IDENTIFYING THE VISUAL INFORMATION AND PROCESSES UNDERLYING EXPERT JUDGEMENTS OF DECEPTIVE INTENT

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By

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Abstract

The aims of the current research programme were, first, to examine expertise effects with regard to anticipation skill and the perception of deceptive movement, and, second, to examine how knowledge of the probability of behavioural events influences anticipation performance and visual search behaviour. In addition, this thesis sought to test the predictions of attentional control theory (ACT) in examining how anxiety affects the influence of top-down probability information on anticipation skill and visual search behaviour. In Chapter 3, skill-based differences in anticipation and decision making were examined using judgement accuracy and confidence ratings. High-skilled soccer players demonstrated superior anticipatory performance and were less susceptible to deception compared with low-skilled players. In Chapters 4 and 5 Posner's spatial cueing paradigm was adapted to examine the influence of top-down probability information on anticipation skill and visual search behaviour. High-skilled participants were found to be more accurate and demonstrate more efficient visual search behaviour compared to low-skilled participants. However, findings demonstrated that both groups benefited from the provision of probability information, and performance was moderated by the degree of certainty conveyed through the probability information. In Chapter 6, the same anticipation task and process tracing measures were used to examine the effects of heightened anxiety on the processing of probability and visual information. The findings supported the predictions of ACT, as the influence of top-down information was suppressed during high-pressure conditions, owing to an increased influence of the stimulus-driven attentional control system. The series of studies in this thesis are the first to explore the influence of top-down probability information on anticipation performance and the perception of deception. Study 4 is also the first to test the predictions of ACT regarding the processing of (top-down) explicit knowledge and (bottom-up) visual information under pressure during a simulated soccer anticipation task. The use of probability information through performance analysis feedback plays a prominent role across a number of sports, and the present findings highlight the importance of understanding the costs and benefits associated with such information. It is concluded that future perceptual training interventions should incorporate context-specific information that mimics the real-life demands of competitive sport, and should be directed towards enhancing players' ability to detect deception rather than training players to become attuned to non-deceptive movement.

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Chapter 1: Introduction

1.1 Study Context

Athletes and their coaches are increasingly placing greater importance on the development of perceptual skills and the incorporation of performance analysis techniques in order to enhance performance. In recent years, perceptual and cognitive processes have been identified as being one of the crucial adaptations that support expert sports performance. During the acquisition of skill, large improvements in decision making and anticipation skill are evident (Mann, Williams, Ward & Janelle, 2007). These adaptations are vital for expert sports performance, as the speed of play often exceeds the time constraints imposed by the player's information processing capacity (Williams & Ford, 2008).

High skilled soccer players are considered to 'read the game' more effectively than low-skilled players, due to advance pick-up of information from cues available prior to an attacker trying to pass a defender with the ball. In fast ball sports like soccer, processing decisions have to be made within short time windows, in environments where players may deliberately attempt to deceive their opponent. The use of the 'step-over' in soccer has become an effective attacking weapon for soccer players around the world, and is one of the most common skills seen on the soccer pitch. Cristiano Ronaldo uses the step-over to devastating effect, demonstrating how skilfully executed deceptive manoeuvres are remarkably difficult to defend against.

Performers are continually looking for ways to improve their performance, and in today's highly competitive sporting world even the smallest improvement margins can be the difference between winning and losing. Performance analysis provides performers and coaches with objective information that helps them understand performance. Over the years, performance analysis has progressed with advancements in technology. Due to these advancements the use of performance analysis has become ever more prevalent within sport and performers have a growing interest in advance information in order to enhance their perceptual ability. However, researchers and sport practitioners currently have very little understanding of the costs and benefits associated with using such information.

Expert sport performance is often accompanied by significant psychological pressure. These conditions place extremely high demands on athletes and their ability to cope. Some of the most memorable moments in sport have been those that have resulted in unexpected failure. The impact of anxiety on sporting performance has been the subject of a great amount of research. Findings have generally revealed that high levels of anxiety can impair cognitive performance. However, in recent years, researchers have sought to test the predictions of ACT, which suggest that anxiety impairs the efficiency of attentional control and has less of an impact on performance effectiveness. Researchers have yet to test the predictions of ACT during simulated anticipation tasks either with respect to performance or visual search.

1.2 Structure of the Thesis

This introduction is followed by a critical review of the literature relevant to this thesis, drawing on research in sport and cognitive psychology. The literature review introduces the theoretical concepts and offers critical appraisal of the empirical research that underpins the current line of investigation. The review covers topics such as perceptual-cognitive expertise, control of visual attention, and anxiety and cognitive performance.

Chapters 3 to 6 include the four studies that comprise the programme of research. These chapters are presented as ‘stand alone papers’ and examine specific hypotheses that contribute to the existing literature and assist in developing areas that currently lack depth. Specifically, Study 1 examines high-skilled and low-skilled soccer players' anticipatory performance and susceptibility to deception, in order to enhance our understanding of expertise effects with regard to anticipation skill and, in particular, the perception of deceptive movement. Initial steps in the investigation of how ‘top-down’ and ‘bottom-up’ processes interact in a time-constrained perceptual task begins in Chapter 4, which introduces a novel approach for examining how ‘top-down’ probability information influences anticipatory performance, again in relation to expertise effects. Expanding further on this work, the study in Chapter 5 aims to further understanding of the costs and benefits associated with receiving ‘top-down’ probability information on anticipation skill and to examine associated attentional processes indexed by visual search behaviour. The final experimental chapter, Chapter 6, examines how anxiety impacts anticipation skill and the perception of deception, and associated attentional processes indexed by visual search behaviour and the interaction between 'top-down' and 'bottom-up' processes. Anxiety’s effect on attentional control is examined within the theoretical framework of attentional control theory (Eysenck, Derakshan, Santos, & Calvo, 2007).

Although interrelated, each chapter addresses an explicit research question, and therefore, were written as independent, stand-alone studies. Due to the core themes that run through each individual chapter; there is inevitably some repetition of literature. Finally, Chapter 7 provides a general discussion that summarises the key findings from the experimental work presented. Theoretical and practical implications are considered, potential limitations discussed and future research directions proposed.

Chapter 2: Literature Review

2.1 Introduction

Experts are continually pushing the boundaries of human performance. Whilst others watch in awe, these exceptional individuals consistently demonstrate outstanding achievements across a variety of domains such as arts, medicine, music and sports. Expertise has been defined as the ability of an individual to consistently demonstrate superior levels of proficiency within a specific domain (Starkes, 1993). Society's fascination with, and admiration of, expert performance has led many researchers into examining the mechanisms underpinning superior performance (Starkes & Ericsson, 2003). Hence, an understanding of the factors that affect individuals' decisions in time-constrained situations is important. For example, the effects of expertise in domains such as chess playing (Chase & Simon, 1973), military operations (Williams, Ford, Eccles, & Ward, 2010) and aviation (e.g., Bellenkes, Wickens, & Kramer, 1997) have attracted considerable research attention; and many sport tasks lend themselves well to such scrutiny. Accordingly, a range of tasks that represent, if not replicate, real-world demands have been devised not only to highlight expert-novice differences, but also to assist with the development of training programmes and talent identification protocols (Ericsson & Ward, 2007; Williams, Ericsson, Ward, & Eccles, 2008).

Although superior sporting performance is readily apparent, the perceptual and cognitive mechanisms that distinguish expert from non-expert performers are less so (Mann, et al., 2007). The ability to quickly and accurately anticipate opponents' future actions and to consequently make optimal decisions is a distinguishing feature of expertise in interceptive sports, so much so that these particular components of performance are more likely to differentiate skill levels than are physiological factors (Williams & Reilly, 2000). Researchers examining differences between experts and non-experts in the perceptual-cognitive aspects of sport have typically revealed no differences in performers' *hardware* such as simple reaction time and visual acuity; however, key differences have been found between experts' and non-experts' *software*, suggesting that information processing strategies can be influenced through training (Starkes & Deakin, 1984).

Perceptual-cognitive skills, such as anticipation and decision-making, have been identified as one of the significant areas of improvement during skill acquisition (Williams & Ford, 2008). This has been acknowledged across a wide variety of domains such as law enforcement (Ward, Suss, Eccles, Williams, & Harris, 2011), driving (McKenna & Horswill, 1999) and sport (for reviews, see Hodges, Huys, & Starkes, 2007; Mann et al., 2007). The development of perceptual skills has become essential for expert performance in many sports, as the speed of play often exceeds the time constraints imposed by the player's information processing capacity (Williams & Ford, 2008). These perceptual-cognitive skills include the ability to recognise and recall complex patterns (Smeeton, Ward, & Williams, 2004) and the ability to anticipate events effectively (Huys, Cañal-Bruland, Hagemann, Beek, Smeeton, & Williams, 2009). The awareness that skilled anticipation precedes an appropriate action has led researchers to examine its role in sport performance.

The present chapter aims to enable the reader to familiarise themselves with the body of knowledge that underpins the present programme of study. The main body of this review offers critical appraisal of the empirical research that underpins the current line of investigation. This aims to provide the reader with the necessary grounding with which to appraise the concepts examined in each of the four research chapters. The individual research chapters contain their own brief introduction and a rationale in relation to its specific area of investigation.

2.2 Perceptual-Cognitive Expertise

Perceptual-cognitive skill is the ability to identify and acquire environmental information for integration with current knowledge in order for appropriate responses to be selected and executed (Marteniuk, 1976). In fast-ball sports, such as soccer, cricket and tennis, the time available for perceiving, and then reacting to, a visual stimulus is severely limited by the inherent processing constraints and latencies associated with reaction and movement times. Highly accurate decisions have to be made within milliseconds, in environments where opponents typically seek to restrict the time and space available to make these decisions (Müller, Abernethy & Farrow, 2006). The development of perceptual-cognitive skills is considered to be one of the most significant adaptations in an elite performer’s repertoire. These adaptations assist performers in predicting what is likely to happen prior to an event occurring and selecting an appropriate action in a given situation (Williams, Davids, & Williams, 1999).

Wickens (1992) suggested that there are three factors that are responsible for experts' superior anticipation and decision-making performance relative to their non-expert counterparts. First, experts are able to select the most information-rich cues from the visual display due to a more efficient processing system. Second, experts possess a greater knowledge base of situational probabilities and are able to make more accurate predictions of the events most likely to occur. Last, experts exhibit more efficient coupling between cue perception, the formation of probabilities and decision making response outcomes than non-experts. It is therefore essential that, for elite-level sports performance, athletes must develop their perceptual skills through focusing their attention on the most appropriate cues at the correct time, under severe time constraints and high levels of pressure (Williams & Ford, 2008).

2.2.1 Advance cue utilisation. Athletes consistently perform sporting activities under a heightened load or strain, which causes physiological responses to compensate for the increased demands of the performance environment. Adaptations do not only occur within physiological systems but there are also changes in brain activity that complement processing speeds, recognition and use of cues (Hill & Schneider, 2006). The ability to discriminate between subtle differences in visual stimuli is considered to be a fundamental characteristic of attaining expertise in numerous domains (Mann, Abernethy & Farrow, 2010). Advance cue utilisation refers to a player's ability to make accurate predictions based on information available from an opponent's posture and bodily orientation; the word 'advance' refers to expert performers' ability use of visual information prior to completion of the respective action (Jackson et al., 2006). The ability to use advance visual information to anticipate an opponent's actions may be applied to several sports where an 'action' and a 'reaction' occur between opposing players. The faster and more accurate anticipation and decision-making of expert performers has been experimentally confirmed in a variety of sports, including badminton (Abernethy & Russell, 1987), squash (Abernethy, 1990), cricket (Müller & Abernethy, 2006), tennis (Crognier & Féry, 2005), and soccer (Williams & Davids, 2000).

Mann et al. (2007) conducted a meta-analysis to quantify the differences in perceptual-cognitive skill between expert and non-expert sports performers. From 42 studies, the results indicated that experts are better at selecting and utilising perceptual cues. This occurs due to experts' extensive experience and knowledge that enables them to extract task-specific information from advance visual cues that is utilised to predict the outcome of a forthcoming event. As a result, expertise helps to reduce reaction time (Helsen & Starkes, 1999) and increase performance accuracy. Systematic differences in visual search behaviours were also found, with experts using fewer fixations of longer duration, indicating that their superior anticipation ability is underpinned by more efficient visual search strategies. The visual search strategies of expert and novice players vary across sports; therefore, it is impossible to define one effective visual search strategy that is applicable to all sports.

It is now well-established that expert sport performers are superior to their less-skilled counterparts in anticipating opponents' future actions (Mann et al., 2007). Researchers have now turned their focus to examining the spatiotemporal properties of advance cue utilisation to understand where and when the performers extract information relevant to successful anticipation (Mori & Shimada, 2013). An array of techniques has been employed to examine how anticipation contributes to expert interception, with much of the research focusing on understanding the spatial and temporal parameters associated with the expert advantage through video simulation. The temporal occlusion paradigm has been successfully employed to establish the critical time points at which a perceiver picks up pertinent kinematic information from an opponent's movements. Temporal occlusion studies have reported that expert performers extract information for anticipation of a forthcoming event; such as prediction of tennis serve direction (Goulet, Bard, & Fluery, 1989) or type of delivery in cricket (Muller, Abernethy, Reece, Rose, Eid, McBean, Hart & Abreu, 2009), more effectively than less-skilled performers. Studies in which the temporal occlusion paradigm has been used typically demonstrate that the expert advantage is magnified at early occlusion points - i.e., when visual information is most limited (Müller, et al., 2006). In cricket, intermediate and novice performers appear to rely on information from the ball's flight to make accurate judgements, resulting in a drastic improvement in performance when veridical information becomes available (Müller et al., 2006).

Abernethy, Gill, Parks, and Packer (2001) also demonstrated that skilled squash players were able to utilise information 620 ms before racquet-ball contact in their anticipatory shot selections.

