$) was identified for reported amounts of attention directed to the speed of the dart during each throw.

How Much Attention Was Directed to the Target: A significant effect of Performance Strategy ($F_{(1, 68)} = 20.84, p = 0.001, \eta_p^2 = 0.24$) was revealed, participants in the External group reported directing more attention towards the target than those in the Internal strategy group during the throws, with means of 6.07 and 4.56 respectively. Figure 5.21 highlights this relationship. No significant main effect of Preferred Focus Strategy ($F_{(1,68)} = 0.78, p = 0.38, \eta_p^2 = 0.01$), or interaction between Performance Strategy x Preferred Focus Strategy ($F_{(1, 68)} = 1.11, p = 0.30, \eta_p^2 = 0.02$) was identified for the reported amount of attention directed to the target during each throw.

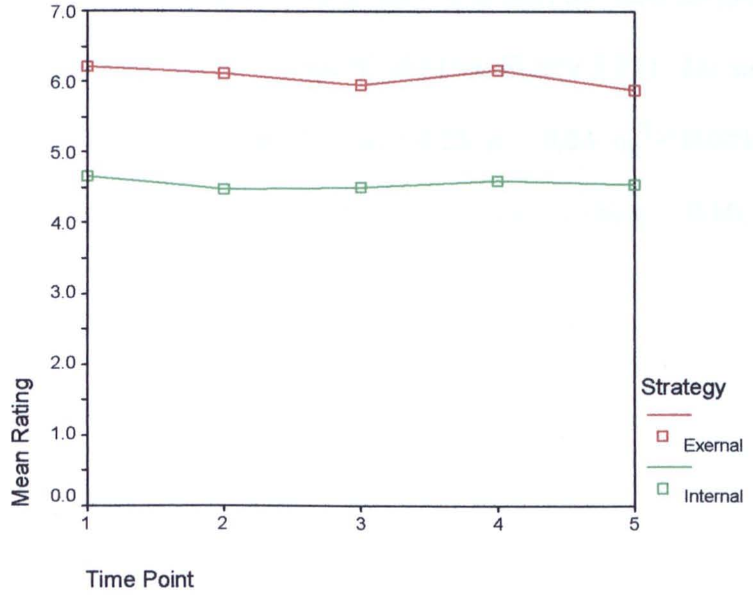


Figure 5.21: Ratings of attention directed to the target for each attentional strategy group during performance

Internal Questions

Table 5.18: Internal subjective question responses during performance

Question	Time Point	Strategy Group Internal (41) Mean (SD)	Strategy Group External (31) Mean (SD)
How Much Attention Was Directed to Your Arm	1	5.32 (1.42)	3.66 (1.76)
	2	5.52 (1.26)	3.83 (1.69)
	3	5.16 (1.51)	3.88 (1.85)
	4	5.35 (1.54)	4.07 (1.78)
	5	5.52 (1.34)	4.00 (1.75)
How Much Attention Was Directed to Your Hand	1	4.84 (1.53)	3.34 (1.76)
	2	4.84 (1.39)	3.37 (1.71)
	3	4.52 (1.48)	3.73 (1.63)
	4	4.35 (1.56)	3.78 (1.65)
	5	4.55 (1.57)	3.68 (1.57)

How Much Attention was Directed to Your Arm: A significant effect of Performance Strategy ($F_{(1, 68)} = 15.77$, $p = 0.00$, $\eta_p^2 = 0.19$) revealed that the External group reported directing less attention towards their arm than the Internal group during throws, with means of 3.86 and 5.35 respectively (see Figure 5.22). No significant main effect of Preferred Focus Strategy ($F_{(1, 68)} = 0.23$, $p = 0.64$, $\eta_p^2 = 0.00$), or Performance Strategy x Preferred Focus Strategy interaction ($F_{(1, 68)} = 0.06$, $p = 0.80$, $\eta_p^2 = 0.00$) was identified.

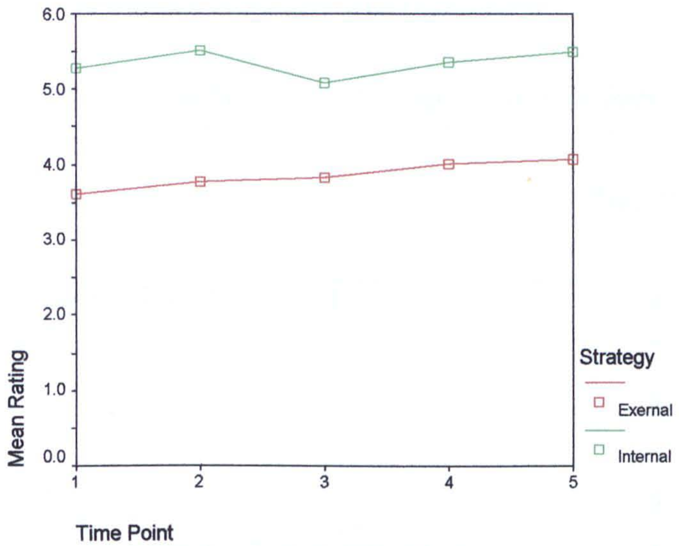


Figure 5.22: Ratings of attention directed to the arm for each strategy group during performance

How Much Attention was Directed to Your Hand: A significant Performance Strategy effect ($F_{(1, 68)} = 9.56$, $p = 0.001$, $\eta_p^2 = 0.12$) revealed that the External group reported less attention directed towards their hand during throws than the Internal strategy group, with means of 3.48 and 4.58 respectively (See Figure 5.23). There was no significant effect of Preferred Strategy ($F_{(1,68)} = 1.54$, $p = 0.22$, $\eta_p^2 = 0.02$) or Performance Strategy x Preferred Strategy interaction ($F_{(1,68)} = 0.04$, $p = 0.85$, $\eta_p^2 = 0.00$).

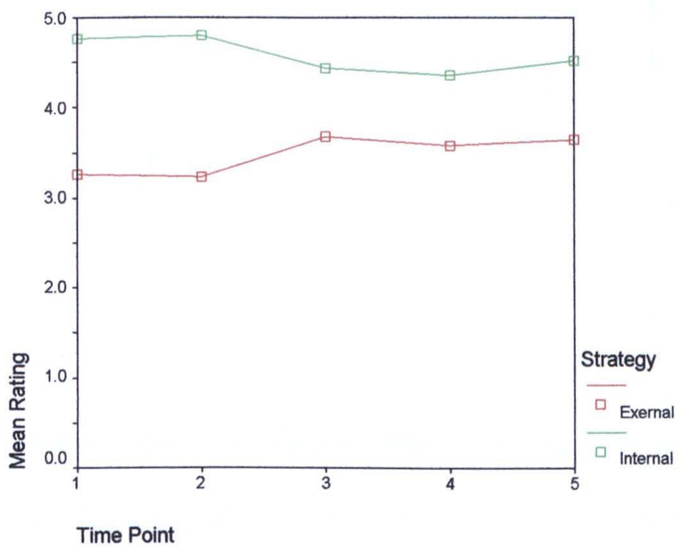


Figure 5.23: Ratings of attention directed to the hand during performance

Instruction General Experience Questions

Table 5.19: General subjective experiences ratings during performance

Question	Time Point	Strategy Group Internal Mean (SD)	Strategy Group External Mean (SD)
How Much Effort Was Needed	1	4.68 (1.02)	4.48 (1.29)
	2	4.00 (1.61)	4.65 (1.08)
	3	4.16 (1.42)	4.83 (1.17)
	4	4.06 (1.41)	4.75 (1.39)
	5	4.26 (1.32)	4.55 (1.32)
How Difficult was it to Follow Instructions	1	2.34 (1.72)	2.37 (1.46)
	2	1.83 (1.04)	2.73 (1.41)
	3	1.93 (1.28)	2.93 (1.57)
	4	2.31 (1.73)	3.00 (1.80)
	5	2.28 (1.73)	3.17 (1.86)
How Physically Demanding was the Task	1	2.55 (1.23)	2.34 (1.15)
	2	2.81 (1.35)	2.78 (1.44)
	3	2.74 (1.32)	2.80 (1.40)
	4	2.77 (1.23)	3.12 (1.55)
	5	2.97 (1.56)	2.98 (1.72)
How Often Did You Use the Instructions	1	6.06 (1.21)	5.95 (1.18)
	2	6.10 (1.22)	5.73 (1.50)
	3	5.68 (1.35)	5.39 (1.79)
	4	5.87 (1.38)	5.59 (1.66)
	5	6.03 (1.38)	5.49 (1.68)
How Distracted Were You	1	2.23 (1.23)	2.76 (1.55)
	2	1.09 (1.04)	2.83 (1.48)
	3	1.84 (0.93)	2.78 (1.26)
	4	2.00 (1.10)	3.02 (1.85)
	5	1.87 (1.06)	3.12 (1.81)

How Much Effort Was Needed During the Last 4 Throws: A significant effect of Preferred Strategy ($F_{(1,68)} = 5.28$, $p = 0.03$, $\eta_p^2 = 0.07$) revealed that participants preferring the instructions they used during performance rated them needing less effort than those who preferred the instructions they were not using during performance, with means of 4.02 and 4.65 respectively (See Figure 5.24). No significant main effect of

Focus Strategy Used ($F_{(1,68)} = 2.02, p = 0.16, \eta_p^2 = 0.03$), or Performance Strategy x Preferred Focus Strategy interaction ($F_{(1,68)} = 0.05, p = 0.82, \eta_p^2 = 0.00$) was identified.

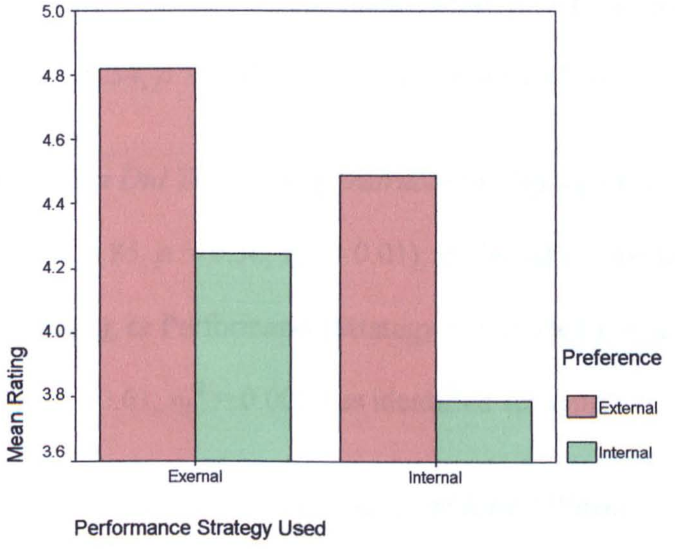


Figure 5.24: Ratings of effort needed during task for performance and preference

How Difficult was it to Follow the Instructions: A significant effect of Performance Strategy ($F_{(1,68)} = 5.28, p = 0.03, \eta_p^2 = 0.07$) revealed that the External group perceived their instructions as more difficult to follow than the Internal group, with means of 2.85 and 2.10 respectively (See Figure 5.25). No significant Preferred Focus Strategy main effect ($F_{(1,68)} = 1.21, p = 0.28, \eta_p^2 = 0.02$), or Performance Strategy x Preferred Focus Strategy interaction ($F_{(1,68)} = 1.46, p = 0.32, \eta_p^2 = 0.02$) was identified.