In the spatial occlusion paradigm, the observers are presented with an opponent's action, as in the temporal occlusion paradigm, but parts of the viewed image are masked from view; the premise is that judgement accuracy will be significantly reduced when the masked region contains information-rich anticipatory cues used by the observer. A number of studies have employed the spatial occlusion paradigm to identify characteristic locations used by expert performers, across a range of sports including badminton (Abernethy & Russell, 1987), cricket (Müller, et al., 2006), fencing (Hagemann, Schorer, Cañal-Bruland, Lotz, & Strauss, 2010), tennis (Shim, Carlton, & Kwon, 2006), and soccer (Williams & Davids, 1998). For example, Müller et al. (2006) discovered that expert batsmen were superior in anticipating ball type before release, specifically from motion of the bowling arm and hand. Less-skilled players were consistently reliant upon ball flight information, thus unable to distinguish early kinematic information.

Johansson (1973) argued that the kinematic motion of an action is more useful than lower level features (e.g., gaze direction, faces) in specifying movement to an observer. From this it has been suggested that expert performers in sport use the relative motion between joints to guide anticipatory responses rather than specific information cues (Abernethy et al., 2001). Hayes, Hodges, Scott, Horn, and Williams (2007) argued that if relative biological motion is an important source of information for expert perception, then anticipatory performance when viewing videos of an oncoming opponent in point-light format should be comparable to that when full colour videos are viewed. To display only movement kinematics, Johansson (1973) introduced a point-light display by placing white dots on each major joint of the human body on a black background. This design allows for human movement to be analysed without interference from pictorial information (Johansson, 1973). Recently, point-light presentations of an opponent's motion have gained popularity in sport anticipation research. The main benefit for using point-light presentation in sport anticipation research is that it prevents the observer from viewing any contour and surface information, keeping the kinematic properties intact.

Several researchers who have used a point-light display have demonstrated that observers are remarkably proficient at interpreting such displays and are able, for example, to accurately judge the gender of an actor (Kozlowski & Cutting 1977; Runeson & Frykholm 1981; Fox & McDaniel 1982). Researchers have shown that point-light presentations result in a marginal reduction in anticipatory accuracy compared with normal video footage, whilst maintaining similar expert-novice differences (Abernethy et al., 2001; Abernethy, Zawi, & Jackson, 2008; Shim, et al., 2005). For example, Abernethy and Zawi (2007) provided clear evidence that experts outperform novice performers in prediction of stroke direction in badminton, regardless of whether the display was film or point-light. Studies that have used point-light stimuli offer strong evidence to suggest that the information extracted by expert performers as anticipatory cues is largely kinematic (Abernethy & Zawi, 2007).

One of the key concerns in anticipation skill research is the degree to which stimuli and their associated responses are related to each other, which is known as stimulus-response compatibility. In recent years researchers have become aware of the need to develop more representative experimental tasks. The fidelity of the experimental design has been shown to influence the perceptual behaviours employed (Dicks, Button & Davids, 2010b). Dicks et al. demonstrated that experienced soccer goalkeepers used more appropriate visual search patterns during a more representative task compared to the less representative task. Roca, Williams and Ford (2014) compared the cognitive thought processes of skilled soccer players when responding to film-based simulations in two different experimental conditions. Participants either remained stationary in a seated position or were allowed to move in response to real life-size film simulations. These findings highlight the need to design representative tasks that recreate the characteristics of the actual performance domain in order to make conclusions about the processes that underpin expert performance.

2.2.2 Deception. Despite a clear relation between anticipation and deception, it has only been in recent years that researchers in sport have conducted systematic research on deception in sporting domains. Deception is understood within the broader context of inferring intentions in the action of others and is defined as providing information that misleads an observer into making an incorrect judgement (Jackson et al., 2006). Anecdotal reports of deliberate deception are common, such as faking to shoot in one direction while actually aiming for the other corner of the goal in soccer. A rich source of information lies in the ways that people move their bodies. While there is some research in the domain of detecting deceit and deception in lying, there are only a few studies that assess the role of nonverbal cues in identifying liars (Frank & Ekman, 1997), and even fewer studies on the impact of detecting deceptive intent in bodily actions. Runeson and Frykholm (1981) were the first to demonstrate that observers are able to distinguish between deceptive and non-deceptive intentions from another person’s movements. In their study they showed participants point-light stimuli of people lifting a box that was also marked with point-lights. They found that information provided by point-light displays (i.e., the joint kinematics) was not only sufficient for participants to perceive the relative weight of the box, but also for recognising whether the untrained actor intended to mislead the observer about the true weight of the box.

More recently, researchers have started to examine deception in more movement-related domains, such as where deceptive movements are employed to actively mislead opponents in sport (Cañal-Bruland & Schmidt, 2009; Dicks, Button & Davids, 2010a; Jackson, Warren & Abernethy, 2006; Kunde, Skirde, & Weigelt, 2011; Rowe et al., 2009; Sebanz & Shiffrar, 2009; Smeeton & Williams, 2012). In the first study to investigate the susceptibility of deception on sport performers, Jackson et al. (2006) found that expert rugby players were better than novice players at detecting deceptive movement. This study revealed that expert rugby players were not susceptible to deceptive movement as they were better able to detect and respond appropriately to advance visual information. Jackson et al. suggested that expert players are likely to encounter deceptive actions more frequently, and as a consequence their greater visual experience allows them to become more proficient in detecting the kinematic information associated with deception.

Other studies have found that expert players are also susceptible to deceptive movement. Rowe et al. (2009) showed that expert tennis players were less accurate in anticipating ball directions from deceptive ground strokes compared to genuine ones, although players still outperformed novices. Dicks et al. (2010a) examined experienced association soccer goalkeepers ability to intercept penalty kicks taken with deceptive and non-deceptive kicking actions. They also found that goalkeepers' penalty saving performance deteriorated when they were unable to watch the penalty kicker's full approach towards the ball, and this deterioration occurred to a larger degree for kicks containing deceptive movement.

Smeeton and Williams (2012) conducted a study that aimed to examine whether exaggeration within an action to be anticipated is responsible for the mode of functioning deception is perceived in. In line with the findings from Jackson et al, it was proposed that exaggerated movements would alter the perceptual mode of functioning from an invariant to a cue-based mode. Skilled and less skilled soccer players viewed penalty kicks involving deceptive, non-deceptive and non-deceptive-exaggerated movement. The judgement accuracy results indicated that high-skilled players were more accurate than less skilled players. Also, judgement accuracy was higher for non deceptive-exaggerated kicks compared to non-deceptive kicks, and both of which recorded a greater judgement accuracy than deceptive kicks. Findings indicated that deceptive kicks were anticipated in a cue-based mode. Confidence ratings did not differ across conditions, providing evidence of over-confidence on deception trials, which is thought to indicate an overestimation of the validity of the cue. The evidence for exaggeration being the reason for anticipation in a cue-based mode was dependent on the temporal occlusion condition and skill level. Evidence was found for exaggeration occurring up until -80 ms being responsible for the cue-based mode of functioning in the less skilled group. Beyond this time point less skilled players used a cue-based mode regardless of the kick type viewed.

There is some research to suggest that expertise assists an athlete in consciously detecting deceptive actions of an opponent (e.g., Cañal-Bruland & Schmidt, 2009; Jackson, et al., 2006; Sebanz & Shiffrar, 2009). However, there is currently very little understanding of why deception misleads an observer, and more specifically which cognitive processes are responsible for the effects of deception. Kunde et al. (2011) recently conducted a series of experiments aimed at identifying the cognitive processes that underlie the effects of deception, in order to better understand when to use deception and how to prevent the detrimental impact for observers. Across the series of experiments participants were required to judge whether a basketball player would pass the ball to the left or right, with and without head feints. Their results demonstrated that incongruence of head orientation and pass direction altered the perceptual processing indicated through a delayed response time during incongruent trials, but did not affect motor-related processes. With regard to practical implications, they also demonstrated that non-specific verbal instructions to ignore fakes did not prevent the detrimental impact of fakes on performance. This supports other evidence, which suggests that players cannot effectively prepare themselves for an upcoming incongruent event in spatial compatibility tasks (Wühr & Kunde, 2008).

Brault and colleagues recently conducted two studies combining biomechanical analysis and anticipation tasks related to rugby players' sidesteps (Brault, Bideau, Craig, & Kulpa, 2010; Brault, Bideau, Kulpa, & Craig, 2012). Brault et al., (2010) analysed the biomechanical differences between a deceptive sidestep in rugby and a non-deceptive movement in an attempt to understand how the unfolding action conveys deception. Their biomechanical analysis revealed that deception is conveyed by exaggerating the movement of certain parts of the body (out-foot placement, head and upper trunk yaw) that are not mechanically related to the final running direction. They also demonstrated that movements of parts of the body that are related to the final running direction (i.e., Centre of Mass displacement and lower trunk yaw) need to be minimised to ensure the player can change the direction of the movement. In another experiment, Brault et al. (2012) found that the expert players were significantly slower than the novices in initiating interceptive motion, but were more accurate. The results from their anticipation tasks suggest that expert rugby players were also susceptible to deception, as well as novice players (cf. Jackson et al., 2006). Furthermore, the findings indicated that experts were more attuned to honest signals (e.g., COM displacement) that specify future running direction whilst novices were more attuned to deceptive signals (e.g., head yaw, upper trunk yaw) that do not specify future running direction. Lastly, they revealed that the tau of the COM (honest signal) explains superior performance in the expert group, while the tau of the upper trunk yaw (deceptive signal) explains poorer performance in the novice group. In sum, Brault et al. (2010, 2012) demonstrate a close relationship between the mechanics of deceptive motion and the spatiotemporal features of expert anticipation from deception.

From this research it is evident that skilled players' superior ability to anticipate movement from advance cues extends to the detection of advance deceptive movement. However, further investigation is required to assess the processes underlying incorrect judgements, the precise nature of differences between skilled and less-skilled performers, and the impact that anxiety has on the detection of deceptive movement.

2.2.3 Visual search behaviours. It is widely accepted that the superior ability of experts to utilise advance visual information cues and to recognise patterns of play is underpinned by effective visual search strategies. Experts must possess the ability to extract information from the most information-rich sources, evaluate that information and respond accurately (Mann et al., 2007). Researchers have revealed systematic differences between experts and non-experts on key visual components such as the number of fixations, fixation duration and the proportion of time spent fixating on various areas of the display (e.g., Harré, Bossomaier, & Snyder, 2012; Savelsbergh, Williams, van der Kamp, & Ward, 2002; Vaeyens, Lenoir, Williams, Mazyn, & Philipparts, 2007; Williams & Davids, 1998).

Williams and Ford (2008) claimed that skilled athletes use more efficient visual search strategies than their less-skilled counterparts. Some studies have suggested that an efficient visual search strategy is typically underpinned by lower search rates (fewer fixations of longer duration), indicating that skilled athletes are able to use their knowledge base to select information-rich areas of the display. A higher search rate (increased fixations of shorter duration) typically indicates a less-efficient search strategy (Moran, Byrne, & McGlade, 2002). A common prediction across visual search studies is that high-skilled performers should present a more efficient search strategy compared to their low-skilled counterparts. Theoretically, this prediction is based on high-skilled performers utilising their rich knowledge base to pick out the most salient features of the display (Wilson, 2008). However, there are inconsistencies within the literature regarding this prediction.

A number of studies have reported that expert athletes make significantly fewer fixations of longer duration than less-skilled athletes (Ripoll, 1991; Savelsbergh et al., 2002; Vickers, 1996; Williams & Davids, 1998), whereas other studies found that experts made more fixations of shorter duration compared to less-skilled performers (Helsen & Pauwels, 1993; Vaeyens, et al., 2007; Williams, Burswitz, Davids, & Williams, 1994). An explanation for these inconsistencies is that athletes' search rates may be context specific (Williams et al., 1999). Savelsbergh et al. (2002) conducted a study to determine key differences in visual search behaviour and anticipatory performance between expert and novice soccer goalkeepers. In keeping with previous research, the study predicted that expert goalkeepers would demonstrate superior anticipation and more effective visual search strategies. The results supported this prediction and demonstrated that expert goalkeepers used a more efficient search strategy, using a search strategy involving fewer fixations of longer duration to fewer areas of the display than their novice counterparts. Differences in visual search behaviours have been found in a large number of studies including soccer (Helsen &

Starkes, 1999), boxing (Ripoll, Kerlirzin, Stein, & Reine, 1995), basketball (Vickers, 1996), karate (Williams & Elliot, 1999) and squash (Abernethy, 1990).

Williams and colleagues (Williams et al., 1994; Williams & Davids, 1998) reported differences in visual search behaviours during 11 vs. 11, 3 vs. 3 and 1 vs. 1 attacking soccer simulations. During the 11 vs. 11 simulations skilled players demonstrated an extensive search of the information sources within the display, using more fixations of shorter duration compared to their less-skilled counterparts who generally maintained fixation on the ball or player in possession. Whilst viewing the 3 vs. 3 simulations, players made fewer fixations of longer duration, with fixations typically focusing on the ball or player in possession. Lastly, in the 1 vs. 1 simulation skilled players made a greater number of fixations to the hip, foot and ball, compared to the less-skilled players whose main fixation was on the ball. These findings demonstrate that visual search behaviours alter as a function of skill level, with different search strategies and information sources becoming more pertinent in relation to the type of task. In comparison to the 11 vs. 11 simulations, players used fewer fixations of longer duration in the 1 vs. 1 simulations, as players only need to extract information from relatively few areas of interest (i.e., one opponent's postural orientation and movements).