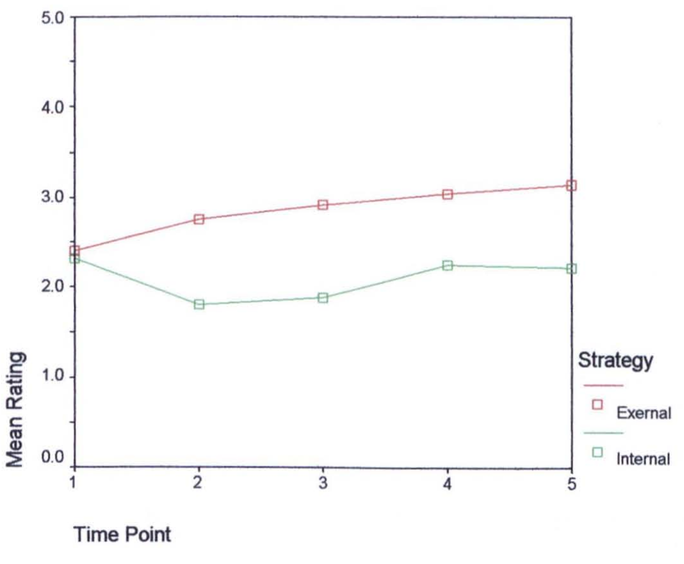


Figure 5.25: Rating of instruction difficulty during performance

How Physically Demanding was the Task: No significant effect of Performance Strategy ($F_{(1,68)} = 0.14$, $p = 0.71$, $\eta_p^2 = 0.00$), Preferred Focus Strategy ($F_{(1,68)} = 1.30$, $p = 0.26$, $\eta_p^2 = 0.02$), or Performance Strategy x Preferred Focus Strategy interaction ($F_{(1,68)} = 0.54$, $p = 0.47$, $\eta_p^2 = 0.01$) was identified for perceived physical demands.

How Often Did You Use the Instructions: No significant effect of Performance Strategy ($F_{(1,68)} = 0.85$, $p = 0.36$, $\eta_p^2 = 0.01$), Preferred Focus Strategy ($F_{(1,68)} = 0.08$, $p = 1.05$, $\eta_p^2 = 0.02$), or Performance Strategy x Preferred Focus Strategy interaction ($F_{(1,68)} = 0.27$, $p = 0.61$, $\eta_p^2 = 0.00$) was identified for reported instruction use.

How Distracted Were You During the Last 4 Throws: A significant effect of Performance Strategy ($F_{(1,68)} = 7.97$, $p = 0.01$, $\eta_p^2 = 0.11$) revealed that participants in the External group reported being more distracted than those in the Internal group, with means of 2.81 and 1.97 respectively. Figure 5.26 highlights this relationship. No significant main effect of Preferred Focus Strategy ($F_{(1,68)} = 26$, $p = 0.61$, $\eta_p^2 = 0.00$), or Performance Strategy x Preferred Focus Strategy interaction ($F_{(1,68)} = 0.37$, $p = 0.55$, $\eta_p^2 = 0.01$) was identified for reported levels of distraction.

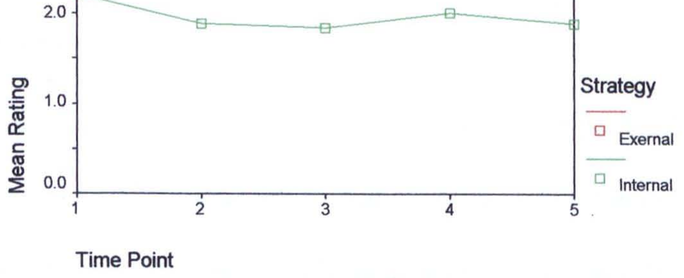


Figure 5.26: Ratings of distraction during performance

Experiment 2 Discussion

The main aim of Experiment 4.2 was to assess the effects on accuracy of allowing participants to practice using both attentional strategies, before performing using a single strategy. Furthermore, this study provided the opportunity for participants to indicate a preference for attentional styles after using each style during practice.

Practice

During practice there was no evidence for an advantage of an external strategy over an internal strategy, supporting the findings of Experiment 4.1. A significant interaction between the two practice groups, at the point of instruction change, demonstrates that the two different instruction types had different effects. This effect was made noticeable at the point when participants changed their instructions, with participants changing to an internal from and external strategy exhibiting a decrease in practice accuracy. Participants changing from an internal to an external strategy demonstrated an increase in accuracy. However no significant overall difference, as with Experiment 4.1, demonstrates that all groups were evenly matched at this stage of the task, with no advantage being held by any group for the subsequent performance session. This supports the proposal of Experiment 4.1 that subtle changes in the goal of a session can impact upon the effect of different attentional focusing instructions. In this case, the practice session emphasised practice over maximal performance accuracy.

Performance and Preference

Participant using an external focus of attention performed significantly more accurately than those who used the internal strategy during the performance session, when the aim was to perform as accurately as possible. Furthermore, the effects of the external and internal strategies were not significantly influenced by the order in which participants practiced with different the attentional strategies. This finding supports the results of

Experiment 4.1 which demonstrated that, during performance, an external focus of attention is the most beneficial strategy regardless of the practice strategy used. As with Experiment 4.1, the short term nature of the present study limits the conclusions, with a more long term study offering the chance to see longitudinal changes in performance in relation to practice strategies. Linked to the finding that overall accuracy was improved by using an external strategy during performance, the number of bull's-eyes was also influenced by the strategy which was used. Those using an external strategy scored significantly more bull's-eyes than those using an internal strategy. This again indicates that, unlike practice, when maximal performance accuracy was emphasised the external strategy became the most beneficial strategy.

Analysis of the locations where darts were hitting the target indicated that participants using an external strategy were significantly more likely to hit the target in the upper two quarters than participant using an internal strategy. Those using an internal strategy were significantly more likely to hit the target in the lower left hand quarter of the target than those using an external strategy and no differences were observed for the bottom right quarter. These findings indicate that as well as influencing accuracy in relation to the centre of the target, the attentional strategy used significantly influenced the area of the target where darts landed. As with Experiment 4.1, it seems that an external strategy promoted better accuracy by increasing the number of darts hitting the target in the upper sections, when compared to an internal strategy. In line with the "constrained action hypothesis" (e.g., Wulf, et al. 2001a), conscious attempts to control movements interfered with action in such a way as to direct darts to the lower sections. This may have produced inappropriate release of the dart during the throwing movement, or inefficient arm movements during the throw, or both. The external focus on the other hand, promoted darts to hit the upper sections through more efficient arm movements and dart release. Unfortunately, without movement analysis of the arm during the task, it is difficult to suggest the true mechanics behind these effects, but the analysis of dart location does provide some insight into the changes in arm movements induced by each attention instruction set.

A significantly larger number of participants preferred the external strategy than those who preferred the internal strategy. Previous research has not controlled the time that participants used different attentional strategies before making a preference choice (e.g., Wulf et al, 2001). The present study provides evidence that, when participants are given the same amount of time to practice using each strategy, they are more likely to choose to use the external strategy over the internal strategy.

Performance was subsequently analysed in relation to attentional instruction preference. Findings demonstrated that, although an external focus was the most beneficial strategy to use during performance, participants who preferred the internal strategy whilst using the external strategy performed significantly worse than those who preferred the external focus. No such difference was observed for the internal strategy, which demonstrated poor accuracy regardless of the preferences of the participants using it. This finding indicates that, somehow, preference for a set of instructions after practice influences the effectiveness of the external instructions. In this case, preference for internal instructions when using external instructions to perform limited accuracy, whereas preference for external instructions benefited accuracy. This can be discussed in two not necessarily exclusive ways. Firstly, a preference for internal instructions may indicate that participants were more comfortable with this type of instruction. This could easily be the case for novices very early in learning who are still building the components of a skill, as the present participants were. Secondly, it could be that participants who preferred the internal over the external instructions found the external instructions difficult to utilise, rather than finding the internal instructions simply the most preferable. Again, the ability to fully utilise an external focus may be linked to the skill level of the participants, and some novices may simply find external instructions difficult to use. These explanations suggest that care must be taken for the tailoring of instructions for some individuals. The discussion of each of these issues will be furthered by the data from the during task questionnaire.

Participants' experiences of their instructions during performance

These results provide the first evidence of participants' experiences during a motor task in relation to their performance and preferences. During performance, no significant differences were observed between the ratings of attention directed towards the dart or the speed of the dart in relation to the performance group or preferred focus type. Participants in the External performance group reported directing more attention towards the target than those in the internal strategy group. This indicates that a significant aspect of the external instructions in the present task was focusing upon the target, and that this may have played a significant role in the effectiveness of the external focus instructions. No significant relationship between attention directed to the target and preferred focus instructions was identified. These findings suggest that, of those participants who preferred the internal strategy but used the external instructions during performance, the ratings regarding the external attentional focus questions were not significantly influenced. The benefits of an external focus, as suggested by Wulf and colleagues (e.g., Wulf & Prinz, 2001), is due to focusing upon the intended outcome, endpoint or effect of a movement. Therefore, as participants in the External group reported directing more attention to the target than those using the internal instructions, we can infer that focusing externally upon relevant movement outcomes or intended effects can significantly influence the efficiency and accuracy of a movement.

The internally based questions revealed that the internal strategy group reported directing more attention towards their hand and arm than the external strategy group, regardless of instruction preference. This finding was found initially in Experiment 4.1 and this replication increases the validity of the possible implications. As the Internal group also performed less accurately, this finding offers indirect support of the constrained action hypothesis. The interference in motor control that is proposed to take place during internally focused movements is due to increased amounts of attention being placed on components of the movement. Therefore, these results suggest that participants themselves are aware that they are directing more attention to their arms and hand during the movements of the dart throw. As the External group report directing less attention to their hand and arm, this further supports the degrading effects of focusing upon movement components during action.

The general experience questions indicated that, with regards effort needed during the task, preference played an important role. A significant interaction indicated that participants who preferred the strategy they were using, reported requiring less effort than those participants who did not prefer the instructions they were using. No significant effect of Performance Strategy group was identified, therefore the effects of focus preference on performance seems linked to the amount of effort needed during the task. As participants using in the External performance group who did not prefer the external strategy performed less accurately than those who did, the finding that preference for the instructions participants were using resulted in less effort needed is particularly useful. If participants needed to use a greater amount of effort during the task to utilise the external instructions, a reduction in movement efficiency seems to have resulted.

Related to effort, participants in the External performance group reported finding the instructions they were given significantly harder than those in the Internal strategy group. As this does not seem to have affected accuracy during the task, its interpretation is difficult. It is possible that, even though participants were more accurate when using external focus instructions, participants found focusing externally difficult. This difficulty may simply reflect the level of expertise that the participants were at, with novices finding focusing externally more difficult, but if they persevered they benefit from it. It also suggests that with practice, the difficulty may reduce and the effectiveness of the external focus during movements may be further improved for novices. This finding, however relevant, does not support that of Experiment 4.1, where no significant finding was observed for the difficulty of the external strategy.

These findings demonstrating a possible increase in the demands or effort needed to effectively use an external focus fit well with the findings of Study 2. In Study 2 HRV values suggested that the external instructions were more attentionally demanding than the internal instructions. Although it is difficult to compare physiological data from one study to another, as the instructions used in the present study are the same as those used in Study 2, this can be seen as further evidence that novices may find using an external focus more attentionally demanding.

Participants using an external focus during practice reported feeling more distracted during the task than those using the internal focus instructions. This can be linked to the increased difficulty associated with focusing externally leading participants to become increasingly distracted. Furthermore, this again demonstrates possible limitations in the ability of novices to fully utilise an external focus. With further practice, novices may feel more comfortable with the instructions they have been given and so become less distracted. It isn't clear what sources of information were distracting novices using an external focus. It is possible that focusing externally leads to more external information being available to distract novices or that novices were being distracted by internal movement related information. More detailed questioning in further research is needed to address the sources of distraction. In light of the reported increased levels of difficulty and distraction experienced by the participants using the external instructions, the increased accuracy seems increasingly impressive. It is possible if external instructions were tailored more carefully for novices then further advantages could be observed as well as decreases in difficultly and distraction.

No significant relationships were identified between performance strategy and preference groups and the corresponding ratings of physical demands during the task and how often the instructions were used. These findings support those of Experiment 4.1, indicating that future research may not need to assess the differences in physical demands of a task in relation to the attentional strategy used. However, it seems relevant to continue to assess the use of instructions during a task as participants did not report using the instructions they were given 100% of the time. Further research may assess what strategies participants did use when not using the instructions they were given.