The control of visual search is a critical determinant of accuracy in the execution of visually guided tasks (Williams, Singer & Frehlich, 2002). Recent research has demonstrated that improved motor performance can be attained when individuals are trained to employ more efficient visual search behaviours (Vine, Moore, & Wilson, 2011). In addition to this, gaze training interventions have also shown to facilitate motor performance that is robust against the detrimental effects of anxiety (Vine & Wilson, 2010). However, the specific mechanisms that exert these beneficial effects have yet to be established (Vine et al., 2011).

2.2.4 Situational probabilities. It is important to recognise that decision-making is often a contextualised process that is not only influenced by the postural cues of opponents, but is also likely to be influenced by prior knowledge and expectations. Indeed, researchers have highlighted skill-based differences in the ability to extract task-specific contextual information from an event as it unfolds. There is also evidence that experts formulate more accurate expectations than non-experts of the events most likely to occur in a given situation (Alain & Proteau, 1977; Alain, Sarrazin, & Lacombe, 1986; Alain & Sarrazin, 1990).

The use of probabilistic information to guide decision-making in sport was initially examined by Alain and Proteau (1980) using a choice reaction time paradigm. Alain and colleagues have consistently demonstrated that skilled racquet players use task-specific experience to assign probabilities to those events likely to occur with any given situation (Alain & Proteau, 1977; Alain, et al., 1986; Alain & Sarrazin, 1990). Paull and Glencross (1997) also found that expert and novice baseball batters' anticipatory performance improved when objective variables (e.g., ball and strike information) were added to a simulated batting task to provide strategic information. From these findings it was concluded that situational probability information plays such a key role during the task of baseball batting that all players use this information effectively (Paull & Glencross, 1997).

Recent research has attempted to develop more representative methods using sport-specific stimuli (e.g., Crogneir & Féry, 2005; Farrow & Reid, 2012; McRobert, Williams, Ward, & Eccles, 2011). McRobert et al. (2011) developed a novel paradigm to investigate whether cricket batsmen could develop accurate expectations of likely bowler 'deliveries'. In one condition, the batsmen viewed a total of 36 random deliveries bowled by ten different bowlers, whereas in a second condition batsmen were presented with an entire over from each of six bowlers who had delivered only one ball each in the first condition. The performance of the batsmen on the final delivery from each six-ball over in the second condition was compared with that of the same delivery when presented as an independent trial in the first condition. Batsmen improved their judgement accuracy in the second condition, with the addition of contextual information compared to the random viewing condition. When additional information was available in the high-context condition there was a reduction in the mean fixation duration, and batsmen also altered their gaze behaviours to spend more time fixating on more central (head-shoulder region) than peripheral (ball-hand region) areas. There was also a significant group main effect for the mean number of fixation locations, with skilled batters viewing significantly more locations compared to their less-skilled counterparts. This finding contradicts previous research that has reported fewer fixations of longer duration by skilled performers in tasks that focus solely on the opponent’s postural orientation and movements (Ripoll, 1991; Savelsbergh et al., 2002; Vickers, 1996; Williams & Davids, 1998).

In summary, there is currently limited evidence concerning the contribution of top-down probability information to anticipation skill. Findings from studies that have examined the effect of contextual information on anticipatory performance have indicated that situational probabilities are a key component of the level of anticipation skill displayed by skilled performers. Further research is required to understand how this information interacts with visual search strategies and whether the same effects occur under high levels of anxiety.

2.3 Control of Visual Attention

Understanding the factors that impact upon the decisions of individuals when quick and accurate responses are required is important in many domains such as fire-fighting, policing, medicine, and sport. In sport, individuals may rely on prior knowledge to formulate expectations that facilitate processing of information and allow performers to make decisions about uncertain events under severe time constraints. While researchers have begun to examine the influence of contextual information, there is currently no research in sport that specifically examines how top-down probability information interacts with perceptual and cognitive processes, particularly during anticipatory tasks.

The extent to which we have control over our visual attention is a key question in vision research. There is growing evidence suggesting that the efficient allocation of visual attention involves a delicate interplay between the stimulus itself and the expectations/behavioural goals of the observer (Folk, Leber, & Egeth, 2002). Although salient stimuli have been shown to attract attention involuntarily (Theeuwes, 1992, 1994), there is also evidence indicating that attentional capture is modulated by top-down information (Dror, Péron, Hind, & Charlton, 2005).

2.3.1 Attentional control systems. Yantis (1998) distinguished between two types of attentional control systems; goal-driven attention and stimulus-driven attention (see also Posner & Peterson, 1990, Corbetta & Shulman, 2002). The stimulus-driven attentional system works in a bottom-up way and is activated when attention is captured by a salient stimulus. Stimulus-driven attention is both faster and more potent than goal-driven attentional control (Yantis, 1998). On the other hand goal-driven attention (top-down) is active and requires voluntary orienting of attention to a certain stimulus or point that is relevant to the task at hand, (Yantis, 1998). Stimulus-driven attentional processing is more automatic as attention is captured immediately by a certain stimulus (Yantis, 1998). This system is activated when relevant sensory events are detected especially if they are salient or threatening. These two networks constantly interact with each other (Corbetta, Patel & Shulman, 2008 for a review).

There is a debate in the literature about the involvement of top-down influences in perception of human motion, where top-down means goal-driven processing. A top-down component occurs when the processing of incoming bottom-up information is mediated by a variety of factors, such as prior experience and knowledge, as well as the person's expectations and emotional state (Dror, et al., 2005). Top-down is a term that encompasses a very wide range of phenomena, such as expectation, hope, context, knowledge, emotional state, and mind set. Researchers have revealed that top-down processing can facilitate more rapid processing of information (e.g., Dror & Kosslyn, 1998). It can also help to interpret ambiguous information or fill in missing information (Warren, 1970). However, there is evidence indicating that top-down influences can be so pronounced that they have the ability override the 'objective' bottom-up information (e.g., Darley & Gross, 1983). Thus, top-down components can contaminate objectivity, leading to biased judgements and more errors (Dror, Charlton & Péron, 2006). For example, one of the main contributors to judgement mistakes in identification within the Federal Bureau of Investigation is the 'mind set' of the expert (Stacey, 2004).

Dror et al., (2005) examined contextual top-down effects in a student population. It was found that participants cued with emotionally charged contextual information, such as explicitly disturbing crime scene photos and emotional background stories, were more likely to indicate a match between ambiguous fingerprints than uncued control participants. The results demonstrated that participants' judgements were affected by the top-down manipulations (e.g., emotional state, prior knowledge), resulting in an increased likelihood to match fingerprints. However, this increased likelihood of making matched judgements was limited to ambiguous fingerprints. The top-down manipulations were unable to contradict clear non-matching fingerprints. These findings suggest that such top-down information was able to bias how gaps are filled, but did not have the power to override clear bottom-up information.

In the sport domain, Jones, Paull and Erskine (2002) investigated the impact of prior knowledge on the decisions of English soccer referees. Referees were randomly assigned to either an experimental or control group and were presented with the same 50 video clips of incidents from matches, from which they were required to indicate what action they would take. The experimental group were informed that one of the teams had a reputation for aggressive play. The results revealed that the experimental group awarded significantly more red and yellow cards against the ‘aggressive’ team suggesting that top-down information in the form of prior knowledge impacted the referees’ judgements.

Top-down information can also be presented through spatial cues. A number of studies have demonstrated that people are sensitive to consistencies in the location of stimuli. Researchers have shown that when targets appear in the expected location they are detected faster compared to when they appear in the unexpected location (e.g., Chun & Jiang, 1998; Geng & Behrmann, 2005). These studies that have employed the contextual cueing paradigm have provided strong evidence suggesting that implicitly presented spatial probabilities are a key requirement for efficient visual processing. However, only a small number of studies have examined the effects of explicit cues, such as an arrow or a flash (e.g., Posner, Snyder, & Davidson, 1980).

The distinction between top-down and bottom-up processing plays a central role in experimental psychology. Nevertheless, despite the dominance of this attentional control model, it has become increasingly clear that in reality the distinction between top-down and bottom-up processing is not quite so clear-cut (Awh, Belopolsky, & Theeuwes, 2012). Real-world contexts are often dynamic, and it is clear that a combination of bottom-up and top-down information is used to optimise the allocation of visual attention by minimising uncertainty. It is important to note that in the present thesis bottom-up processing refers to the processing of visual information and top-down processing refers to the processing of statistical information.

2.3.2 Spatial cueing paradigm. Posner and colleagues developed a technique for exploring top-down control over attention (Posner 1978, 1980; Posner, et al., 1980). Posner (1980) developed an experimental paradigm in which participants were required to detect the onset of a light in one of several possible locations in the display, while their eyes were fixated on a point in the middle of a screen.

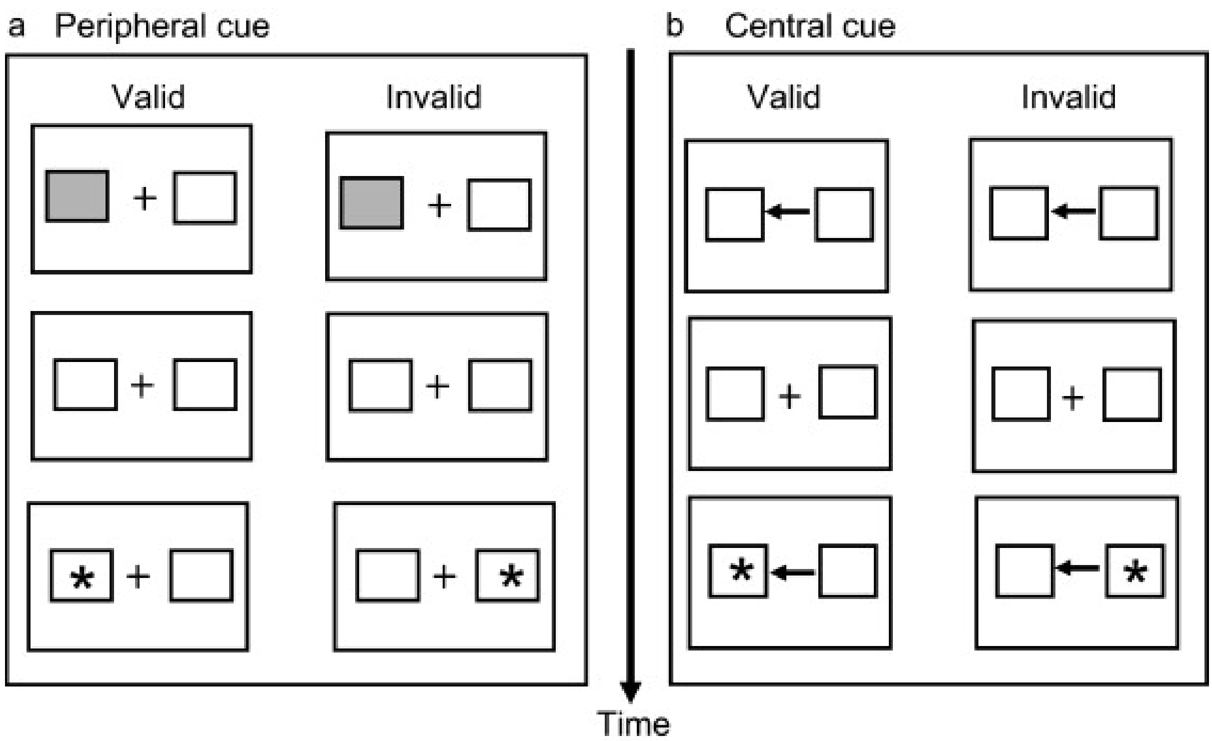

Figure 1.1. A version of the spatial cueing paradigm experiment developed by Posner (1980), with valid and invalid trials. The target in this example is represented by stars presented in the panels on the right and left box.

Targets were preceded by explicit spatial cues, ‘valid’ on a majority of the trials (i.e., indicating the likely location of the target) and ‘invalid’ on a minority of the trials (i.e., the target would appear on the side opposite to the cue). Cues with a predictive validity of either 50% or 80% were used to generate ‘neutral’, ‘valid’, and ‘invalid’ trials. Locations could be indicated by a peripheral cue (i.e., a brief illumination of the box in which the target would appear, Figure 1.1, panel a) or a central cue (i.e., a centrally presented arrow pointing to the left or right side of the display, Figure 1.1, panel b). Some experiments also included a neutral cue, which provided no information about the likely target location. Posner (1980) demonstrated that directing attention to the location of an upcoming target resulted in a faster analysis of perceptual features of the target. Valid trials showed attentional benefits (shorter RTs than on neutral trials), while invalid trials showed attentional costs (longer RTs than on neutral trials). Peripheral cues showed costs and benefits even in contexts where they correctly indicated the target location on a minority of trials.

According to Posner and colleagues, visual attention may be first oriented towards the cued location in an automatic manner. If the target does not appear after the cue, then attention is reoriented towards a central point in the visual display. Attention may then be inhibited from returning towards the original cued location, with the idea that attention should be biased against re-sampling old locations and instead biased in favour of sampling new locations. This bias in favouring new locations was interpreted as a manifestation of ‘inhibition of return’; the tendency of attention to be inhibited to return to a location where it has just been, therefore choosing to sample a novel locations (e.g., Posner & Cohen, 1984; Posner, Rafal, Chaote, & Vaughan, 1985). Posner’s ‘costs and benefits’ (spatial cueing) paradigm can be used as a guide to design experimental sport tasks in order to further understand how 'top-down' and 'bottom-up' processes interact in time-constrained perceptual tasks.

There has been an abundance of research conducted in cognitive psychology that examined the influence of top-down processing, with several having employed Posner’s spatial cueing paradigm. However, in the sport psychology literature there has been minimal research examining the influence of top-down processing on sporting performance. This is despite performance analysis becoming more prevalent within sport, and athletes having a growing interest in advance information sources. It is therefore without question that further research needs to be conducted to enhance our understanding of how top-down information interacts with anticipation skill and the visual processes that are known to underpin expertise.

2.4 Anxiety and Cognitive Performance

Elite-level sport is often characterised by a demand to perform at peak levels under conditions of intense pressure. The ability to control attention and maintain focus is considered to be a key component of success at the top-level (Janelle, 2002). Therefore, it is not surprising that the effect of anxiety on both cognitive and motor performance has received significant research attention as researchers focus on understanding how performers are affected by, and learn to cope, with extreme levels of anxiety (e.g., Eysenck, et al., 2007; Vine, Moore, & Wilson, 2012). Anxiety is typically defined as an aversive emotional state that occurs under threatening conditions (Eysenck & Calvo, 1992). Research has indicated that the negative performance effects of anxiety occur due to cognitive interferences, particularly from disruption to attentional control (Janelle, 2002).

The effects of anxiety on cognitive performance have been subject to considerable research in cognitive psychology. Findings have typically revealed that high levels of anxiety impair cognitive performance (e.g., Derakshan & Eysenck, 2009; Derakshan & Eysenck, 2010; Eysenck & Derakshan, 2011; Berrgren & Derakshan, 2012). Baumeister and Showers (1986) defines choking under pressure as the occurrence of inferior performance under conditions of heightened anxiety, despite incentives for superior performance. Researchers in sport and other domains have sought to further understand the anxiety-performance relationship and to identify how anxiety affects attentional control.

Cognitive psychology literature has presented a number of theories to account for the negative effects of anxiety to attentional control, which have been examined in sporting environments. One of the earliest models related to attentional control and anxiety was developed by Easterbrook (1959). The cue utilisation hypothesis predicts that arousal causes attentional narrowing, facilitating or maintaining performance on central tasks at the expense of performance on peripheral tasks (Janelle, 2002). Janelle, Singer and Williams (1999) provided support for this theory in an auto racing simulation. Drivers were required to navigate a racecourse while identifying the onset of relevant and irrelevant peripheral cues. The results revealed that participants were less able to discriminate between relevant and irrelevant peripheral cues. When anxious, participants visual search behaviours altered with more fixations made to peripheral locations. This study highlighted that the narrowing of peripheral vision required participants to employ compensatory fixations.

In a review of cognitive anxiety, Hanton, Neil and Mellalieu (2008) suggested that anxiety might not always have a negative influence on sports performance. Researchers have sought to develop a theoretical framework to examine the effects of anxiety on performance and provide an explanation for these equivocal findings (Wilson, 2008). The most researched theory designed to explain the relationship between anxiety, performance and attention in sport is processing efficiency theory (PET; Eysenck & Calvo, 1992).

One of the central points of the PET is the distinction between performance effectiveness and processing efficiency (Eysenck & Calvo, 1992). Performance effectiveness is related to the quality of performance and is typically measured in terms of response accuracy. Processing efficiency refers to the relationship between performance effectiveness and the amount of attentional effort or resources invested in the performance. Response time is generally used as an indirect measure of processing efficiency. According to PET, anxiety will impair processing efficiency more than performance effectiveness (Eysenck & Calvo, 1992). Worries caused by anxiety drain the limited attentional resources available in the central executive. The adverse effects of anxiety may be compensated for by a second stream of processes involving increased on-task effort and activities to improve performance; however, this is likely to impair processing efficiency (Eysenck & Calvo, 1992).

PET provides an explanation for why anxiety does not necessarily lead to a decrement in performance. Sport psychology literature has supported many of the predictions of PET across several sporting tasks, including archery (Behan & Wilson, 2008), golf-putting (Wilson, Smith & Holmes, 2007) table tennis (Williams, Vickers, & Rodgrigues, 2002) and racing driving (Wilson, Smith, Chattington, Ford, & Marple-Horvat, 2006).

Eysenck et al., (2007) highlighted several limitations associated with PET. First, PET is vague about the effects of anxiety on the central executive component of working memory. PET predicts that anxiety will impair the processing efficiency of the central executive; however, the central executive is argued to conduct five specific functions (switching attention between tasks, planning subtasks, selective attention and inhibition, updating the working memory, and coding representations in the working memory for time and place of appearance), and PET does not specify which of these is negatively affected by anxiety (Eysenck et al., 2007). In addition, PET does not provide an explanation about why anxious individuals are more distracted by task irrelevant stimuli (e.g., Calvo & Eysenck, 1996) nor does it account for the increased effect when the distracting stimuli are threat-related (e.g., Eysenck & Byrne, 1992; Keogh & French, 2001).

2.4.1 Attentional control theory. Attentional control theory (ACT; Eysenck et al., 2007) is a development and extension of PET. The distinction between performance effectiveness and processing efficiency remains a central tenet in ACT (Eysenck & Calvo, 1992); however, ACT makes more specific predictions about the impact of anxiety on attentional processes. First, ACT predicts that under heightened levels of anxiety there will be an increase in the allocation of attentional resources to the detection of threat-related stimuli. This impairment of attentional control is related to a disruption in the balance between the two attentional systems, which were first outlined by Corbetta and Shulman (2002): the goal-directed and the stimulus-driven attentional systems. The goal-directed attentional system represents top-down attentional control, which is shaped by an individual's current goals, knowledge and expectations; whereas the stimulus-driven attentional system represents bottom-up attentional control, and is influenced by salient environmental stimuli (Derakshan & Eysenck, 2009). Anxiety is associated with an increased influence of the stimulus-driven attentional system and a decrease of the goal-directed attentional system, due to the impairment of the inhibition and shifting functions of the central executive (Miyake, Friedman, Emerson, Witzki, Howerter, & Wager, 2000). PET suggested that worries caused by anxiety affected processing efficiency but it was not clear as to which processes of the central executive were affected.

Miyake et al. (2000) identified three key central executive functions; the inhibition function (the capacity to resist distraction or prepotent responses), the shifting function (the capacity to shift attention to maintain focus on task relevant stimuli) and updating (information updating and monitoring). Miyake et al. (2000) identified the inhibition and shifting functions as those most affected by anxiety during cognitive performance. The shifting and inhibition functions both involve attentional control. The shifting function involves positive attentional control that shifts attention between tasks, and the inhibition function involves negative attentional control inhibiting distracting stimuli or prepotent responses from interfering with the task (Miyake et al., 2000; Eysenck, et al., 2007, Derakshan & Eysenck, 2009). When faced with anxiety or a threatening situation, attentional resources are allocated to detection of a specific threat. As a result attention is more likely to be diverted away from task-relevant stimuli (top-down attentional control) to the more threatening, task-irrelevant stimuli (stimulus-driven attentional control). The updating function is believed to be less affected by anxiety and research has produced inconsistent findings (e.g., Dutke & Stöber, 2001; Eysenck et al., 2007).

The predictions of ACT have recently received empirical tests in the cognitive psychology literature. ACT’s first main prediction, and the one that has been the subject of most empirical research to date, is that anxiety should disrupt the ability to successfully suppress task-irrelevant information (inhibition function). These studies have generally employed process-pure tasks to provide direct tests of the effect of anxiety on the specific functions of the central executive. Miyake et al., (2000) found that the anti-saccade task was associated with the inhibition function. The anti-saccade task involves the presentation of a visual cue and participants are instructed to look to the opposite side of the cue as quickly as possible. In the control condition participants perform a pro-saccade task in which their task is to look at the cue. The latency of the first correct saccade is measured for pro- and anti-saccades and then compared (Eysenck & Derakshan, 2011). For example, Ansari and Derakshan (2010) used a mixed anti-saccade paradigm to study the effects of anxiety in task switching. Participants were required to make eye movements to the opposite direction of a presented cue. The results revealed that anxious individuals made more inaccurate saccades to the cued target and were slower to fixate on the opposite location than non-anxious individuals, indicating an impaired use of the inhibition function (Ansari & Derakshan, 2010; Derakshan, Ansari, Shoker, Hansard, & Eysenck, 2009). There are a number of studies that have provided support for the first prediction of ACT (see Cisler & Koster, 2010, for review).

The second prediction of ACT is that anxiety is associated with a reduced ability to flexibly shift attention between relevant task demands. There is some support of this prediction; however, there are fewer studies that have investigated the effects of anxiety on tasks involving the shifting function (Berggren & Derakshan, 2012). For example, Derakshan, Smyth, and Eysenck (2009) used a task-switching paradigm that involved mentally calculating additions and subtractions (low complexity task) or multiplications and divisions (high complexity task). Participants were required to perform both repetitive and task switching blocks. The results revealed that the high-anxious group had significantly longer response time during task switching compared to when the task was repetitive, but only when the task complexity was high.

ACT states that anxiety impairs the central executive (Eysenck et al., 2007). The theory, which incorporates the executive functions identified by Miyake et al. (2000)

identifies the shifting and inhibition functions as the two most impaired by anxiety. The cognitive psychology literature has typically adopted process pure tasks in which the specific functions of the central executive are isolated. These process pure tasks (e.g., anti-saccade tasks) are difficult to replicate in sport settings and are not considered to be representative of many real world environments. However, ACT provides a framework for understanding how anxiety may impact on attentional control in sport through examining response accuracy and visual search behaviours. ACT predicts that anxiety will increase stimulus-driven attentional control and decrease goal-directed attentional control, resulting in an attentional bias towards threat-related stimuli and increasing susceptibility to distraction (Eysenck et al., 2007).

2.4.2 Attentional control theory in sport. Recent work in sport has used ACT to examine the effects of anxiety on sporting performance (Nibbeling, Daanen, Gerritsma, Hofland, & Oudejans, 2012; Nieuwenhuys & Oudejans, 2011; Navarro, Miyamoto, van der Kamp, Morya, Ranvaud, & Savelsbergh, 2012; Noël & van der Kamp, 2012; Wilson, Vine, & Wood, 2009a; Wood & Wilson, 2010).

Several recent studies have revealed that under high-anxiety conditions performers display reduced Quiet Eye (QE) duration as a result of less efficient processing, leading to more fixations of shorter duration. QE has been defined as the final fixation toward a relevant target before the initiation of movement, and in far aiming tasks, the amount of time that one looks at the target appears to be strongly correlated with performance (Vickers, 1996). These findings have emerged from a number of studies examining QE in far aiming tasks, including archery (Behan & Wilson, 2008), shot gun shooting (Causer, Holmes, Smith & Williams, 2011), basketball (Vine & Wilson, 2010), golf putting (Vine, et al., 2011), and soccer penalty kicks (Wilson, Wood & Vine, 2009b). With less time spent fixating on relevant targets, anxious individuals tend to spend more time fixating on threat-related stimuli (Nieuwenhuys & Oudejans, 2011). Wilson, Wood and Vine (2009) examined soccer penalty kicks under condition of high-anxiety. The results revealed that participants increased their number and duration of fixations to the goalkeeper (a source of threat), which resulted in them shooting closer to the goalkeeper's position.

While these studies have shown support for the predictions of ACT, there is currently no empirical evidence exploring the attentional disruption that anxiety may induce in non-aiming sport tasks with regard to the predictions of ACT (e.g., one-vs-one soccer task). However, there are relevant findings from Williams and Elliot's (1999) study on expert and novice karate players visual search strategies employed under heightened anxiety. While not specifically examining ACT there are relevant findings that can help direct the predictions of the present research programme. The performance results revealed that expert performers exhibit superior anticipation skill, with both groups performing better during high-anxiety compared to low-anxiety conditions. There were no statistically significant differences in the visual search behaviours of the two groups. Under heightened anxiety the visual search behaviours altered for both groups, which was highlighted by an increase in the number of fixations and fixation locations, and a decrease in the mean fixation duration. However, the findings did indicate that this increase in search activity was more pronounced in novices, with fixations moving from central to peripheral body locations. In summary, these findings revealed that anxiety has a greater effect on the visual search behaviours of novice performers and that these changes in search strategies may be due to a narrowing of the perceptual field. The task presented in Chapter 6 provides an opportunity for a comprehensive test of ACT's predictions in a task that is comparable across a range of sporting tasks.

2.6 Rationale for Present Study

The literature and theories reviewed in this chapter indicate the importance of anticipation skill and decision-making and the effects of anxiety on sporting performance. Furthermore, in this chapter I have explored research that has examined the influence of top-down processing on performance, both within and outside of sporting contexts. In recent years, a number of studies have established the importance of contextual information for enhancing response accuracy and decreasing response time (Crognier & Féry, 2005; Paull & Glencross, 1997); however, our understanding of how specific top-down probability information affects perceptual processes is limited within the sporting domain. The spatial cueing paradigm was introduced in cognitive psychology for exploring top-down control over attention (Posner 1978, 1980; Posner, et al., 1980), with valid trials demonstrating attentional benefits (shorter RTs), and invalid trials showed attentional costs (longer RTs). The basic principles of Posner's paradigm can be used to guide the development of a novel approach to explore the use of top-down information in a sporting context, addressing the questions of how such information impacts anticipatory performance and the allocation of visual attention. However, according to ACT, anxiety suppresses input from the goal-directed attentional system. By inference, the effect of top-down probability information should be suppressed under high-pressure, and the overriding stimulus-driven attentional system may increase performers' susceptibility to deception. An alternative prediction relates to reinvestment theory (Masters, 1992). Masters and Maxwell (1994) defined reinvestment as "the propensity for manipulation of conscious, explicit, rule based knowledge, by working memory, to control the mechanics of one's movements during motor output" (p. 208). Reinvestment theory suggests that individuals would be more reliant on explicit information under pressure, which in this case would result in a greater use of top-down probability information.

The current research programme had three main aims. The first aim was to enhance understanding of expertise effects with regard to anticipation skill and, in particular, the perception of deceptive movement. The second aim was to increase understanding of how 'top-down' and 'bottom-up' processes interact in time-constrained perceptual tasks, again in relation to expertise. The third aim was to extend understanding of how anxiety impacts anticipation skill, especially the perception of deception, and associated attentional processes indexed by visual search behaviours and the interaction between 'top-down' and 'bottom-up' processes. It is expected that enhanced understanding of how probability information interacts with the processing of early visual information will have implications for the design of more effective perceptual training protocols. In addition, the present thesis will determine the potential use of ACT as a theoretical framework for understanding the influence of anxiety on anticipation skill, visual search behaviours and the interaction between ‘top-down’ and ‘bottom-up’ processes.