Summary

It seems that the preference of attentional focus plays an important role in the effectiveness of an external focus. Even though an external focus during performance was always more accurate, those who did not prefer it performed worse than those who did. This suggests that, considering these participants' preference for the internal instructions, some participants may benefit from external instructions that emphasise different factors. Wulf and Prinz (2001) have suggested that there may be different effective distances of an external focus. It may be that the effectiveness of this distance changes with level of expertise or preference. In this experiment, those who preferred the internal instructions but performed using the external instructions, may have benefits from instructions which emphasised an external focus closer to their movements rather than onto the target. The distance of the external focus in the present study may have been too large for these participants to fully utilise. This is further emphasised by the finding that these participants also found the instructions more difficult. Individually tailored instructions, although time consuming, may provide further benefits. These instructions could be created from feedback given by the participant during practice. For instance, if the participant reports focusing upon the target is too difficult, then the focus could be brought closer to the movement by focusing upon an intermediate factor such as dart trajectory or dart movement. This is speculative, and future research needs to assess this, but the flexibility offered by such an approach reflects the individual variation in ability to learn motor skills.

In conclusion, it seems that Wulf et al.'s (2001) claims that "it appears we can discount the notion that individual differences play a significant role in the relative effectiveness of an external versus internal focus of attention" (p.342) may be too simplistic. This may well true of comparisons between internal and external strategies, but considering the vast amount of data produced demonstrating the benefits of an external focus, this comparison seems unfair. When comparing participant preference *within* an External Focus group, as in the present experiment, clear advantages are seen for those who prefer an external focus over those who preferred internal instructions. Individuals who do not prefer the external focus would not necessarily benefit from using an internal focus, but may benefit from external instructions tailored to their preferences.

General Discussion

This study offers the first experimental attempt to assess the effectiveness of changing the types of attentional focus during practice and performance. Both Experiment 4.1 and 4.2 provide further support for the findings of Wulf, Shea and Park (2001) who stated that, independent of whether participants are assigned to an external condition (e.g., Shea & Wulf, 1999; Wulf et al., 1998, 1999), or asked to explore different attentional foci and make their own decisions (e.g., Wulf et al., 2001), an external focus seems to results in superior performance and learning than an internal focus. What the present study adds is that, regardless of previous practice condition, an external focus of attention during a performance session where the aims are to perform as accurately as possible promotes more efficient and accurate motor execution. Both Experiment 4.1 and 4.2 demonstrated that, during practice, when the aim was not to perform as accurately as possible but to practice and become accustomed to the skill, an external focus was no more effective than an internal focus. This does not support research indicating benefits of an external focus immediately during learning of movements (e.g., Shea & Wulf, 1999). What this does suggest is the aim of a motor skill execution session affects the effectiveness of the strategy being used. An external focus promotes more accurate performance, but in practice, when the aim may not be to perform as accurately as possible, it may not be fully relevant. However, in light of the fact that using either an internal or external focus during practice did not promote better accuracy during performance, the argument for retaining the internal focus is limited in this context. Beilock et al. (2001) argue that an internal focus during practice would enable a novice to identify areas of the skill which are not productive and adjust them. This limited period of skill focused attention, although initially detrimental, would produce performance benefits later on away from practice. But this has not been shown to be the case. One way to fully assess the possible benefits of an internal focus during practice on later performance may be to assess the biomechanics of the movements, as an internal focus during practice may promote efficient movement patterns later when an external focus is used, which may not necessarily be fully observable in accuracy scores. Another would be to use a longer time frame for the assessment of influences of instructions during practice and performance. The present study used only a short time frame as an initial assessment. Future research may need to assess different attentional focusing instructions during a number of practice and performance sessions.

These findings add to the growing body of research demonstrating that using instructions that focus attention upon outcomes or the effects of one's movements is more effective than using instructions that focus upon the actual movements being executed. During tasks that require performing well, the beneficial effects of an external focus seem to be a general phenomena (Wulf et al., 2001). The findings of the two present studies are in line with the proposal that focusing upon movement effects allows motor systems to self-organise more naturally (e.g., Kelso, 1995), unconstrained by conscious control, even in relatively complex accuracy tasks performed by novices. In fact, Wulf and colleagues (e.g., Wulf, Shea and Park, 2001) propose that focusing externally on the remote effects of a movement "frees up" conscious attention so that it can be directed to other aspects of the task, and that this may be more effective for complex skills. During more complicated movements, if a performer was to consciously control the many degrees of freedom then processing overload will result (Wulf, Shea and Park). The inefficient performance promoted by the internal focus has been explained in line with the "constrained action hypothesis" (Wulf et al., 2001), which proposed that attempts to control one's own movements consciously disrupts the function of the motor system by interfering with automatic processes (Totsika & Wulf, 2003). Although no Control condition was used for comparison in the present study, the findings that an internal focus of attention resulted in more darts hitting the target in the lower sections and the external condition resulted in more darts hitting the upper sections of the target when compared to each other, demonstrates significant differences in movement execution. Conscious control of movement in both studies resulted in darts being released inappropriately. During the study, the experimenter noted that some participants commented that whilst using the internal instructions they became very aware of when they were releasing the dart. Such comments are reflected in the subjective experience questionnaire analysis showing increased attention to the hand

and arm for internal instruction participants. The increased amount of attention to the dart release seems to have had a large impact on the efficiency of skill execution.

Regarding the practice session, both studies indicated that neither focusing strategy presented an overall benefit. This is not in line with previous research (e.g., Totsika & Wulf, 2003; Wulf, Höβ, & Prinz, 1998; Wulf et al., 1999, 2002) which demonstrated that external focus benefits were seen early in practice. However, in these studies, the emphasis of the practice sessions was not the same as that of the present study. For example, in Wulf et al. (1999) study participants practicing golf pitch shots were given the emphasis of hitting the target, and similarly no different emphasis for the practice sessions was given in Wulf et al.'s (1998) study. Only Totsika and Wulf (2003) indicated that participants should complete the practice session "at their own pace" for a pedalo task. The present study emphasised practice as being a chance to become aware of the task and the movements it required, and this emphasis seems to have changed the effects of the attentional focusing strategies. An interesting conclusion made by Totsika and Wulf was that attentional focusing instructions have "a long term effect on motor skill learning" which are "relatively permanent in nature". The findings from the present study suggest that this is not necessarily so. If the aim of the practice session is simply to practice the task with less emphasis on performing well, attentional focus effects are reduced and do not significantly effect a later performance session. However, the Totsikaq and Wulf study did not emphasise any attentional focus instructions during the retention tests, whilst the present study controlled for attentional style during performance. Therefore, any permanent effects of the practice session were overridden by the performance strategies used. Considering performers would not approach a task without a strategy in mind, the present findings have important implications for which instructions should be applied during practice and performance.

Results from both experiments provide data that links with previous research within this thesis. Study 1 demonstrated that an external focus promoted more efficient movement control in the vertical plane, and any such effects in the present study would be evident in the location profile of darts hitting the target. Results demonstrated that an external focus of attention promoted movements that produced dart throws to hit the target within the upper half of the target when compared to an internal focus. Linking these findings together, it would be reasonable to suggest that the internal focus has produced movements that were inefficient in the vertical plane, rather than the horizontal place, producing darts which are more likely to hit the bottom half of the target. As suggested, the analysis of this would be furthered through biomechanical analysis of movements during execution of skills.

One of the proposed mechanisms behind the benefits of an external focus has been that it promoted more automatic control processes than an internal focus, therefore leaving attentional resources free to process key elements of the environment. For example, Wulf, McNevin and Shea (2001) found faster probe reaction times (RTs) from participants carrying out an unstable balancing task using external instructions when compared to internal focus instructions. This finding offers a possible explanation for the increased amount of distraction reported by participants using an external strategy in Experiment 4.2. One explanation is that this increased distraction will be problematic for the novice use of an external focus. However, this finding may also support the reported increased amount of attentional resources by Wulf et al. (2001). The increased amount of spare attentional resources associated with an external focus may have made participants more open to distraction from external sources than if their attentional resources were being used up by an internal focus of attention. As this task was limited to simply carrying out the dart movement, there was little relevant external information other than the target to occupy participants' attention. Although this is only indirect support for this theory, Experiment 4.2 demonstrates than an external focus of attention leaves additional attentional resources free whereas an internal focus takes up a larger amount of attentional resources. Another possible explanation is, as the novices were at an early stage of learning the task after only one practice session, the distraction may be due to a need or automatic propensity to focus onto the skills being produced. This conflict may have produced increased distraction, and may have also accounted for the increased level of difficulty reported for the external strategy in Experiment 4.2.

Previous research has demonstrated that directing a learner's attention to appropriate external cues can have almost immediate beneficial effects (e.g., Totsika & Wulf, 2003; Wulf et al., 2000, Experiment 2; Wulf et al., 1998, Experiment 1; Wulf et al., 1999). In the present experiments however, this immediate effect has been cancelled out by changing the aims of the practice session. By emphasising practice over accuracy during the practice session, neither the external or internal strategies offered a clear advantage. When accuracy was emphasised during the performance session an external strategy offered clear accuracy advantages, whereas the internal strategy promoted poorer accuracy. What was not found was any underlying advantage of either focusing strategy during performance in relation to specific orders of instructions participants received during practice, suggesting that an external strategy is the most effective strategy during performance regardless of practice strategy. As the internal strategy was not shown to be detrimental compared to the external strategy during practice it suggest that there may be some benefit to its use during practice, but this may only become apparent during more longitudinal research approaches to motor learning.

Why should there be no benefit for the external focus during practice when accuracy was not emphasised? There are two, not mutually exclusive explanations. Firstly, as the practice session emphasised practice of the skill and participants becoming accustomed to the skill being carried out, the internal focus may be the more natural focus to apply in this situation. Secondly, the more internally focused emphasis of the practice session made the external focus more difficult to utilise due to its confound with the aims of the session. Both issues combined suggest that the external focus may be a more difficult focus to employ during practice, when accuracy is not emphasised. Whereas an internal focus, although more naturally suited to the practice condition, offers no clear accuracy advantages at that stage. Other researchers such as Beilock and Carr (2002) and R. Gray (2004) have proposed that an internal focus may not be as detrimental as previously thought if applied in appropriate circumstances such as practice. Specifically, Beilock and Carr propose that, when the aim is not to maximise real-time performance but instead to alter or change performance processes, skill-focused attention may be beneficial. Due to the limitations of this study, future research will be needed to assess Beilocks and Carrs' additional claims that although monitoring of performance will most likely break down execution procedures, the subsequent changes will ultimately improve performance.

One limitation of the present study is the instructions used to manipulate attentional focus, particularly the external focus instructions. Although the external instructions did produce beneficial effects, it may also be the case that more effective external instructions are possible for this task. The instructions used in the present study emphasised focusing upon the target as the intended outcome of the movements, specifically the centre of the target. However, research such as Wulf, McNevin, Fuchs, Ritter and Toole (2000) suggests that directing attention to movement effects related to the movement form seems to be more beneficial than focusing on more remote effects that are not related to the movement technique. Therefore, focusing upon the target in the present study, although more effective than focusing upon arm movements, may be less effective than focusing upon an external factor related to the movement of the arm. Such a focus may be difficult to define in a skill such as dart throwing, but factors such as dart trajectory may well correspond with focusing upon a ball leaving the racket used by Wulf et al.'s (2000, Experiment 1). Wulf et al. (2000, Experiment 2) also suggest that focusing upon the movement of the club head in a golf task was more effective than focusing upon the target. Furthermore, R. Gray (2004) proposed that the internal and external focus concept should be viewed as a longitudinal scale along which one can focus attention onto different aspects of a movement, from movement components to movement outcome. Clearly, appropriate external instructions are task specific, and efforts should be made to identify instructions for different tasks within the guidelines offered by Wulf et al. Indeed, as Wulf et al. point out, even relatively "minor" variations in the instructions given to learners can result in dramatic performance differences. This is particularly relevant for skills such as dart throwing that do not use implements that offer distant points of reference such as golf clubs. It may be that a dart throwing task, focusing upon the target is the only effective external focus available.

An additional factor not assessed in the present study, but open for investigation, is the proposal by Masters et al. (1992) that skills learned using a skill-focused approach are more susceptible to the effects of pressure during performance. Although not differences were observed in both experiments regarding the effects practice condition instructions on subsequent performance, no pressure was instilled during the performance task. Further research is needed to assess whether, practicing using internally based instructions would leave participants vulnerable to the detrimental effects of pressure even when they are using an external focus during pressurised performance. Masters et al.'s research does not give specific strategies to use during pressurised performance, and although it is interesting to note that skills learned under skill focused conditions are susceptible to breakdown under pressure, having no strategy in mind to use during performance is not naturally how performers would approach a performance situation. This may have exaggerated the breakdown in skill that was observed. The combining of these research areas, focusing instruction and performance under pressure has yet to be carried out and offers a possible avenue of research which could shed light on both effective practice strategies as well as performance strategies.

In conclusion, the present findings support previous studies as well as providing new evidence to add to the discussion of attentional focus effects during movement. An external focus of attention promotes more efficient movement during sessions when maximal performance is emphasised, and therefore performers should be encouraged and instructed to focus their attention away from their movements and onto their intended effects. A performers preference plays an important role in the effectiveness of an external focus, and future research should assess whether some individuals may benefit from different external focus emphasises in instructions.

CHAPTER 6

FINAL DISCUSSION AND IMPLICATIONS

This thesis aimed to investigate the effects of attentional focusing instructions during the performance and learning of motor skills. Previous research had demonstrated that even subtle differences in the attentional emphasis of instructions can affect the execution of movements, and that directing attention externally to outcomes or goals of a specific movement is more effective than directing attention to the movement being carried out (e.g., Wulf & Prinz, 2001). The research here developed along two distinct but related lines of enquiry. Firstly, the effects of attentional focusing instructions on the performance of automated skills were investigated using postural control tasks. Secondly, the effects of attentional focusing instructions on novices learning a motor skill were assessed using self-paced motor task (dart throwing).

There were other overriding aims of this research project, which influenced approaches within all the studies conducted. Firstly, a consideration for the possible application of findings was of primary concern. As a result, issues such as fatigue, situational changes and personal preference were considered. Secondly, a consideration of participants' experiences whilst they used attentional focusing instructions was identified as an area for consideration.

Summary of Findings

Motor Skill Execution Research

Study 1 aimed to expand on McNevin and Wulf's (2002) study from just kinetic analysis of postural control to include kinematic analysis of arm movement during the supra-postural task and also to assess participants' experiences of the instructions that they were given. Results indicated that postural control was significantly influenced by the type of attentional instructions used during a supra-postural task. An external focus of attention was associated with smaller SD of Ground Reaction Force (GRF) movement, particularly in the Anterior-Posterior direction, and a smaller range of GRF movement. Analysis of arm movements during the supra-postural pointing task revealed that an external focus of attention was associated with reduced SD and range of finger tip movement, the latter of which was particularly evident in the Medial-Lateral and Vertical Directions. A significantly reduced range of wrist movement in the vertical direction was also associated with the use of an external focus.

These findings suggested that attentional focusing strategies used during supra-postural tasks can affect postural control but also have clear effects on the movements involved in the supra-postural task. These effects were more apparent closer to the point of focus of the task (keeping the fingertip/curtain still). Directly focusing attention onto the movements of a specific body part degrades these movements through increasing the size and variation in movements. As this was a relatively simple skill to carry out, that any effects were observed suggests that the detrimental effects of an internal focus on more complex skills would be more apparent. From an application perspective this suggests that, in a one-off performance situation, directing performers to direct attention to their own movements is detrimental not only to the movements involved in the task but also overall postural control.

Study 1 assessed participants' experience of using attentional focusing instructions using post-task questionnaire; this was the first attempt of such an investigation of this thesis and also the attentional focus and movement execution literature. Findings indicated that there was no clear difference in participants' preferences for either attentional style. Previous research has limited itself to this level of consideration by only assessing preference (e.g., Wulf, Shea, & Park, 2001), yet additional questions included in the post-task questionnaire indicated clear differences between participants' experiences of the two instruction sets. Participants rated the external instructions as being more successful for the performance of the supra-postural task than the internal instructions. No differences were revealed for participants' ratings of the difficulty to carry out or maintain each strategy, or the mental demands which each strategy required. Further analysis revealed that participants who preferred the internal instructions rated the external instructions as being significantly more difficult to maintain than those who preferred the external instructions. Such a finding suggests that preference may well be linked to an ability to successfully maintain a particular attentional focus. Participants who preferred the internal focus instructions exhibited significantly higher levels of trait anxiety than those who preferred the external instructions. This suggests that participants' attentional focus preference may be linked to their ability to maintain this focus, and that this ability could be linked to an individual's anxiety levels. These findings emphasise that only assessing preference is a limited approach to understanding participants' experiences of different focusing styles.

Study 2 aimed to expand on Radlo et al.'s (2002) study to include a Control group for comparison of both the attentional strategies, a more in depth analysis of the HR data to include heart rate variability, and a consideration of participants' experiences of the instructions that they were given. An External focus condition benefited novices dart throwers' accuracy when compared to an Internal focus condition, but not the Control 'no-instruction' condition. HR profiles for each attentional focus group followed a similar pattern, with an internal focus exhibiting slower HR prior to dart throw when compared to the External and Control conditions, which did not significantly differ from each other. This did not support the previous findings of Radlo et al. (2002) or the predictions of Lacey's (1967) 'Intake Rejcetion Hypothesis'. Analysis of Heart Rate Variability (HRV), yet to be considered in attentional focus research, revealed a different pattern, with an external focus being associated with lower HRV than both the

Internal and Control conditions, which themselves did not significantly differ. A lower HRV is indicative of reduced attentional demands (Vincente et al., 1987), and this fits the predictions of reduced attentional demands associated with an external focus of attention demonstrated by Wulf, McNevin and Shea (2001).

These findings suggest that, when the aim of a session is to perform as accurately as possible, novices can gain an advantage from focusing externally during a one-off session. Although the external instructions were no more effective than a Control condition, from an applied perspective not giving people any instructions before performing is limited and may not hold long-term benefits, whereas directing a performer's attention externally using specific instructions provides the practitioner control over what information the performer processing during movements and their physiological state.

Using a post-task questionnaire Study 2 assessed participants' experiences of the attentional instructions they were given. Whereas Study 1 offered a within subjects analysis of participant experiences, Study 2 offered a between subject analysis with participants split into separate attentional focus groups. However, this design meant that analysis of preference was not possible. Additional to the analysis of Study 1, assessment of participants' experiences of the Control strategy was also carried out. No significant differences were observed between each groups' ratings of perceived difficulty to maintain their instructions. The Control group rated their instructions as being significantly less mental demanding to use than both the Internal and External Groups' instruction sets, which did not differ in their ratings perceived mental demands. Similar to the relationship revealed in Study 1, participants rated the internal strategy significantly less successful in aiding movement execution than the External group rated their instructions. Regardless of the differences in perceived success, no significant differences were observed in the reported percentage of dart throws where the instructions were used between each strategy. Participants high in State Anxiety using the External condition perceived these instructions to be more mentally demanding than participants who were low in State Anxiety. This mirrors the findings of Study where 1 lower levels of Trait Anxiety was shown to be significantly associated with the ability to efficiently focus externally.

In two experiments Study 3 assessed the influence of attentional focusing strategies upon unstable balance control before and during either a localised or generalised fatigue state. Research had shown that both localised and generalised fatigue can significantly impair postural control (see Chapter 4 for a review of this literature), but no research to date had assessed what influence attentional focusing instructions may have on this. It is clear that knowing the benefits, and indeed possible limitations, of different attentional strategies in different situations will improve their effective application.

Results from Experiment 3.1 and 3.2 indicated that although no clear advantages were identified for the external focus instructions on postural control whilst at a resting state, the induced fatigue states resulted in a significant degrading of postural control with the use of an external focus. In contract, an internal focus of attention seems to offer some protection against the detrimental effects of fatigue as no degraded effects were observed; in both experiments postural control at rest and fatigue did not significantly differ. This is the first demonstration of such an affect and further research is needed to establish whether this is a consistent relationship. Nevertheless, as the relationship was demonstrated using two different fatigue protocols it suggests a strong effect.

One possible explanation for the protective effects of an internal focus is that, when fatigue interferes with the structure and execution of a skill, the active intervention into postural control using an internal focus actually takes over and maintains performance. Although this results in a more cognitively demanding strategy for postural control, it does result in performance not being degraded significantly. For efficient performance an individual must be able to adjust and refocus their attention in light of changing circumstances. Such a notion was proposed by Gray (2004) who suggested that attentional focus during skill execution should be considered as a continuum, along which attention can be directed according to the situation. Gray's research suggested that focusing onto the execution of a skill during a slump in performance benefits later performance by taking control and adjusting the skill. This may well be the case here, where fatigue has produced a slump in the ability to balance effectively, therefore online control benefits postural control by taking control of the movements that have become inefficient. From an applied perspective, practitioners and performers should be aware that different performance circumstances may necessitate different attention strategies. In this case, the onset of physical fatigue may require the use of an internal focus of attention to maintain performance until a non-fatigued state resumes.

Study 4 investigated the effects attentional focusing instructions have on novice motor skill execution during a practice and a performance session. Previous motor learning and attentional focus research has used longitudinal research where participants used a single set of instructions throughout and where the session aims were to perform accurately and to one's maximal ability (see Chapter 1). The present study manipulated the aims of each of the sessions which participants performed the motor skill within. The aim of the practice session was for participants to practice the movements of the skill with little emphasis on maximal performance. This approach was informed by Beilock et al.'s (2002) proposal that skill-focused attention may be beneficial in practice situations where the goal is not to maximise performance. The performance session one week later emphasised as accurate performance as possible. Two experiments followed this protocol using a the self-paced dart task used in Study 2 as the motor skill. Experiment 4.1 gave participants the chance to use either internal or external instructions during the whole practice session, and then participants would perform using either the instructions they received during practice or changed to the set they had not received. Experiment 4.2 gave participants the chance to practice with both instructions, receiving either internal or external instructions for the first half of the practice session and the other instruction set for the last half of the session. This resulted in two practice groups Internal-External and External-Internal. After the practice session participants indicated their preferred focus style from the ones they had used. In the follow-up performance session, participants used a single focus instruction throughout, which was either their preferred style or not.

Experiment 4.1 demonstrated that during practice neither internal nor external attentional focusing instructions provided an accuracy benefit. This goes against research findings indicating benefits of an external focus immediately during learning (e.g., Shea & Wulf, 1999), but emphasises the effect that changing the aim of a session can have. During performance however, the External group performed significantly more accurately than the Internal group. Additionally, participants who changed from Internal to External instructions from practice to performance significantly improved their accuracy, whereas those who changed from external to internal significantly found their accuracy decreasing. Analysis of dart hit location indicated that an external focus produced throws where darts were more likely to hit the target in the upper half, whereas an internal focus produced throws that were more likely to hit the target in the lower half of the target. This demonstrates that focusing externally during performance significantly benefited movement, whereas an internal focus interfered with movement efficiency. This supports the benefits of an external focus associated with more efficient movement, whereas under internal-focus conditions participants tend to constrain the motor system by consciously trying to control their movements (e.g., Wulf, McNevin, & Shea, 2001; Wulf, Shea, & Park, 2001). Furthermore, these findings suggest that subtle changes in the aim of a session (e.g., practice or maximal performance) can influence the impact a strategy can have on movement. Although no benefit was shown for an internal focus during practice there was also no detriment compared to an external focus. Other researchers (e.g., Beilock et al., 2002; Gray, 2004) have suggested that skill focused attention can be beneficial during practice for the break down and alteration of skill components. These results suggest that an internal focus could be used during practice with few detrimental effects as no carry over detriments were observed for those who used an internal focus in practice but performed with an internal focus. Practitioners and performers should be aware that different types of focus might play a different role in different circumstances, and knowing which to use in which situation would be a valuable skill. Further research needs to establish in which situations different types of attentional focus are beneficial.