Chapter 3

Study 1: Anticipation Skill and Susceptibility to Deceptive Movement in Soccer Players

3.1 Introduction

Skilled performers are able to anticipate an opponent's actions through pick up of early visual cues (Hodges, Huys, & Starkes, 2007; Mann, et al., 2007). Indeed, in time-constrained tasks it is the ability to pick up subtle differences in information conveyed by these cues that distinguishes highly-skilled performers from their less-skilled counterparts (Mann, et al., 2010). This ability has been demonstrated in a variety of sports, including soccer (Bishop, Wright, Jackson, & Abernethy, 2013; Williams, 2000), cricket (Müller & Abernethy, 2006; Müller, et al., 2006) badminton (Abernethy & Russell, 1987; Hagemann & Memmert, 2006) and tennis (Jackson & Mogan, 2007; Crognier & Féry, 2005; Rowe & McKenna, 2001; Shim, Chow, Carlton, & Chae, 2005).

Researchers have historically employed cross-sectional designs, using temporal and/or spatial occlusion paradigms to determine the spatiotemporal characteristics of visual information pick-up. Research using the spatial occlusion paradigm has suggested that skilled performers rely on a more global pickup strategy during a one-on-one situation, allowing them to process visual information from several areas of the body; conversely, low-skilled players are more reliant on 'local' information conveyed in single cues such as the arm or racquet position (Huys, et al., 2009; Huys, Smeeton, Hodges, Beek, & Williams, 2008). Huys et al. (2009) manipulated stick figure images of tennis players by either spatially occluding or neutralising (i.e., averaging out) dynamical differences from bodily areas (e.g., the arm and racket, shoulders). In the spatial occlusion experiment, skilled players outperformed their less skilled counterparts in all conditions, except the arm-racket condition. Less skilled players were not significantly affected by the different manipulations. In the neutralisation experiment, the skilled players showed a significant decrease in performance relative to the control condition in the trunk, arm-racket, and leg conditions, whereas less skilled players did not differ in response accuracy across conditions. These findings suggest that skilled performers employ a more global rather than local perceptual strategy. Yet, other researchers have suggested that a local information pick-up strategy, whereby information is extracted from the end-point of the movement (e.g., arm and racket regions), is also beneficial for making accurate predictions about an opponent's stroke direction (Abernethy, 1990).

Researchers have also suggested that skilled performers anticipate the actions of their opponent based upon their perception of relative motion between joints, rather than extracting information from specific information cues or more superficial features (Jackson, Abernethy & Wernhart, 2009; Williams, et al., 2010). Hayes, Hodges, Scott, Horn, and Williams (2007) argued that if relative biological motion is a key discriminating variable for expert perception, then anticipatory performance when viewing videos of an oncoming opponent in point-light format (cf. Johansson, 1973) should be comparable to that when full colour videos are viewed. Indeed, studies incorporating point-light displays have demonstrated that skilled performers are able to maintain their perceptual-cognitive advantage under such conditions (Abernethy & Zawi, 2007; Abernethy, Zawi, & Jackson, 2008; Wright, Bishop, Jackson, & Abernethy, 2011).

Although visual information from patterns of body movement allows an observer to anticipate the unfolding actions of an opponent, there are instances where the opponent may successfully use the movement of the body to deceive (e.g., Jackson, et al., 2006). Deceptive movement is designed to provide information that misleads an observer into making an incorrect judgement (Jackson, et al., 2006). A step-over in soccer is a pertinent example of how an attacking player may use their body movement to mislead a defender, by stepping over the ball in one direction and then taking the ball in the opposite direction with the other foot. Jackson, et al. examined how expertise affects performers' ability to anticipate deceptive movements using the temporal occlusion paradigm to assess rugby players' ability to judge an opposing player's change of direction. The findings demonstrated that low-skilled players were susceptible to deceptive movement (i.e., they tended to go with the ‘fake’), whereas the high-skilled players maintained their level of performance.

High-skilled performers’ superiority in tasks incorporating deception has been demonstrated in basketball (Sebanz & Shiffrar, 2009), soccer (Dicks, et al., 2010a; Smeeton & Williams, 2012), handball (Cañal-Bruland & Schmidt, 2009) and tennis (Rowe et al., 2009). In contrast to Jackson et al.’s (2006) findings, some of these studies have shown that high-skilled performers are also susceptible to deceptive movement though to a lesser extent than their low-skilled counterparts (Dicks et al.; Smeeton & Williams).

Researchers have used several measures to attempt to identify the processes underlying perceptual-cognitive expertise, including verbal reports (Ward, Williams, & Ericsson, 2003) and eye movements (Vaeyens, Lenoir, Williams, Mazyn, & Phillippaerts, 2007). To assess participant awareness of the information underpinning their judgements, Jackson et al. (2006) adapted the methodology of Runeson, Juslin, and Olsson (2000) for distinguishing between direct-perceptual (sensory) and inferential (cognitive) judgements associated with the invariant-based and cue-heuristic models of perception, respectively. In accordance with Rosenthal’s (1986, 2000) Higher Order

Thought theory, a judgement that involves a conscious inference will be open to higher-order thoughts about the judgement, such as a higher level of confidence. Jackson et al. (2006) found evidence of over-confidence on deception trials, interpreted as evidence for participants making more inferential judgements in these trials.

Smeeton and Williams (2012) aimed to examine whether exaggeration within an action to be anticipated is responsible for the mode of functioning deception is perceived in. In line with the findings from Jackson et al, it was proposed that exaggerated movements would alter the perceptual mode of functioning from an invariant to a cue-based mode. Skilled and less skilled soccer players viewed penalty kicks involving deceptive, non-deceptive and non-deceptive-exaggerated movement. Findings indicated that deceptive kicks were anticipated in a cue-based mode. Judgement accuracy was significantly greater in non-deceptive kicks compared to deceptive kicks, but confidence ratings did not differ across conditions, providing further evidence of over-confidence on deception trials, which is thought to indicate an overestimation of the validity of the cue. The evidence for exaggeration being the reason for anticipation in a cue-based mode was dependent on the temporal occlusion condition and skill level. Evidence was found for exaggeration occurring up until -80 ms being responsible for the cue-based mode of functioning in the less skilled group. Beyond this time point less skilled players used a cue-based mode regardless of the kick type viewed.

The purpose of the present study was, first, to examine the moderating effect of expertise in discriminating between non-deceptive and deceptive motion. Second, this study sought to examine the relative importance of the upper-body and lower-body regions to perceiving deceptive intent. Third, we aimed to examine the nature of the judgements being made. To achieve these aims, high-skilled and low-skilled female soccer players took part in two experiments in which we combined the spatial occlusion and temporal occlusion paradigms in a one-on-one soccer direction judgement task. We presented test stimuli in full-colour (Experiment 1) and point-light (Experiment 2) video formats while recording both judgement accuracy and confidence.

Consistent with previous research into other sport skills, we predicted that the expert advantage in anticipation skill would extend to judgements of deceptive intent such that high-skilled players would be less susceptible to deception than low-skilled players. We further predicted that the high-skilled players' advantage would be greatest at early occlusion points. Previous findings suggest that successful anticipation during soccer penalty simulations is associated with a greater focus on the angle of the hips (Williams & Burwitz, 1993), and the non-kicking leg (Savelsbergh et al., 2002; 2005). Brault et al. (2010) analysed the biomechanical differences between deceptive and non-deceptive movements, with the key finding indicating that deception was conveyed by exaggerating the out-foot placement. Upper body differences only occurred in the upper body yaw. They also indicated that COM displacement and lower trunk yaw must be minimised to ensure the player can change the angle of the run. In summary, they claimed that exaggerated body movements can be thought of conveying deceptive signals while the minimised body movements can be thought of as conveying honest signals. In line with these findings, we predicted that the occlusion of the lower body would cause the greatest disruption in judgement accuracy compared to occlusion of the upper body. Given the strong evidence that the information extracted from advance visual cues is largely kinematic, it was further predicted that high-skilled players would outperform low-skilled players in both full video and point-light display formats. In regard to awareness, it was predicted that deceptive movement would be anticipated in a cue-based mode, evidenced by overconfidence on deceptive trials but not on the normal (non-deceptive) trials.

3.2 Experiment 1

The aim of experiment 1 was to examine the ability of high-skilled and low-skilled soccer players to judge direction change in a simulated one-on-one defensive situation employing combinations of four temporal and three spatial occlusion conditions.

3.3 Method

3.3.1 Participants. Twelve high-skilled and 12 low-skilled adult female soccer players participated in this experiment. High-skilled participants (*M* age = 22.0 years, *SD* = 4.9) had an average of 13.3 years' (*SD* = 4.3) playing experience. All players were competing in the FA Premier League National Division at the time of data collection. Of the 12 members of the group, two had competitive experience at senior international level and a further five had competitive experience at junior international level (up to under-23 age group). The low-skilled participants (*M* age = 21.3 years, *SD* = 1.2) had not participated in soccer above club level, and had played recreationally for an average of 5.6 years (*SD* = 3.5). Participants provided informed consent and were free to withdraw from testing at any stage. Institutional ethical approval was granted and the experiment was conducted in accordance with institutional guidelines.

3.3.2 Test design. Two high-skilled female soccer players (*M* age = 21.0 years, *SD* = 2.8) with a mean playing experience of 13.5 years (*SD* = 2.1) were asked to dribble a soccer ball in an attacking-style, both with and without the use of a step-over. A total of 40 video sequences were filmed using a Canon HD digital video camera (Canon HV40, Toyko, Japan) recording at 25 Hz from a position located in front of the approaching model and at a height of 1.4 m on a tripod. The footage was recorded in a sports hall; the camera was positioned 12.8m from the model's starting position. On each trial, the model ran from the start position and then changed direction at a point located 5.3 m from the camera towards one of two targets placed at an angle of 45˚ to the initial approach. Two types of trials were filmed: 'no deception' and 'deception' trials. In the 'no deception' condition, the models were instructed to run directly towards the camera and then to change direction (left/right). In the deception trials, the models were asked to perform a step-over prior to changing direction. During the step-over the model gives the impression of changing direction one way, before taking the ball in the opposite direction. The models were instructed to perform each trial at game pace, whilst maintaining excellent control of the ball and a consistent direct approach towards the camera until the point of execution.

The footage was divided into individual trials and these were placed into four categories: (a) no deception - left, (b) no deception - right, (c) deception - left, and (d) deception - right. Three UEFA B Licensed coaches rated each clip according to three factors: the smoothness of the approach, the speed of the movement and the model's execution when changing direction. Each category was equally weighted and the mean score was taken from each coach to determine which 12 trials would be selected for each player. The selected clips were digitally edited using Pinnacle Studio (version 14) and Jasc Paint Shop Pro (version 9) software, to construct a two-choice prediction task that consisted of 192 test trials. Four temporal occlusion points relative to the final frame before the foot made contact with or passed in front of the ball were used in the test: -160 milliseconds (ms), -80 ms, 0 ms, +80 ms. Three spatial occlusion conditions were used: (A) No Occlusion (NO), (B) Lower Body Occlusion (LBO: the hips and below were occluded, leaving the upper body and soccer ball), and (C) Upper Body

Occlusion (UBO: everything above the hips was occluded, leaving the lower body and soccer ball).

The final test footage comprised 192 individual trials, presented in four blocks of 48 trials. The two models were blocked separately, and block order was counterbalanced. Order of presentation within each block was randomised with respect to deception condition, spatial occlusion and temporal occlusion. Each trial lasted approximately two seconds with an inter-trial interval of five seconds. The practice and test trials were presented on a widescreen 15.6” laptop computer, viewed from a seated distance of approximately 0.7 m. Participants were asked to imagine that they were defending against the player depicted in each trial; their aim was to judge the direction in which their opponent’s intended to go. After each trial, participants gave a verbal response ('left' or 'right') and rated their confidence in their judgement on a 5-point scale (1 = *not at all confident*, 5 = *extremely confident*).

3.3.3 Procedure. Participants were given written instructions, in which the test footage was described and they were informed about the nature of the task. They were then asked to complete a demographic information questionnaire and an informed consent form. Prior to the test trials, the participants were presented with a block of 16 familiarisation trials, followed by a two-minute break. This block comprised of eight trials from each model, containing examples from each spatial and temporal occlusion condition, with and without deception. Four blocks of 48 trials were then presented with an inter-block interval of two minutes. Each test session lasted approximately 25 minutes, after which participants were asked to complete a post-experiment questionnaire.

3.3.4 Analysis of data. Prior to the main analysis, the data for the two models used to create the test stimuli were compared. The response accuracy data were entered into a 2 (expertise) x 2 (model) x 2 (deception) x 4 (temporal occlusion) x 3 (spatial occlusion) ANOVA with repeated measures on the last four factors. The analysis revealed no significant main effects of model, nor any significant interactions between level of expertise and model factors. As a result, the data were collapsed across the two models for the main analysis.

The dependent measures were the mean number of correct judgements and mean confidence ratings in each condition. Response accuracy and confidence data were entered into separate 2 (expertise) x 2 (deception) x 4 (temporal occlusion) x 3 (spatial occlusion) ANOVAs, with repeated measures on the last three factors. A Greenhouse-Geisser correction to the degrees of freedom was applied in the case of any violations of sphericity and partial eta squared (η_p^2), were provided as effect size measures for all significant main effects and interactions. Significant main effects and interactions were followed up with an analysis of simple effects and simple interactions.