Supporting these findings, Experiment 4.2 demonstrated that when the aim of a session is not to perform to at your maximal best, the effects of attentional focusing strategies were not different. When the aim was to perform as accurately as possible, an external focus was the most beneficial attentional style to employ. However, the effectiveness of an external focus during performance was shown to be effected by a participant's attentional preference. Those who preferred an internal style after practice were less accurate using an external focus during performance than those preferring an external focus. Although those who preferred the internal focus would not have benefited from using an internal focus, it seems that preference does play a role in the effectiveness of instruction, something discounted by Wulf, Shea and Park (2001). These results suggested that care must be taken by practitioners and coaches to be aware of the preferences and individual styles of a performer/learner, so that instructions can be tailored to their own needs. Although further research needs to establish this, it seems more appropriate than assuming one style of instruction will be beneficial to all. This is made more obvious by Wulf's regular conclusion that even subtle differences in instruction can significantly influence performance. Therefore it is possible that subtle differences in emphasis of an external focus may provide significant benefits for different individuals; whereas some may prefer to focus on more distal end-points of a movement, others may find it more beneficial to focus upon end-points closer to the movement producing them.

Study 4 offered the most comprehensive investigation of participants' experiences carried out in this thesis, using a during task questionnaire to assess participants experiences throughout the task. In the practice and performance sessions of Experiment 4.1 it was found that participants using the internal instructions reported directing significantly more attention to their arm and hand than those using the external instructions. Those using the external instructions reported directing more attention to the target before and during each throw. This supports the accuracy benefits of an external focus during performance is linked to focusing upon the target. This also indicates that the detrimental effects of an internal focus during performance were due to focusing upon the movements and disrupting their execution.

It was possible to observe any changes in the experiences of the participants between the two sessions when they changed strategy in Experiment 4.1. Participants using the external instructions during practice but the internal instructions during performance reported a significant increase in the amount of attention directed to the dart. This supports the change in emphasis of the internal focus instructions. Participants using the internal or external instructions during practice but who used the internal instructions during performance reported a significant increase in the amount of attention paid to the speed of the dart. This suggests that when maximal performance was emphasised and internal instructions were used, the speed of the dart became a key focus of attention. Although this seems contradictory to the emphasis of the internal instructions, the speed of the dart is closely related to the internal focus through increased amounts of attention paid to the arm and hand during movements. Participants practicing with the internal instructions but performing using the external instructions reported a significant increase in the mount of attention directed to the target, and a subsequent decrease in the reported amount of attention directed to the arm and hand. Conversely, those who practiced using the external instructions but performed using the internal instructions reported a significant increase in the amount of attention paid to their arm and hand.

When participants used the external strategy for both practice and performance they reported a significant increase in the difficulty to follow the instructions they were given, possibly a reflection of the boredom of using the same instructions throughout the trial. This is supported by participants using the internal instructions for both practice and performance reporting a significant decrease in the number of throws they actually used their instructions during, suggesting that repetitive use of these instructions may have increased boredom and instruction use. As participants were able detect the poor success associated with internal instructions in Study 1 and 2, low instruction use may also be linked to lack of confidence in the instructions used.

During the performance session of Experiment 4.2, as with Experiment 4.1, participants using the external instructions reported directing more attention to the target than those using the internal strategy, a finding linked to their superior accuracy during performance as a consequence of focusing on an external intended movement outcome. Participants using the internal instructions reported directing more attention towards their hand and arm than the External group, highlighting their inferior accuracy during performance due to focusing on their own movements.

Participants who preferred the strategy they were using during performance reported that it required less effort than those who were not using the strategy which they preferred. The finding that effort was linked to preference supports the findings of Study 1, and suggests that some individuals may simply find specific instructions or attentional focuses harder to effectively use than others. This indicates that in some cases care must be taken in the wording instructions for some individuals. Linked to effort, participants using the external instructions during performance reported finding these instructions harder to use and increasing their levels of distractibility than participants using the internal instructions. Taken together with the finding that some individuals find the internal strategy more preferable or easier to use, this finding further suggest that the external focus may be the more difficult to efficiently establish and use, particularly for novices. As this group performed more accurately than those using the internal strategy, it seems the perceived difficulty was not detrimental to performance. Increased distractibility may be a consequence of the difficulty or may reflect an increased susceptibility to distraction as a result of focusing externally onto environmental information.

Methodological Issues in the Manipulation of Attentional Focus

One issue apparent throughout this thesis has been the methodological manipulation of attentional focuses. As indicated in Chapter 1, different researchers have approached this manipulation from different perspectives depending upon their research aim. For instance, the research carried out by Wulf and colleagues and to some extent Singer and colleagues has focused upon the manipulation of attention through instruction which directs attention to specific sources of information during a task. Researchers such as Beilock et al. (2002) and Gray (2004) have avoided the use of instructional manipulation and focused upon using multi-task approaches where attention is directly drawn from the execution of a skill through processing another task (often a word monitoring or production task). Liao and Masters (2002) have proposed that psychological stress increases the amount of skill-focused attention. In line with this, some researchers (e.g., Beilock & Carr, 2001; Lewis & Linder, 1997) advocate that learning skills under levels of increased skill-focus through increased pressure produced more versatile skills in the face of future stress. However, as highlighted by Wulf and Prinz (2001) the lack of manipulation checks carried out by these researchers to assess the success of the manipulations is limiting.

The research presented in this thesis primarily followed the approaches of researchers such as Wulf and Singer, using instructional manipulation of attentional focus. This was primarily due to instructional manipulation giving itself readily to application. Instructional manipulation is the main form of influencing an individual's approach to a movement, whether it is a coach teaching a sport skill or a physiotherapist instructing a client on a specific rehabilitative movement. Yet much knowledge about what instructions are beneficial at what times is currently based on anecdotal evidence (McNevin, Wulf, & Carlson, 2000). If research can identify which instructions are appropriate and when, then this can directly inform the use of instruction in practice. Other methodological approaches of using dual-task manipulations can give more direct control over a participant's attentional state, particularly the internal skill focus. Yet the application of these findings is more difficult as manipulation of attentional focus using dual-task may not, in the end, fully equip an athlete or novice with the necessary attentional skill to perform in real world situations. Furthermore, although appealing for protection against the breakdown of skills under pressure, the long-term application possibilities of creating high-pressure/psychologically stressful learning environments seem limited. How long would learners persevere with a new task or sport if the learning environment was always psychologically stressful? Therefore, research assessing how directing of attentional focus during learning and performance through instructional manipulation can influence learning is most likely to be able to influence application and teaching.

As R. Gray (2004) states, the major limitation of the instructional approach is that it is not clear to what extent performers actually used the attentional focus that was intended. Even with the use of psychophysiological assessment, researchers cannot be sure what exactly participants were focusing upon. Also, expertise complicates instructional manipulation as it seems unlikely that a performer would continue to use an instructional set on a task they were experienced with if they found it unproductive. Therefore, participants' experiences of the attentional focusing instructions were assessed using either post-task questionnaire (Study 1 and 2) or during-task questionnaire (Study 4). This is the first attempt to address this issue and the preliminary results offer information and guidance for further research. What this approach has demonstrated is that the manipulation of attentional focus using instruction is difficult. Findings suggest that participants are sensitive to the success of the instructions they are given, regardless of whether they have used a different instruction set for comparison or not (Study 2). It also seems that perceptions of effort needed to use a particular focus of attention, specifically the external focus of attention, influences whether an individual will prefer those attentional instructions.

A problem for the manipulation of attentional focus is the finding that participants never reported using the instructions they were given consistently throughout a task. It may also be the case that participants overestimated their use of instructions, leading to the worrying conclusion that participants are using the instructions much less often than reported. Although the kinematic, kinetic, accuracy, HR, and balance evidence suggest that there were clear differences between the attentional instructions given, knowledge of what participants were focusing upon when not using the instructions they were given would be extremely valuable. As Gray (2004) suggests, the focus of attention can be thought of in terms of a linear scale, along which an individual can effectively (or not) direct their attention depending upon circumstances. It may be that when participants report that they are not suing the instructions they were given, they have simply adjusted their focus temporarily in light of their current level of performance.

If we cannot be sure that the instructions we have given are used or that participants are following them fully, or even understand them, the aim of influencing application becomes difficult. In developing research which is applicable to the real world this research faces the same dilemmas that the coach, trainer, teacher or physiotherapist faces; do we know that the instructions we have just given are in fact being followed? Yet the use of instructions is so widespread that research cannot afford to ignore questioning how they can be refined. Regardless of the methodological issues facing the manipulation of attentional focus, research should continue to assess the effects of instruction on movement performance and learning. Rather than indicating that participants may not follow instructions, researchers should make efforts to assess why and when participants don't use the instructions they were given, and what strategies they use when they don't.

Associated with the problems of manipulating different attentional states is the problem of operationalising a control condition for analysis. Wulf and McNevin (2003) and Radlo et al. (2002) indicate that the use of control conditions for comparison would allow more accurate conclusions that an external focus is beneficial, rather than an internal focus is simply detrimental. Efforts were made in the present research to use control conditions, yet is has become clear that control conditions bring methodological issues of their own. Research implies that attention is directed either internally or externally during performance, but no control state is suggested to exist as attention has to be directed somewhere. Where should attention be directed in a control condition? Previous research has advocated a 'no-instruction' state where no specific instruction is give regarding how to direct attention during a task (e.g., Wulf & McNevin, 2003; Wulf et al., 1998, Experiment 1; Wulf & McNevin, 2003; Wulf, Weigelt, Poulter, & McNevin, 2003). Yet it cannot be assumed that individuals in this condition are in some 'control no-instruction' state, the concept of attention indicates that they will be directing their attention internally or externally during the execution of the skill. Therefore control conditions offer a comparison between different attentional states a *non-controlled* attentional focus state, not a no-focus state. Such a state can offer an ideal opportunity for investigating what participants direct their attention to when not given specific attentional direction instructions. However, it is a conclusion of this thesis that operationalising control conditions in attentional focus research is difficult as theory implies that attention is directed somewhere at all times, and effort needs to be taken to find more appropriate comparisons. It may be that the nature of a task will dictate what information participants focuses upon when in a control 'no-instruction' condition. For example, the control condition in Study 2 performed as accurately as the external group, but this may be due to the nature of the dart throwing task forcing participants to be more likely to focus externally because of the presence of a target.

Conceptual Issues

The findings from this thesis have implications for the conceptualisation of attentional focus during movement execution. The processes and conceptualisation behind the definitions of internal and external attentional focuses need clarifying. It is inaccurate to see the internal and external focus as a spotlight that either shines into a dark room (e.g., the brain) or out of the room (e.g., into the environment). Farah (1994) states that "attention is not allocated to objects at locations in space, but rather to internal representations in space" (p. 44). External attention is still internally based; the attention is directed to cognitive representations of stimuli. Fernandez-Duque and Johnson (1999) suggest that advances in brain imaging research has facilitated a major shift in the conception of the attention-as-spotlight metaphor – which has now been moved from an attentional spotlight shining on "objects" in a visual or auditory field, to an inner spotlight shining on brain areas and neural connections. Attention is no longer allocated "quite mysteriously" to the external field (Fernandez-Duque & Johnson, 1999). Wulf and Prinz (2001) proposal of distance in the external focus suggests that an optimal external focus as being directed to an effect that is as remote as possible but can still be related to the movements that caused it. Here the spotlight is not simply shone further away, the metaphor of distance relates to the type of information being processed. The information being processed should not be the mechanics of the movements, but should still related to the movements in some way. Therefore, the external focus is not simply 'looking' at a target or implement, but processing information related to achieving desired outcome related to the target or implement. As Wulf's balance research regularly states, participants were not instructed to actually look at the markers on the balance platform, rather they should look straight ahead but think about the movement of these markers. Similarly, this conceptualisation clarifies our understanding of the internal focus. An internal focus is not simply looking at your hand or arm whilst you carry out the movements required, but processing the bodily related information associated with the movement. In none of the research covered were participants instructed to 'look' at a movement body part, they were instructed to think about the movement of the body part. For instance in the unstable balance task used in Study 3 participants were told to either focus on the movements of their feet (internal) or the movements of the markers on the platform (external), but throughout they were directed to look straight ahead and not to look at either of these points.

A psychophysioogical perspective can also add to our understanding of attentional focus during movement. For instance, Abernethy (2001) suggests that the key abilities of shifting, disengaging and engaging of attention are associated with specific brain areas.

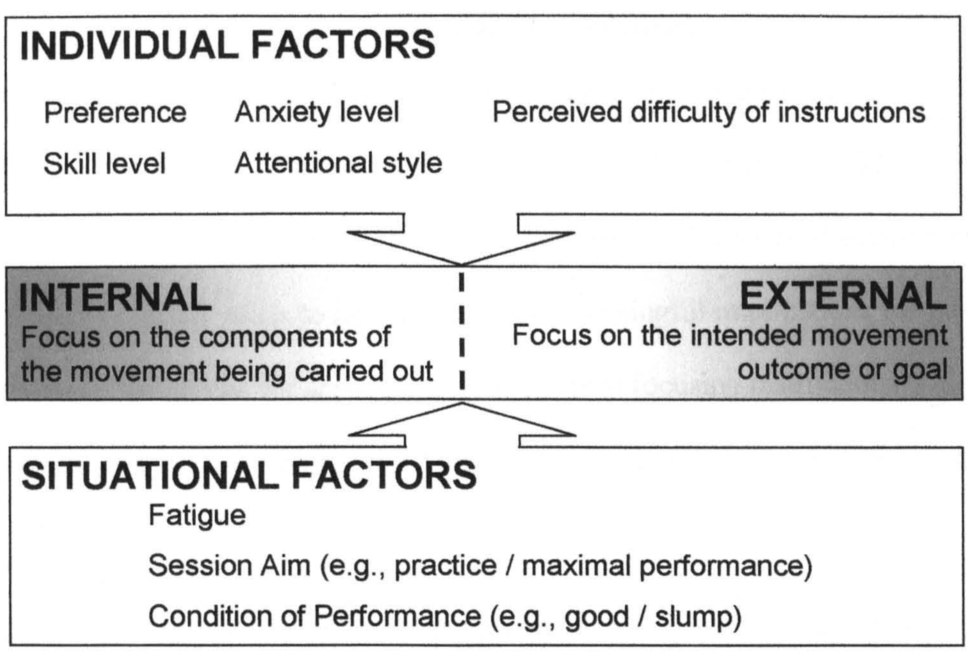
Relating to an internal focus Smid, Hausier, Weiler, Awiszus, Henrichs and Heinze (2004) suggest that there may be multiple levels of movement awareness associated with specific brain regions. Furthermore, they propose that athletes could be trained to activate and suppress appropriate brain areas through biofeedback, and that this may be a more effective approach to attentional training. Different attentional focuses should be considered as the activation and suppression of appropriate cortical areas. At this level, attentional focusing instructions influence what information a performer should be processing while ignoring other information in relation to specific brain areas.

The findings presented in this thesis suggest that by considering factors which influence performance such as fatigue then the concept of attentional flexibility becomes critically important. In particular, the ability the shift and engage activation of appropriate cortical areas whilst suppressing other areas is critical to effective performance and offers a better understanding of attentional focus during performance. Such attentional flexibility between internal and external sources of information during performance is seen as essential during endurance exertion. For example, research has demonstrated that runners at all levels of skill use both internal (associative) and external (dissociative) strategies during a long run (e.g., Schomer, 1986; Summers, Machin, & Sargent, 1983; Summers, Sargent, Levey, & Murray, 1982). The use of either strategy depends on a number of factors, such as whether it is a training or competitive run, the length and stage of the run and the terrain (Morris & Summers, 1995). In line with this Gray (2004) proposed that a high level of skill is not characterised by only one type of attentional allocation, and that skill-focused attention is not an all or nothing phenomenon. Expert performers may continuously cycle back and forth between different types of attentional focus in line dependent upon situational needs. This conceptualisation is useful, and brought into line with Wulf et al.'s definitions of distance of the external focus it seems that a scale of attentional focus may exist. At one end the distant external attentional focus exists, consisting of information relating to distant outcomes related to a movement. At the internal end, information regarding the movements being carried out exists. Beilock et al. (2002) and Gray (2004) suggest that situations where the aim is not to maximise performance or where a skill has become inefficient, then moving along this scale to an internal skill-focus of attention would enable to performer to take control of the movement and adjust it inline with the desired outcome. The current thesis supports this notion in that when the aim of a session was to practice a skill, then both internal and external focuses of attention produced similar performances. On the other hand situational factors such as fatigue influence the effectiveness of different attentional focuses. Another factor to influence the attentional focus scale is personal preference, with may limit the extent of the scale at specific extremes.

A new conceptual model considers attentional focus along a continuum, with Gray's (2004) conceptualisation of the internal focus at one end, whilst the external extreme is informed by Wulf and Prinz's (2001) conceptualisation of distance, with the external continuum progressing from external sources of information that are closely related to their associated movements to information far removed from the movements that are producing them. Movement along this continuum will be influenced by a number of factors such as psychological stress and fatigue, yet ultimately it is the individual who will control the focus of attention in the face of such factors. How they focus their attention along the continuum will determine whether their movements are executed effectively or not. The extent to which the individual can effectively focus onto the appropriate information is determined by the individual and situation. Attention can still be directed inappropriately along the continuum, even if directed in the correct direction. Other errors which may occur include limited flexibility or speed in changing attentional focus, where a previously effective attentional focus becomes ineffective as the situation changed. For example, an individual carrying out a repetitive motor task will use an external focus for maximal performance. Subsequently they may become fatigued and an internal focus becomes the appropriate focus for online control of movement and maintenance of performance. When the fatigue subsides, if the individual cannot shift their attention back to an effective external focus then performance will deteriorate. Similarly, if a coach or practitioner cannot identify instructions which may help an individual focus their attention appropriately then performance will suffer.

This new model is a combination of the work of Wulf and colleagues (e.g., 2001, 2003), Beilock and colleagues (e.g., 2002) and Gray (2004) and is not exhaustive of the possible factors which may influence the effective direction of attentional focus. It is possible that other factors exist in the areas identified such as individual differences and situational changes. The model presented in Figure 6.1 indicates the factors which influence the effective direction of attention, using the framework research will consider attention as a flexible resource critical to optimal performance.

Figure 6.1: Model of attentional focus dimension and influencing factors



A critical part of this approach to attentional focus during movement execution is that an internal focus may provide benefits in specific situations. Current findings are demonstrating that Masters' (1992) claim that skill-focused attention, particularity in experts, should no longer be considered a negative trait that must be avoided at all costs may be accurate, and Future research needs to address this issue. Although research carried out by Wulf and colleagues indicates that focusing attention onto the specific movements being carried out is detrimental, Moran (1996) concluded that an athlete may benefit more from an external attentional strategy when unaware of the precise bodily signals to which attention should be paid. This is important for directing research and ultimately practice; if an appropriate internal focus can be identified for specific situations then performers will find this more beneficial than the detrimental focus onto movement execution. In line with this, Moran suggests that a promising line for future research is the possibility that different *types* of *internal* attentional focus may have different effects on performance. As with Wulf and Prinz's (2001) proposed effective range of an external focus, a similar effective range exists internally for appropriate situations.

Applied Implications

Research assessing the effects of different attentional strategies on the performance and learning of motor skills has obvious implications for interventions. Hardy, Jones, and Gould (2001) indicate that if research on psychological aspects of performance is to be of any use then it needs to be translated into meaningful implications for guiding practice. Directions for application of attentional focusing instructions will now be discussed with a consideration for the present findings and conceptual issues.

Motor learning

Wulf McNevin and Shea (2001) emphasised that subtle differences in verbal instruction can affect the learner's attentional focus and performance success is dependent upon attention being directed away from the movement being carried out and onto an intended outcome or goal of the movement. Findings from Study 2 would suggest that directing a learner's attentional focus internally whilst attempting to perform a new skill as accurately as possible would result in degraded movement quality. Directing a learner's attention externally onto the outcome of the movement they are producing will result in a more efficient movement execution. This finding also indicates that directing attention externally can be used effectively in a one off performance situation, where no training has been given in the use of the attentional focuses given.

When learners are given the opportunity to practice a skill with less emphasis on performing at their best/most accurate as in Experiment 4.1, they will not suffer degradation if an internal focus of attention is emphasised. It may be that a practice situation is the best time for internally directed instructions, where a closer focus is given to the mechanics of the skill being learned. Such a focus would be detrimental during a performance situation, but if a skill needs to be adjusted or modified then an internal focus could be used during practice. In the long term, the practitioner should be aware that different attentional focuses exist. By directing the learner's attentional focus appropriately using a combination of instructions throughout the learning period, skill should be learned to a high degree of proficiency whilst teaching effective attentional skills.

Motor Performance

One of the major implications for application that this thesis is offering relates to the findings from the effects of attentional focus during fatigued states. Fatigue is a natural by product of motor skill execution, and is associated with many motor performance and sporting situations. Results from Study 3 indicate that an internal focus of attention may offer protection against the detrimental effects of fatigue whilst an external focus of attention does not. Practitioners concerned with the execution of skills should be aware that fatigue will play a role in the effectiveness of an individual's ability to perform a skill. But with appropriate direction of attention, it may be possible to overcome some of the detrimental effects of fatigue. As long as a performer is able to effectively shift their attention between the different attentional types, then adopting an internal focus whilst fatigued may be more beneficial, and then when this state subsides, an external focus of attention can again be utilised. Training may be necessary so that attention can effectively be shifted to appropriate sources of information to avoid attention becoming fixated on one area that may be, or may subsequently become due to changes in a situation, inappropriate.

Another finding with implications for the application of cognitive strategies during performance is from Study 4 (Experiment 4.2) where preference for attentional focus was found to be important. Practitioners should be aware that preference is an important variable for consideration when directing attention focus, as well as factors such as ratings of difficulty, effort, and distraction. Although preference did influence the effectiveness of an external focus, those who preferred an internal focus did not perform better with an internal focus. This indicates that care must be taken in developing instructions as some individuals may benefit from external focusing instructions with particular emphasis. For example, emphasising an outcome that is more closely related to the movements being carried out. Close collaboration between experts in a particular skill set (coaches) and sport psychologist should help to identify the appropriate instructions for an individual based on the characteristics.

Understanding the internal-external dimension of attentional focus as suggested by Wulf (e.g., Wulf & Prinz, 2001), Gray (2004), and presented in Figure 6.1 can help inform the tailoring of instructions so that an effective attentional focus is induced. This approach would avoid a catch-all approach to attentional strategy application. This view is not in conflict with Wulf, Shea, and Park's (2001) suggestion that individual differences do not play a role. What is not being suggested is that some individuals prefer an internal focus and therefore should use an internal focus. An external focus is effective for the maximal performance of skills, but as some individuals did not prefer it suggests that different emphasises of external attention focus are not effective for all individuals.

Physical Therapy

Although this thesis is primarily driven by research and interest in sport psychology and the learning and performance of motor skills, there are further implications for application. One particular area is that of physical rehabilitation. Wulf and Prinz (2001) and McNevin et al. (2000) have suggested that the application of appropriate attention focusing instructions in physical therapy would result in savings in time and resources, as well as improving efficiency and may even lead to a reduction in re-injury following rehabilitation. Motor learning is a critical part of physical therapy interventions and Pohl, McDowd, Filion, Richards, and Stiers (2001) indicate that a critical part of the cognitive process of perceptual-learning is the ability of the learner to comprehend and utilize the instructions provided to the learner. However, McNevin et al. state that the one area within physical therapy that has received remarkably little interest is the role that instructions play in promoting learning. Indeed, they stress that therapists may well be familiar with the techniques associated with attention focusing instructions, however, the rationale behind their use is often anecdotal, rather than research based.