3.4 Results

3.4.1 Response accuracy. Analysis of variance revealed significant main effects for expertise, deception, spatial occlusion and temporal occlusion. As expected, the high-skilled group (*M* = 0.75, *SE* = 0.01) outperformed the low-skilled group (*M* = 0.61, *SE* = 0.01). Performance was better on non-deceptive trials (*M* = 0.89, *SE* = 0.01) than on deceptive trials (*M* = 0.47, *SE* = 0.02) and improved across the temporal occlusion conditions; from t1 (*M* = 0.52, *SE* = 0.02) to t2 (*M* = 0.56, *SE* = 0.01) to t3 (*M* = 0.71, *SE* = 0.02) to t4 (*M* = 0.93, *SE* = 0.01). The highest mean performance score was recorded in the NO condition (*M* = 0.71, *SE* = 0.01), followed by the LBO condition (*M* = 0.68, *SE* = 0.01) then UBO condition (*M* = 0.66, *SE* = 0.01). In all cases, the maximum mean score was 1, with a score of 0.5 being equivalent to chance level.

3.4.1.1 Deception. In addition to the significant main effect of deception, there was a significant interaction with expertise, $F(1, 22) = 11.01$, $p < .01$, $\eta_p^2 = .34$. This interaction was caused by a greater difference in performance between deceptive and non-deceptive trials for the low-skilled players (*M* Difference = 0.49) compared to the high-skilled players (*M* Difference = 0.36). Consistent with the experimental hypothesis, the significant interaction between deception and expertise was caused by the high-skilled group being less susceptible to deception than the low-skilled group. As illustrated in Figure 3.1, performance was considerably worse on deceptive trials than on non-deceptive trials for both groups; however, the low-skilled group suffered a greater decrement in performance.

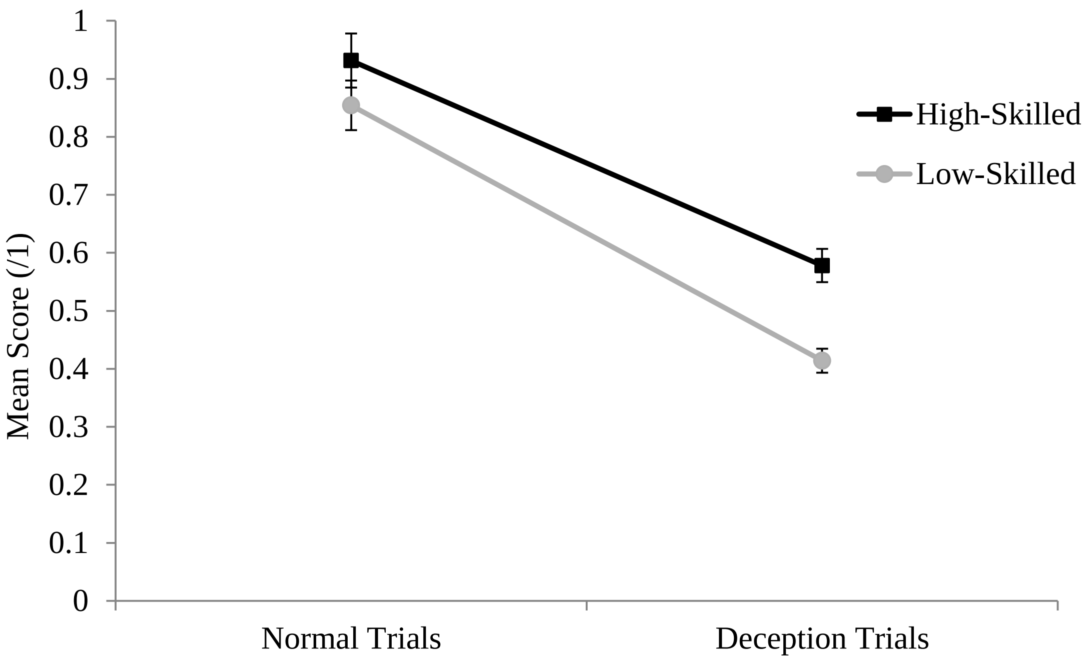

Figure 3.1. The mean score, expressed as the mean proportion of correct judgements made by the high-skilled and low-skilled groups on non-deceptive and deceptive trials, with standard error bars.

3.4.1.2 Spatial occlusion. As well as the main effect of spatial occlusion, the analysis revealed a significant interaction between spatial occlusion and deception, $F(1.40, 30.77) = 6.55$, $p < .01$, $\eta_p^2 = .23$. There was a substantial difference in judgement accuracy between the non-deceptive and deceptive conditions in each spatial occlusion condition; however, this difference was greater in the UBO condition (*M* Difference = 0.54), compared to the LBO condition (*M* Difference = 0.46) and the NO condition (*M* Difference = 0.44).

The analysis also revealed a significant spatial occlusion by temporal occlusion interaction, $F(3.53, 77.63) = 4.69$, $p < .01$, $\eta_p^2 = .18$, caused by greater improvement from t1 to t4 in the NO condition ($M = 0.46$) than in the UBO condition ($M = 0.39$) and LBO conditions ($M = 0.38$). The two-way interaction between expertise and spatial occlusion was non-significant, $F(1.59, 35.00) = 0.03$, $p = .18$, $\eta_p^2 = .08$, as were the remaining three-way interactions ($p > .05$).

3.4.1.3 Temporal occlusion. The significant main effect of temporal occlusion was superseded by significant two-way interactions with expertise, $F(3, 66) = 3.34$, $p < .05$, $\eta_p^2 = .13$ and deception, $F(2.42, 53.37) = 61.31$, $p < .001$, $\eta_p^2 = .74$. With respect to expertise, the high-skilled group's advantage over the low-skilled group was relatively consistent across t1 (*M* Difference = 0.15), t2 (*M* Difference = 0.16), and t3 (*M* Difference = 0.19); however, there was a much smaller advantage for the high-skilled group at t4 (*M* Difference = 0.07).

The interaction between temporal occlusion and deception was caused by the impact of deception on performance being greater at early occlusion points (especially t1 and t2) after which performance on deceptive trials improved markedly to t3 and again to t4, prior to the appearance of veridical information (Figure 3.2). There was also a three-way interaction between temporal occlusion, spatial occlusion, and deception, $F(3.55, 78.17) = 3.72$, $p < .01$, $\eta_p^2 = .15$. In the NO and LBO conditions performance on deceptive trials improved markedly to t3 and again to t4, however, in the UBO condition there was only a noticeable improvement in the deceptive trials from t3 to t4. All remaining three-way and four-way interactions were non-significant (p > .05).

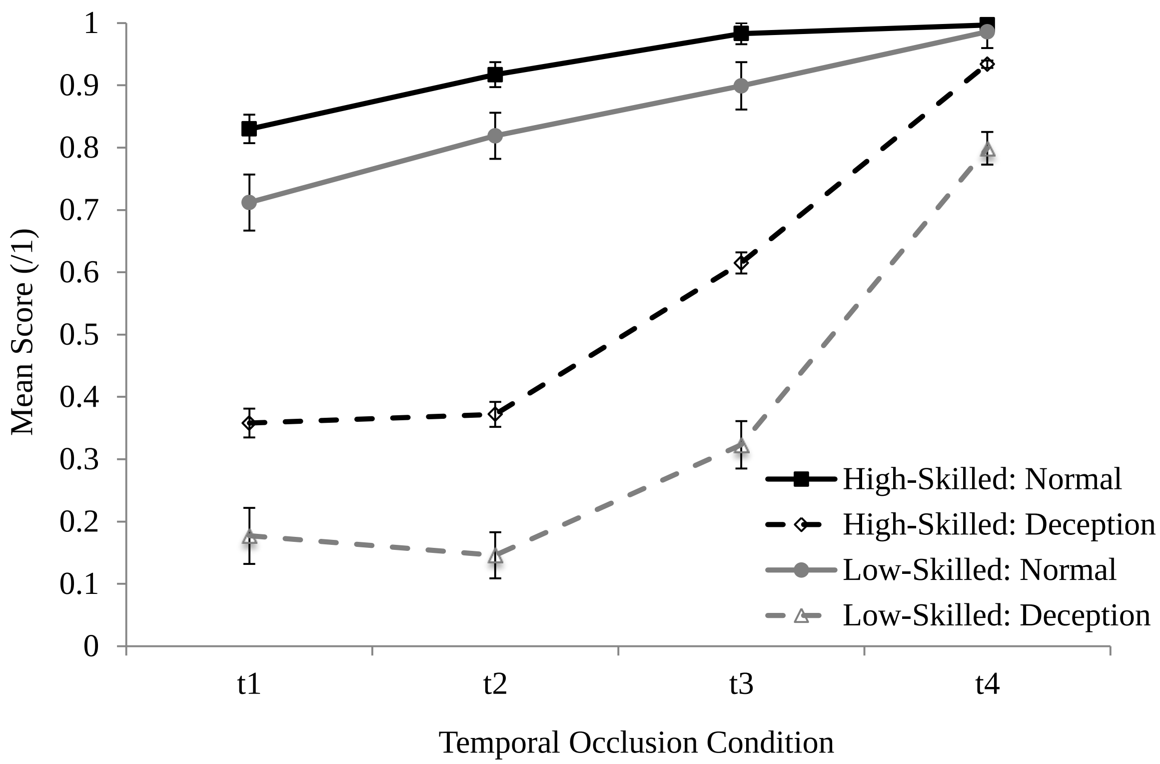

Figure 3.2. The mean score, expressed as the mean proportion of correct judgements for normal and deception trials in each temporal occlusion condition. The data are collapsed across expertise and displayed with standard error bars.

3.4.2 Confidence ratings. Analysis of variance in the confidence rating data revealed significant main effects for deception, $F(1, 22) = 105.93$, $p < .001$, $\eta_p^2 = .83$, spatial occlusion, $F(1, 22) = 121.89$, $p < .001$, $\eta_p^2 = .85$, and temporal occlusion, $F(2.10, 46.27) = 120.76$, $p < .001$, $\eta_p^2 = .85$. Consistent with the performance data, judgement confidence was higher on non-deceptive trials (M = 3.72, SE = 0.08) than on deceptive trials (M = 2.89, SE = 0.13) and increased from t1 (M = 2.63, SE = 0.13) to t2 (M = 3.21, SE = 0.10) to t3 (M =3.61, SE = 0.10) to t4 (M = 3.78, SE = 0.10). In contrast to the performance data, judgement confidence was markedly higher for the UBO trials (M = 3.44, SE = 0.10) than for the LBO trials (M = 2.88, SE = 0.12), with the highest mean confidence recorded in the NO condition (*M* = 3.60, *SE* = 0.09). The main effect of expertise was non-significant, $F(1, 22) = 2.81$, $p = 11$, $\eta_p^2 = .11$.

There were also significant interactions between deception and temporal occlusion, $F(1.75, 38.54) = 37.20$, $p < .001$, $\eta_p^2 = .63$, and deception and spatial occlusion, $F(2, 44) = 20.72$, $p < .001$, $\eta_p^2 = .49$. The deception by temporal occlusion interaction was caused by a greater increase in judgement confidence from t1 to t4 in the non-deceptive trials (*M* = 1.61) than in the deceptive trials (*M* = 0.69). The deception by spatial occlusion interaction reflected a greater difference in judgement confidence between deceptive and non-deceptive trials in the UBO trials (*M* Difference = 1.02), compared to NO (*M* Difference = 0.82) and LBO (*M* Difference = 0.66). These effects were superseded by a three-way interaction between temporal occlusion, spatial occlusion, and deception, $F(6, 132) = 3.03$, $p < .01$, $\eta_p^2 = .12$. As can be seen in Figure 3.3, this was chiefly caused by judgement confidence in the NO Deception and UBO deception conditions showing a relatively large increase from t1 to t2 then levelling off, whereas confidence ratings in the LBO deception condition showed a linear increase from t1 to t3 then decreased slightly at t4. By contrast, the pattern of confidence rating data from t1 to t4 for the non-deceptive trials was similar for all three spatial occlusion conditions. All other interactions were non-significant ($p > .05$).

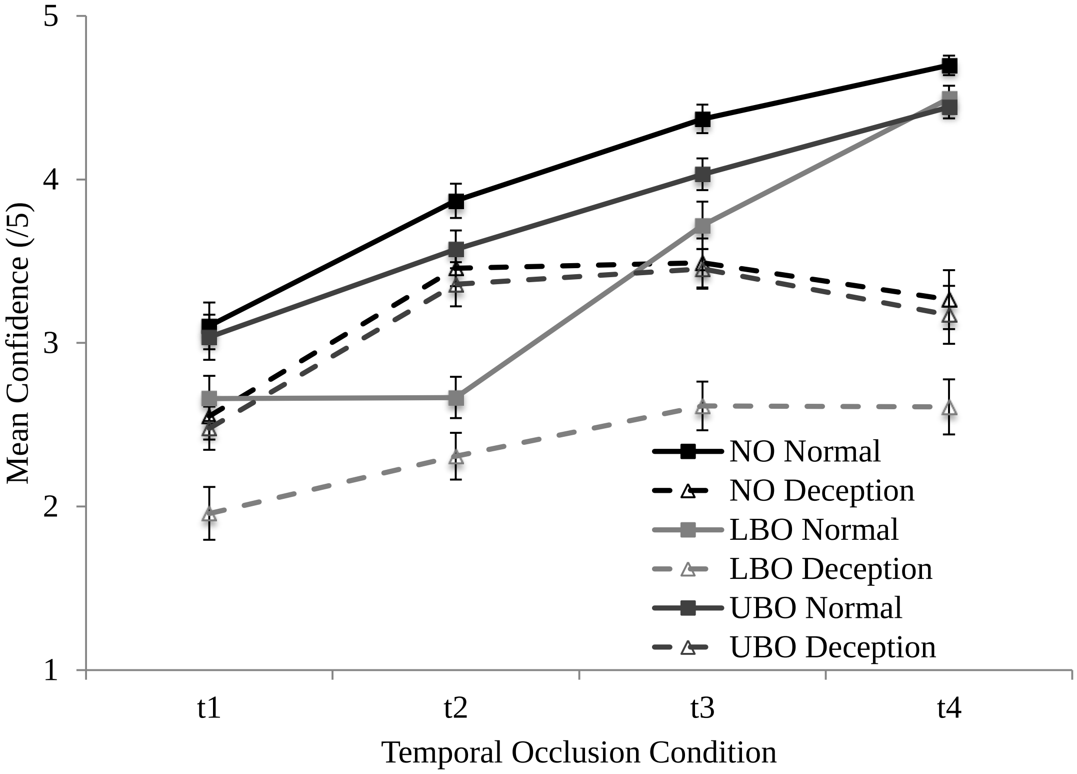

Figure 3.3. Mean confidence ratings for all participants in each spatial occlusion and deception condition, across the four temporal occlusion points, with standard error bars.