Therefore, research is needed along two lines before effective different attentional focusing instructions can be applied in rehabilitation. Firstly, the actual effects attentional focusing instructions can have during rehabilitative exercises need to be identified. In light of the research presented here, this line of inquiry needs to take into account a number of considerations such as situational influences (e.g., fatigue) and individual differences (e.g., preference). The second line of enquiry is for research to assess what kinds of instructions are currently being used by therapists. Such research would identify what types of instructions are currently used and whether any specific attentional focuses are emphasised in different situations. However, this area has so far received no research interest and therefore such research should be a priority.

The limited research in this area was discussed in Chapter 1. In summary the research so far has identified that an external focus was found to improve stride length in Parkinson patients to within 90%.of normal values (Morris et al., 1996) and externally focused instructions directed toward naturalistic task performance improved movement speed and force in the hemiparetic arm after stroke (Fasoli et al., 2002). Although specific research is needed to establish the possibilities in physical therapy for attentional focusing instructions, particularly with specialist patient groups, it is suggested that research and practice may benefit from guidance from the attentional focus and motor learning literature. The incorporation of attentional focus into rehabilitation protocols has the potential to enhance the effectiveness of rehabilitation procedures (McNevin, et al. 2000). Practitioners should be aware that subtle differences can have specific effects on a client's movements and learning, and that these effects can be influenced by individual and situational factors.

Physical Training

Similar to physical therapy, there are implications of attentional focus research findings for individuals carrying out physical training such as weight lifting for strength gains. Ives and Shelley (2003) highlight attentional factors as being key to effective functional strength and power training. In particular, the physiological adaptations resulting from a training program are not only influenced by the movements performed but also the cognitive state in which the movements are performed. Ives and Shelley state that sport specific physiological adaptation is enhanced by creating the optimal cognitive environment, and altering attentional elements is a starting point for manipulating this.

The practitioner wanting to enhance an individual's benefits from a training routine may find that altering the attentional focus used will be influential. As in the previous examples, practitioners teaching individuals to use weight lifting techniques need to be aware that subtle differences in the emphasis of their instructions will have an influence in the quality of the movement carried out. The differences in instructions will also alter the cognitive environment that the movements are being carried out in and therefore influence the physiological adaptations which take place. For effective movement production it will be beneficial if a performer focuses externally onto a movement outcome, such as the final lifting position of the weight. However, an internal focus of attention during movements may be beneficial when different aims are needed. For example, in two experiments Vance et al. (2004) found that EMG activity was reduced under external focus conditions. There was also evidence that an external focus of attention was associated with more effective recruitment of motor units. Vance et al. went on to suggest that an external focus can benefit force production skills. However, if force production was not the aim, but increased muscle recruitment was, then an internal focus during a weight lifting movement would be beneficial.

Future Research

Research continues to assess the effects of attentional focusing instruction on the performance and learning of motor skills. Effort should now be taken to assess the effects attentional strategies have under different situations. The present research offered insight into physical fatigue and practice, but many others remain. For example, high anxiety has been shown to effect the execution of motor skills and has been suggested to be the consequence of an internal focus of attention (Masters, 1992). However, no research has suggested or assessed whether using an external attentional focusing could help protect against increased anxiety. Another area following on from the present research would be mental fatigue. Only physical fatigue was assessed in the present study, but many tasks are also associated with increases in mental fatigue. Van der Linden, Frese and Meijman (2003) tested whether behavioural manifestations of mental fatigue may be linked to compromised executive control; the ability to regulate perceptual and motor processes for goal-directed behaviour. Their findings indicate compromised executive control under mental fatigue, which may explain the typical errors and sub-optimal performance that are often found in mentally fatigued people. Lorist, Boksem, and Ridderinhof (2005) also demonstrated reduced cognitive control associated with mental fatigue. In a sporting setting, differences in the levels of mental and physical fatigue have been observed in Rugby players in different playing positions (Mashiko, Umeda, Nakaji, Sugawara, 2004) and utilising different recovery strategies (Suzuki, Umeda, Nakaji, Shimoyama, Mashiko, Sugawara, 2004). It may be that increases in mental fatigue reduce participants' ability to effectively utilise different focuses of attention due to compromised executive control.

As already discussed in relation to application of attentional focusing findings, research should assess whether individually tailoring attentional instructions may be beneficial in specific situations. Some individuals may perform better when external instructions are tailored with goals/outcomes closer to or further from them. The range of external focus suggested by Wulf and Prinz (2001) proposes an ideal focus point, yet it is possible that this ideal focus point may vary in relation to individual preferences, skill level, anxiety level or confidence. Although the findings from Experiment 4.2 only tentatively suggest this, research in this area may provide fruitful information for the appropriate application of attentional focusing instructions.

Although only heart rate was utilised in the Study 2 with relation to psychophysiological research, future research needs to address the effectiveness of attentional focusing strategies using a psychophysiological approach. Access to technology is obviously a major limitation for many sport psychology researchers, but where possible, research should attempt to assess attentional focusing strategies using brain-scanning technology such as EEG. Furthermore, Study 1 indicated that the use of kinematic analysis can offer more detailed insight into the effects of attentional focus instructions on specific body parts. Study 1 only used a very simple pointing movement as a supra-postural task, and future research should focus on assessing changes in movement kinematics of more complex movements. Such an approach may require collaboration with experts such as biomechanists, and this thesis emphasises the value of multidisciplinary research. Morris and Summers (1995) stress the need for collaboration with colleagues in other sports sciences in addressing important practical issues, it is clear that few real world issues can be addressed by a single discipline approach.

This research has established that assessing participants' experiences of using different attentional strategies can offer valuable insight into their effectiveness. In particular, this approach expanded and challenged previous methodology assessing preference. Rather than simply asking for preferences, by assessing such factors as difficulty and perceived success of the instructions used offers information relating to the subtleties of individual preferences. This thesis has utilised both post-task and during-task assessment of experiences, with both offering key experience information. The later use of during-task assessment offers a direction for further research. Even though the effort was made to avoid task disruption, the methodology used was still relatively obtrusive, requiring the participant to stop at regular intervals to answer questions. A less obtrusive approach may be for participants to verbally report their experiences at regular intervals during a task. This approach may also offer more richer information due to its qualitative nature which, although more time-consuming to process, should not overly interfere with the task. However, one problem associated with this approach would be any effects it would have on directing attention on undesired information. Nonetheless, this offers a promising avenue for future research.

The notion of flexibility between different attention styles is an important area of research interest to develop from the findings of this thesis. The current thesis proposes that flexibility between different styles is critical to effective performance and research should address how individuals can effectively do so. Indeed, in their assessment of the research on attentional control during performance Hardy, Jones and Gould (2001) suggest that how elite performers are able to switch rapidly from one style to another, and how they have developed such attentional flexibility, is of particular interest. Hardy et al. go on to suggest that although mental training and rehearsal are currently the prominent techniques for creating control over attentional focus, technological advances mean than biofeedback training could be an important method of training individuals to use their attentional focus. This would be a particularly valuable approach in acquiring control over key physiological processes associated with effective attentional focus.

The above areas are only some examples of possible future directions; however these offer avenues where findings may have the biggest implications for practice. There is a need for sports psychology research to address real word issues, and hopefully the present research and those areas above would succeed in this. By following these lines of research a more complete theory of attentional focus during performance and learning may emerge, including such variables as situational factors (physical fatigue, practice/performance), individual differences (preferences, instructional tailoring), and, importantly, flexibility. As Morris and Summers (1995) state, theories which do not apply to real world issues tend to be lifeless and models must be generated to describe processes in real athletes involved in real sporting and performance situations. And critically, Morris and Summers stress the need to use a range of paradigms in a systematic manner so that theory can progress to the stage where it can be used to generate predictions about the best techniques to employ in a particular situation. Although this has been achieved to a degree in the present research with attentional focus interventions, it is by no means exhaustive of the available factors which need to be addressed.

Conclusions

The body of research on attentional focus motor performance and learning which has developed has been extremely useful and influential. The findings have concluded that directing individual's attention towards goals or intended outcomes of movement (an external focus of attention) is more beneficial to both learning and performance of motor skills than directing attention towards the movement components themselves (an internal focus of attention). Research presented in this thesis supports this approach, demonstrating an advantage of an external focus when participants attempted to perform at their best (Study 1 and 2). Advancing this body of research, research presented in this thesis suggests that some care should be taken when discussing the findings and implications of attentional focus and movement research. Specifically, over-generalising the benefits of the external focus may lead to inappropriate application of findings as well as an inaccurate understanding of the nature of attention during movement. By performing controlled experiments in the lab, researchers have been able to isolate and demonstrate the effects of instructions manipulating attentional focus. However, by not assessing other factors that can affect performance, some of the suggestions made regarding the application of their findings may be too generalised. This thesis presents evidence that factors such as physical fatigue (Study 3) can influence the impact attentional focusing instructions can have on an individual.

Furthermore, the notion of personal preference for specific instructions or attentional styles, something discounted by Wulf, Shea and Park (2001) but has long been advocated by attentional focus conceptualisers such as Nideffer (e.g., 1979), does seem to affect the impact on the effectiveness of external focus instructions (Study 4). The effects of attentional focusing instructions were also shown to be influenced by subtle differences in the goal of the situation where the motor task was being performed (Study 4). Carrying out skills in a practice situation, where performing accurately and efficiently is not necessarily the aim but practicing the movement is, influences the effectiveness of an external focus relative to an internal focus. Just as subtle differences in instructions can influence the attentional focus, subtle differences in situation can influence their effectiveness.

Efforts should now be made to assess what situations benefit from different attentional styles. From an applied perspective, effort should be made to identify how individuals can be trained to move effectively between different attentional styles so that efficient performance can be maintained, rather than promoting a single focus for all situations. Although the present body of research has advanced our knowledge of attentional focus during movement considerably, recent findings (e.g., Beilcok et al. 2002; Gray, 2004) and the findings from this thesis suggest that flexibility is key to effective performance. Indeed, researchers such as Nideffer (e.g., 1979) and Naatanen (1992) have suggested that a certain degree of attentional flexibility is needed for optimal performance. This certainly seems to be the way forward for both application and research of attentional strategies.

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APPENDICES

APPENDIX 1: Trait Anxiety Questionnaire

APPENDIX 2: State Anxiety Questionnaire

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APPENDIX 1: TRAIT ANXIETY QUESTIONNAIRE

A number of statements which people have used to describe themselves are given below. Read each statement and then mark the appropriate box to the right of the statement to indicate how you *generally* feel. There are no right or wrong answers. Do not spend too much time on any one statement but give the answer which seems to describe how you generally feel.

	Almost Never	Sometimes	Often	Almost Always
I feel pleasant	1	2	3	4
I feel nervous and restless	1	2	3	4
I satisfied with myself	1	2	3	4
I wish I could be as happy as other seem sot be	1	2	3	4
I feel like a failure	1	2	3	4
I feel rested	1	2	3	4
I am "cool, calm and collected"	1	2	3	4
I feel that difficulties are piling up so that I cannot overcome them	1	2	3	4
I worry too much over something that really doesn't matter	1	2	3	4
I am happy	1	2	3	4
I have disturbing thoughts	1	2	3	4
I lack self confidence	1	2	3	4
I feel secure	1	2	3	4
I make decisions easily	1	2	3	4
I feel inadequate	1	2	3	4
I am content	1	2	3	4
Some unimportant thought runs through my mind that bothers me	1	2	3	4
I take disappointments so keenly that I can't put them out of my mind	1	2	3	4
I am a steady person	1	2	3	4
I get in a state of tension or turmoil as I think over recent concerns and interests	1	2	3	4

APPENDIX 2: STATE ANXIETY QUESTIONNAIRE

A number of statements which people have used to describe themselves are given below. Read each statement and then mark the appropriate box to the right of the statement to indicate **how you feel *right now***, that is, ***at this moment***. There are no right or wrong answers. Do not spend too much time on any one statement but give the answer which seems to describe your present feelings best.

	Not at all	**Somewhat**	**Moderately so**	**Very much so**
I feel calm	1	2	3	4
I feel secure	1	2	3	4
I am tense	1	2	3	4
I feel strained	1	2	3	4
I feel at ease	1	2	3	4
I feel upset	1	2	3	4
I am presently worrying over possible misfortunes	1	2	3	4
I feel satisfied	1	2	3	4
I feel frightened	1	2	3	4
I feel comfortable	1	2	3	4
I feel self-confident	1	2	3	4
I feel nervous	1	2	3	4
I am jittery	1	2	3	4
I feel indecisive	1	2	3	4
I am relaxed	1	2	3	4
I feel content	1	2	3	4
I am worried	1	2	3	4
I feel confused	1	2	3	4
I feel steady	1	2	3	4
I feel pleasant	1	2	3	4

APPENDIX 3: STUDY 1 POST-TASK QUESTIONNAIRE

Thank you for your participation so far. It would be helpful if you could take the time to answer the following questions, after which the session is over. These questions are not a test, nor are there right or wrong answers. Simply answer with what you feel is right for you.
To answer the questions simply circle a response.

★ Of the two focus conditions (**Focusing on Your Finger** and **Focusing on the Sheet**), which did you find most comfortable / appropriate?

Focusing on your finger **Focusing on the Sheet**

★ If you were to do this task again with your preferred focus, which would you use?

Focusing on your finger **Focusing on the Sheet**

★ For the following Questions consider the condition:
"Focusing on Your Finger"

1. How difficult was it to carry out this condition?

Not Very Difficult	1	2	3	4	5	Very Difficult

2. How difficult was it to maintain this focus throughout the task?

Not Very Difficult	1	2	3	4	5	Very Difficult

3. What was the level of the mental demands?

Not Very High	1	2	3	4	5	Very High

4. How successful do you think this condition was in keeping the sheet still?

Not Very successful	1	2	3	4	5	Very successful

★ For the following Questions consider the condition:
"Focusing on the Sheet"

5. How difficult was it to carry out this condition?

Not Very Difficult	1	2	3	4	5	Very Difficult

6. How difficult was it to maintain this focus throughout the task?

Not Very Difficult	1	2	3	4	5	Very Difficult

7. What was the level of the mental demands?

Not Very High	1	2	3	4	5	Very High

8. How successful do you think this condition was in keeping the sheet still?

Not Very successful	1	2	3	4	5	Very successful

Are there any comments you would like to make regarding the **Focusing on Your Finger** condition? (please write them here):

Are there any comments you would like to make regarding the **Focusing on The Sheet** condition? (please write them here):

APPENDIX 4: STUDY 2 POST-TASK QUESTIONNAIRE

These were the instructions you were given to carry out this task:

ATTENTIONAL INSTRUCTIONS HERE

Please answer the following questions about your experience of using these instructions during the task:

How difficult was it to carry out these instructions?

Not Very Difficult	1	2	3	4	5	Very Difficult

How difficult was it to maintain these instructions throughout the task?

Not Very Difficult	1	2	3	4	5	Very Difficult

What was the level of the mental demands?

Not Very High	1	2	3	4	5	Very High

How successful do you think this condition was in making your dart throws accurate?

Not Very successful	1	2	3	4	5	Very successful

Approximately, on how many of the throws do you think you used the instructions? (Please circle)

100% 90% 80% 70% 60% 50% 40% 30% 20% 10% None

Do you have any comments or information you would like to give regarding the instructions you were given? Please give as much detail as possible:

APPENDIX 5: STUDY 3 BIODEX BALANCE SYSTEM SPECIFICATIONS

Maximum height: 76" (193 cm)

Width: 30" (76 cm)

Depth: 44" (112 cm)

Support Rails: Adjustable from 25" to 36.5" above platform (63.5 to 92.7 cm). Rails swing away
from platform if desired

Platform Height: 8" above floor (20.32 cm)

Platform Diameter: 21.5" (54.61 cm)

Platform Tilt: 20 degrees from horizontal in all directions

Display Height: Adjustable from 53" to 68" above the platform

Display Angle: Adjustable from vertical back to ~45 degrees

Display Viewing Area: 122 mm x 92 mm

Display Resolution: 320 pixels x 240 pixels

Patient Weight Capacity: Up to 300 lb (136 kg)

System Weight: 165 lb (419 kg)

Printer: HP DeskJet

Printer Stand: 24" x 24" (61 x 61 cm)

Electric: 115 VAC, 50/60 Hz, 15 amp or 230 VAC, 50/60 Hz, 15 amp

Power Rating: 300 watts

Game Port: Simulates joystick output suitable for an IBM PC compatible game port

Display Accuracy: +/- 1 degree of tilt

Stability Levels: 8, plus locked

ETL approved to UL 2601 and ETL© approved to CAN/CSA c22.2 No. 601.1-M90

Mfg.: Biodex Medical Systems

20 Ramsay Road

Shirley, NY 11967

Classification: Class I measuring, Type B, ordinary equipment, continuous operation.

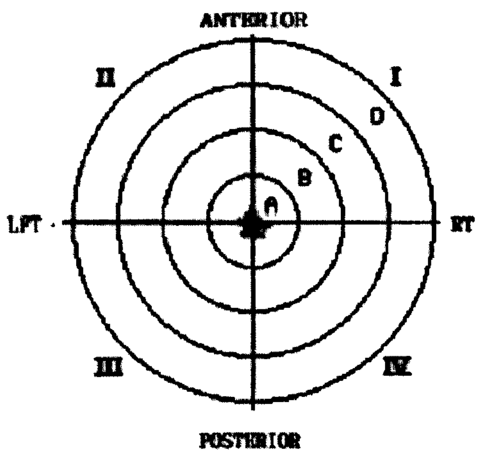
APPENDIX 6: STUDY 3 BIODEX BALANCE SYSTEM BALANCE REPORT

EXAMPLE OUTPUT

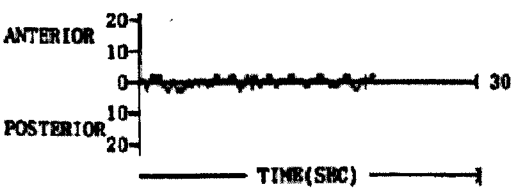
BIODEX BALANCE ASSESSMENT: PREDICTIVE VALUES

Name ____________________
Date ____________________
Weight 150 Lbs
Height 60 in

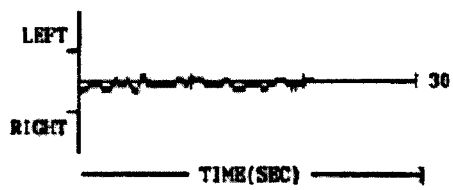
Test Type: BOTH FEET
Protocol: Time 0 min 20 sec   Level: Start 8 End 8
Foot Position Right D17   Left D4
Eyes: OPEN   Leg Involved: BOTH   Age: 30



ANT/POS DEFLECTION (DEGREES)



LAT/MED DEFLECTION (DEGREES)



	PREDICTIVE VALUES	ACTUAL VALUES	(SD)
OVERALL BALANCE INDEX	<1.54	1.4	14.0
ANTERIOR/POSTERIOR INDEX		1.2	20.0
MEDIAL/LATERAL INDEX		1.1	20.0

LEGEND:
Overall Balance Index: Represents the patients ability to control their balance in all directions. High values represent patient had difficulty and further assessment may be needed
Anterior/Posterior Index: Represents the patients ability to control their balance in front to back direction. High values represent patient had difficulty and further assessment may be needed.
Medial/Lateral Index: Represents the patients ability to control their balance from side to side. High values represent patient had difficulty and further assessment may be needed
Represents repeatability in performance. A low SD indicates
Standard deviation(SD): Represents repeatability in performance. A low SD indicates the range of values, from which the data was calculated, was close together.

APPENDIX 7: STUDY 3 BIODEX BALANCE SYSTEM REPORT

PARAMETERS DEFINED

Stability Level: Indicates the stability of the foot platform. When "locked", the platform is fully stable. A setting of eight is the most stable "released" setting. A setting of one is the least stable foot platform setting. Stability settings of eight through one allow the foot platform to a full 20 degrees of deflection from level in any direction. For patient centring prior to testing, the foot platform deflection is limited to less than five degrees.

Overall Stability Index (SI): Represents the variance of foot platform displacement in degrees, from level, in all motions during a test. A high number is indicative of a lot of movement during a test.

Use as a starting point for a perfectly balanced state.
COB x=0; COB y=0 COB is "Centre of Balance"

$$(DI)^2 = \sqrt{\frac{\Sigma (0 - X)^2 + \Sigma (0 - Y)^2}{\text{number of samples}}} \qquad DI = \sqrt{(DI)^2}$$

Anterior/Posterior (AP) Stability Index: Represents the variance of foot platform displacement in degrees, from level, for motion in the sagittal plane.

$$DIy = \sqrt{\frac{\Sigma (0 - Y)^2}{\text{number of samples}}}$$

Medial/Lateral (M/L) Stability Index: Represents the variance of foot platform displacement in degrees, from level, for motion in the frontal plane.

$$DIx = \sqrt{\frac{\Sigma (0 - X)^2}{\text{number of samples}}}$$

APPENDIX 8: ATTENTIONAL FOCUSING INSTRUCTIONS USED IN EACH EXPERIMENT

Study 1: The influence of attentional focusing strategies during supra-postural tasks on standing balance, movement kinematics and participants' experiences

Instructions adapted from: McNevin and Wulf (2002)

Baseline Instructions: Stand quietly for the duration for the trial

All participants were instructed to "minimize the movements of the sheet for the duration of the trial"

Internal Instructions: "try to minimize the movement of the index finger over ther duration of the trial"

External Instructions: "try to minimize the movement of the sheet over the duration of the trial by focusing your attention on the sheet itself"

Study 2: The effects of attentional focusing strategies on novice dart throwing performance and heart rate

Instructions adapted from: Radlo et al (2002) and direction from Wulf and Prinz (2001).

All participants were instructed to perform as accurately as possible using the instructions they were to be given.

Control Instructions: No other specific instructions were given.

Internal Instructions: "feel the weight of the dart in your hand, think about drawing the dart back to the ear, feel the bend in the elbow, feel the dart as it leaves the finger tips."

External Instructions: "focus on the centre of the dartboard, slowly begin to expand upon perspectives of the dart board, then refocus on to the centre of the dartboard, expanding the centre, making it as large as possible, toss the dart when so focused".

Study 3: The effects of attentional focus during balance at rest and in fatigued states

Instructions adapted from attentional focus and balance studies (e.g., Wulf, Hoss and Prinz, 1998; Wulf, McNevin, & Shea, 2001).

The instructions used were the same for both Experiment 1(Generalised Fatigue) and Experiment 2 (Localised Fatigue).

All participants were instructed to balance as well as they could for the duration of the trial.

Baseline Instructions: participants were given no other specific focusing instructions other than to balance as well as they could for the duration of the trial.

Internal Instructions: "keep your foot level and stable for the duration of the trial".

External Instructions: "keep the markers on the platform level for the duration of the trial".

Study 4: Effects of attentional focusing strategies during practice and performance of a motor skill

The instructions used were the same for both Experiment 1(Single practice strategy) and Experiment 2 (Combined practice strategy). The instructions were those that were found to be effective in Study 2.

Internal Instructions: ""feel the weight of the dart in your hand, think about drawing the dart back to the ear, feel the bend in the elbow, feel the dart as it leaves the finger tips."

External Instructions: "focus on the centre of the dartboard, slowly begin to expand upon perspectives of the dart board, then refocus on to the centre of the dartboard, expanding the centre, making it as large as possible, toss the dart when so focused."