3.4.3 Test item solution probabilities. The distribution of solution probabilities for the 96 normal and 96 deception trials plotted separately for the high-skilled and low-skilled groups is presented in Figure 3.4. These represent the proportion of correct responses recorded for each trial and are plotted against the mean confidence rating recorded for the relevant group on that item. In the high-skilled group the variance in solution probabilities was larger for deception trials (s^2 = .073) than for normal trials (s^2 = .012). Hartley's variance ratio test indicated that this difference was significant, $F(47,47) = 6.08$, $p < .01$. The variance in solution probabilities was also larger for deception trials (s^2 = .083) than for normal (s^2 = .028) in the low-skilled group, $F(95, 95) = 2.96$, $p < .01$. Pearson's product-moment correlations of the linear relationship between mean response accuracy and mean confidence for the high-skilled group revealed significant relationships for both normal and deceptive trials. In contrast, only a significant linear relationship was found for normal trials in the low-skilled group (see Table 3.1).

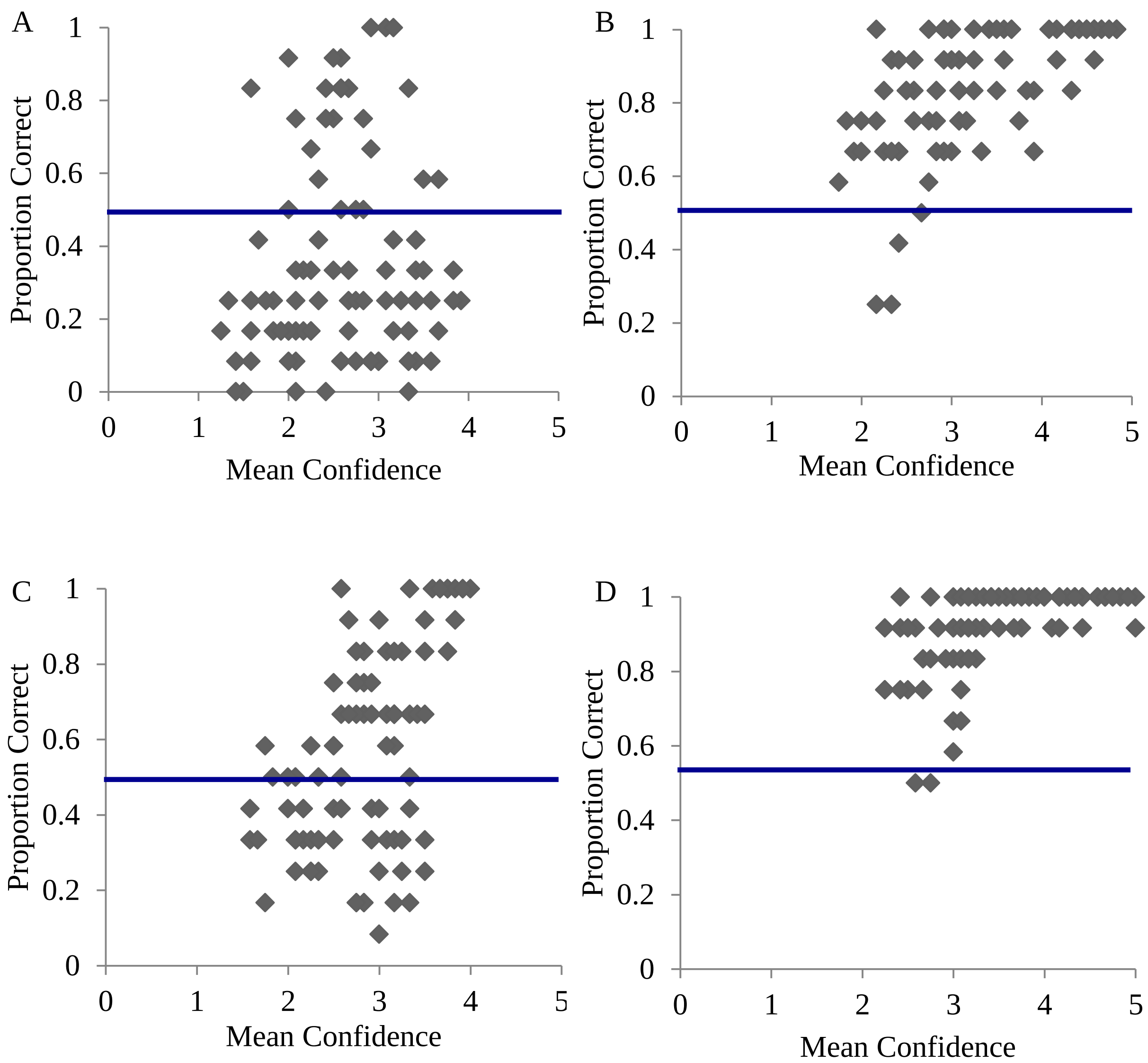

Figure 3.4. The proportion of correct responses on each trial plotted against the mean confidence rating for that item. Panels A and B show data for the low-skilled group and Panels C and D show data for the high-skilled group, on deceptive and normal trials, respectively.

Table 3.1.

Pearson's product-moment correlation coefficients (r) from Judgement Accuracy (JA) and Confidence Rating (CR) in normal and deception trials for high-skilled and low-skilled soccer players.

JA vs. CR	Normal	Deception
High-skilled	.598**	.547**
Low-skilled	.627**	.084

$^{**}p < .01$

3.5 Experiment 2

In Experiment 2 we aimed to examine the effects of viewing only movement kinematics on the ability of high-skilled and low-skilled soccer players to discriminate between genuine and deceptive movement. The video sequences from Experiment 1 were edited to depict 19 moving white dots representing each major joint of the human body (see Figure 3.5). It was hypothesised that high-skilled performers would maintain their advantage over low-skilled performers due to an enhanced ability to detect another's intentions from kinematic information alone.

3.6 Method

3.6.1 Participants. A total of 24 (12 high-skilled and12 low-skilled) adult female soccer players were recruited. None of the participants took part in Experiment 1, although they were of equivalent skill level as the previous groups. The high-skilled group (*M* age = 21.8 years, *SD* = 3.7) comprised semi-professional players, with a mean of 11.2 years' (*SD* = 3.2) playing experience. They were currently competing in the FA Women's Super League, with three having competed at international senior level and a further seven having competed at international youth level (under 23 and below) during the year preceding testing. The low-skilled participants (*M* age = 21.8 years, *SD* = 1.5) had not participated in soccer above club level, and had played recreationally for an average of 4.6 years (*SD* = 3.5). All participants provided informed consent and were free to withdraw from testing at any stage. The study was approved by the institution's ethics committee and carried out under its ethical guidelines.

3.6.2 Experimental task and presentation of test stimuli. The test film was the same as used in Experiment 1, except that all trials were presented to participants in point-light display format, as illustrated in Figure 3.5. As in Experiment 1, Pinnacle Studio (Version 14.0) and JASC Paintshop Pro (version 9.0) software was used to generate single frame images for modification into point-light display format and to create the three spatial occlusion conditions. Specifically, a layer of 19 white dots was manually added to each frame and a solid black background layer was then inserted between the original image and the layer of white dots to create the point light image. The point-light images were then re-imported into Pinnacle Studio to rebuild the video sequence.

3.6.3 Design and procedure. The design and procedure were the same as for Experiment 1.

3.6.4 Data analysis. The measures of performance and confidence were the same as for Study 1. The response accuracy data were entered into a 2 (expertise) x 2 (model) x 2 (deception) x 4 (temporal occlusion) x 3 (spatial occlusion) ANOVA with repeated measures on the last four factors. The analysis revealed no significant main effects of model, nor any significant interactions between level of expertise and model factors. As a result, the data were collapsed across the two models for the main analysis.

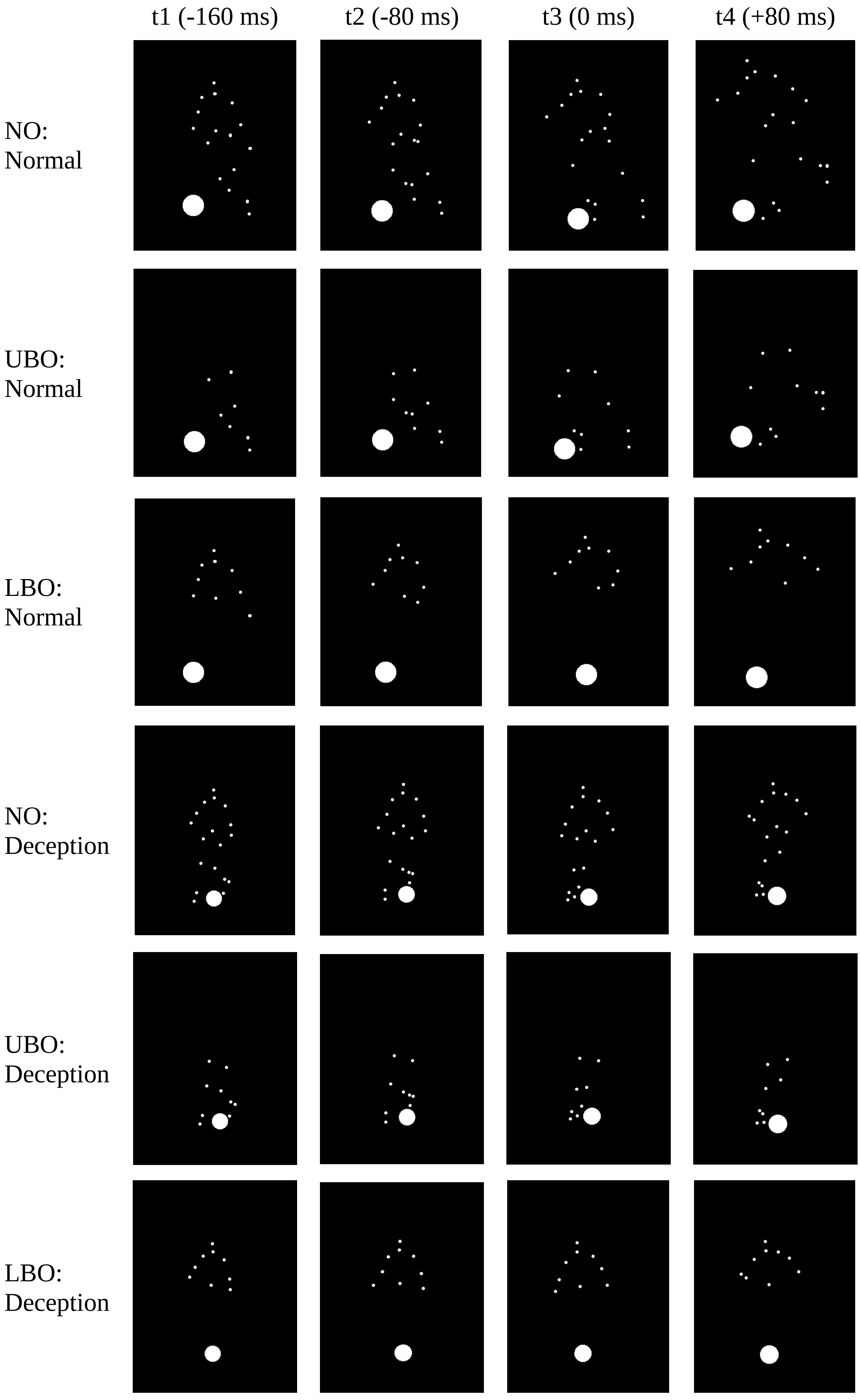

Figure 3.5. A schematic representation of the temporal and spatial occlusion conditions in point-light display, for both normal and deception trials.

3.7 Results

3.7.1 Response accuracy. Data were highly comparable to those from Experiment 1. The analysis of variance revealed significant main effects for expertise, deception, spatial occlusion and temporal occlusion. High-skilled players were more accurate than low-skilled players at anticipating their opponents' actions (*M* = 0.74, *SE* = 0.01 vs. *M* = 0.59, *SE* = 0.01). Performance was again better on non-deceptive trials (*M* = 0.89, *SE* = 0.01) than on deceptive trials (*M* = 0.44, *SE* = 0.01). Similarities were also evident across the temporal occlusion conditions, with performance improving from t1 (*M* = 0.53, *SE* = 0.01) to t2 (*M* = 0.56, *SE* = 0.01) to t3 (*M* = 0.68, *SE* = 0.01) to t4 (*M* = 0.89, *SE* = 0.01). Performance in the three spatial occlusion conditions was again better in the NO condition (*M* = 0.69, *SE* = 0.01), with slightly lower levels of performance in the LBO (*M* = 0.65, *SE* = 0.01) and UBO (*M* = 0.65, *SE* = 0.01) conditions.

3.7.1.1 Deception. The analysis again revealed a significant interaction between deception and expertise, $F(1, 22) = 24.19$, $p < .05$, $\eta_p^2 = .52$. As with the full video display in Experiment 1, there was a greater difference in performance between deceptive and non-deceptive trials for the low-skilled players (*M* Difference = 0.55) compared to the high-skilled players (*M* Difference = 0.35).

3.7.1.2 Spatial occlusion. The analysis revealed a significant interaction between spatial occlusion and deception, $F(1.34, 29.42) = 13.47$, $p < .001$, $\eta_p^2 = .38$. In line with the findings from Experiment 1, there was a greater difference in judgement accuracy between the non-deceptive and deceptive trials in the UBO condition (*M* Difference = 0.52), compared to the NO condition (*M* Difference = 0.46) and LBO condition (*M* Difference = 0.38).

The spatial occlusion by temporal occlusion interaction also attained statistical significance, $F(4.14, 91.11) = 8.54$, $p < .001$, $\eta_p^2 = .28$, caused by a greater improvement in judgement accuracy from t1 to t4 in the NO condition ($M = 0.41$) and UBO condition ($M = 0.41$), than the LBO condition ($M = 0.26$). There was a non-significant interaction between expertise and spatial occlusion, $F(2, 44) = 0.62$, $p = .54$, $\eta_p^2 = .03$.

3.7.1.3 Temporal occlusion. In line with the findings from Experiment 1, the significant main effect of temporal occlusion was superseded by significant two-way interactions with expertise, $F(3, 66) = 6.46$, $p < .001$, $\eta_p^2 = .26$ and deception, $F(2.31, 50.93) = 68.24$, $p < .001$, $\eta_p^2 = .76$. Once again, high-skilled participants were able to successfully determine direction change at earlier temporal occlusion points than were their low-skilled counterparts. As can be seen in Figure 3.6, the high-skilled group's advantage over the low-skilled group was apparent at t1 (*M* Difference = 0.13), increased to t2 (*M* Difference = 0.17) and t3 (*M* Difference = 0.21) then decreased once veridical information was apparent at t4 (*M* Difference = 0.07).

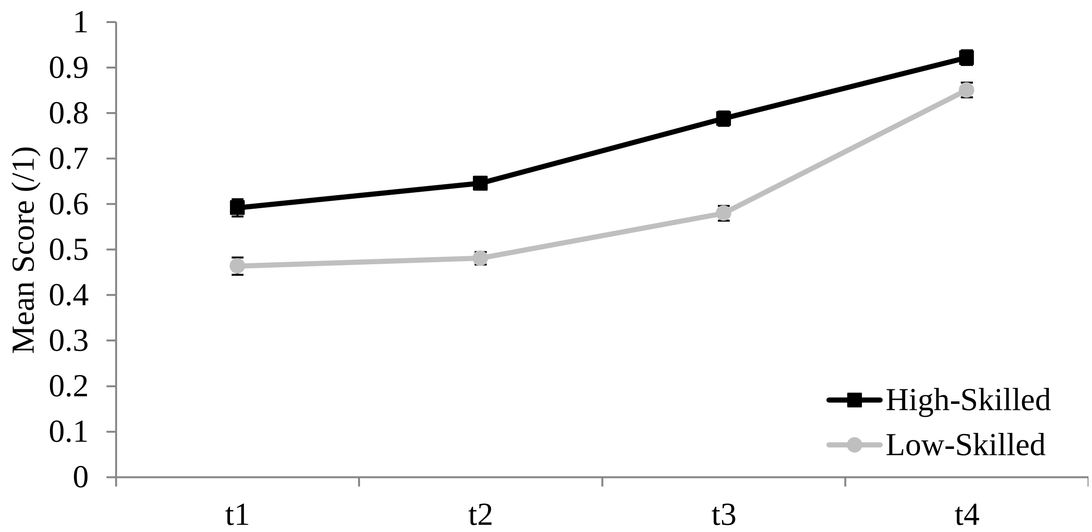

Figure 3.6. The mean score, expressed as the mean proportion of correct judgements for high-skilled and low-skilled groups in each temporal occlusion condition, with standard error bars.

The temporal occlusion by deception interaction was caused by the impact of deception on judgement accuracy being greater at t1, t2, and t3 compared to t4 (see Figure 3.7). This falls in line with the findings in Experiment 1, confirming that performance improved once veridical information became available at the later time points. There was again a significant three-way interaction between spatial occlusion, temporal occlusion, and deception, $F(6, 132) = 15.90$, $p < .001$, $\eta_p^2 = .42$. Once again in the NO and LBO conditions performance on deceptive trials improved markedly to t3 and again to t4, however, in the UBO condition there was only a noticeable improvement in the deceptive trials from t3 to t4. All other interactions were non-significant ($p > .05$).

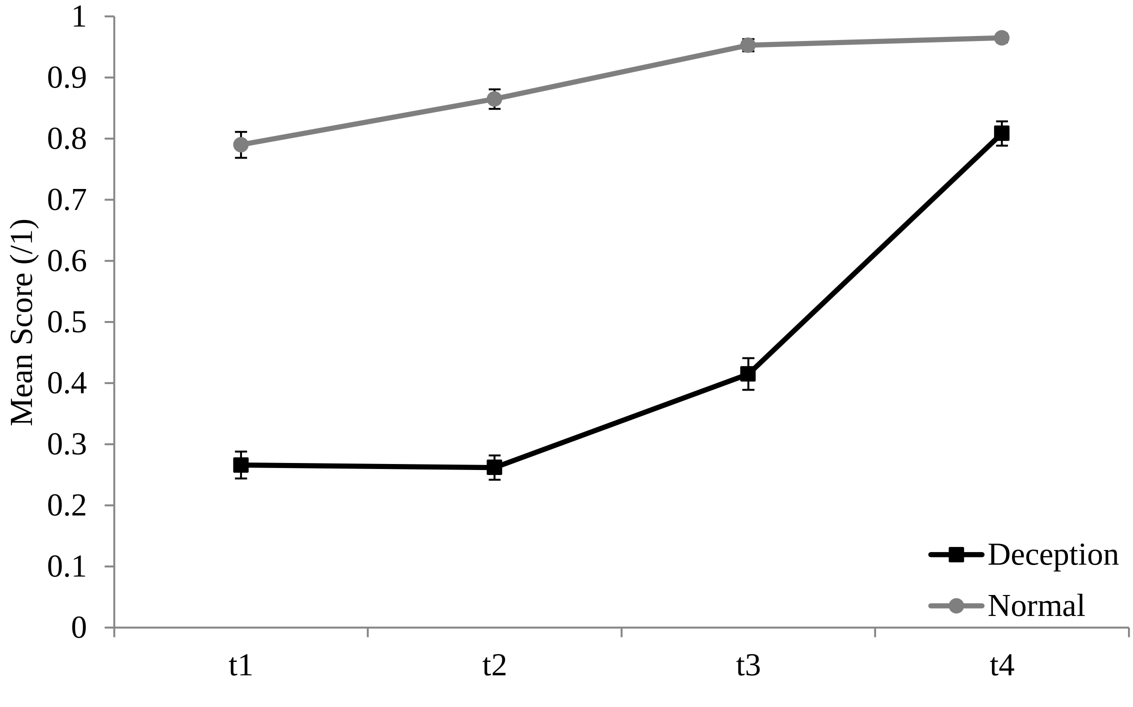

Figure 3.7. The mean score, expressed as the mean proportion of correct judgements for normal and deception trials in each temporal occlusion condition. The data are collapsed across expertise groups and displayed with standard error bars.

3.8 Confidence ratings

The analysis of variance revealed significant main effects for deception, *F*(1, 22) = 105.93, $p < .001$, $\eta_p^2 = .83$, spatial occlusion, *F*(1.59, 34.88) = 121.89, $p < .001$, $\eta_p^2 = .85$, and temporal occlusion, *F*(2.10, 46.27) = 120.76, $p < .001$, $\eta_p^2 = .85$. In line with the performance data and consistent with Experiment 1, mean judgement confidence was higher on non-deceptive trials (*M* = 3.72, *SE* = 0.08) than on deceptive trials (*M* = 2.89, *SE* = 0.13). Judgement confidence again increased across the temporal occlusion conditions from t1 (*M* = 2.63, *SE* = 0.13) to t2 (*M* = 3.21, *SE* = 0.10) to t3 (*M* =3.61, *SE* = 0.10) to t4 (*M* = 3.78, *SE* = 0.10). As in Experiment 1, judgement confidence was markedly higher for UBO trials (*M* = 3.44, *SE* = 0.10) and NO trials (*M* = 3.60, *SE* = 0.09) than for the LBO trials (*M* = 2.88, *SE* = 0.12).

There was a significant interaction between deception and temporal occlusion, *F*(1.75, 38.54) = 37.20, $p < .001$, $\eta_p^2 = .63$ caused by a greater increase in judgement confidence from t1 to t4 in the non-deceptive trials (*M* = 1.61) than in the deceptive trials (*M* = 0.69). Further significant interactions were reported between spatial occlusion and deception, *F*(2, 44) = 20.72, $p < .001$, $\eta_p^2 = .49$ and between spatial occlusion, deception and temporal occlusion, *F*(6, 132) = 3.03, $p < .01$, $\eta_p^2 = .12$. The spatial occlusion by deception interaction was caused by the difference in judgement confidence between deceptive and non-deceptive trials being greater in the UBO condition (*M* Difference = 1.01), than in the NO condition (*M* Difference = 0.82) and LBO condition (*M* Difference = 0.66). Once again these effects were superseded by a three-way interaction between temporal occlusion, spatial occlusion, and deception, *F*(6, 132) = 3.17, $p < .01$, $\eta_p^2 = .13$. In line with the findings in Experiment 1, this interaction was caused by judgement confidence in the NO Deception and UBO deception conditions showing a relatively large increase from t1 to t2 then levelling off, whereas confidence ratings in the LBO deception condition showed a linear increase from t1 to t3 then decreased slightly at t4. By contrast, the pattern of confidence rating data from t1 to t4 for the non-deceptive trials was similar for all three spatial occlusion conditions. All other interactions were non-significant ($p > .05$).

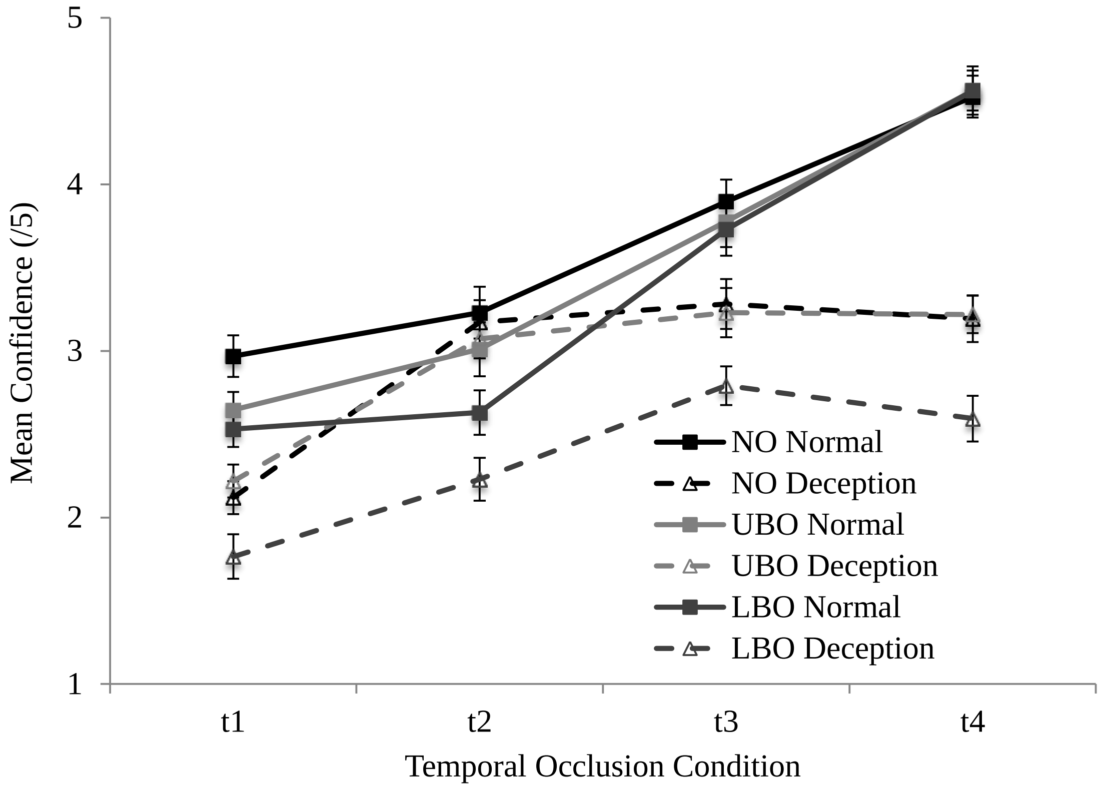

Figure 3.8. Mean confidence ratings for all participants in each spatial occlusion and deception condition, across the four temporal occlusion points, with standard error bars.

The distribution of solution probabilities for the 96 normal and 96 deception trials plotted separately for the high-skilled and low-skilled groups is presented in Figure 3.9. These represent the proportion of correct responses recorded for each trial and are plotted against the mean confidence rating recorded for the relevant group on that item. In the high-skilled group the variance in solution probabilities was larger for deception trials ($s^2 = .062$) than for normal trials ($s^2 = .016$). Hartley's variance ratio test indicated that this difference was significant, $F(47,47) = 3.88$, $p < .01$. The variance in solution probabilities was also larger for deception trials ($s^2 = .087$) than for normal (s^2

= .024) in the low-skilled group, $F(95, 95) = 3.63$, $p < .01$. Pearson's product-moment correlations of the linear relationship between mean response accuracy and mean confidence for the high-skilled group revealed significant relationships for both normal and deceptive trials. In contrast, only a significant linear relationship was found for normal trials in the low-skilled group (see Table 3.2).

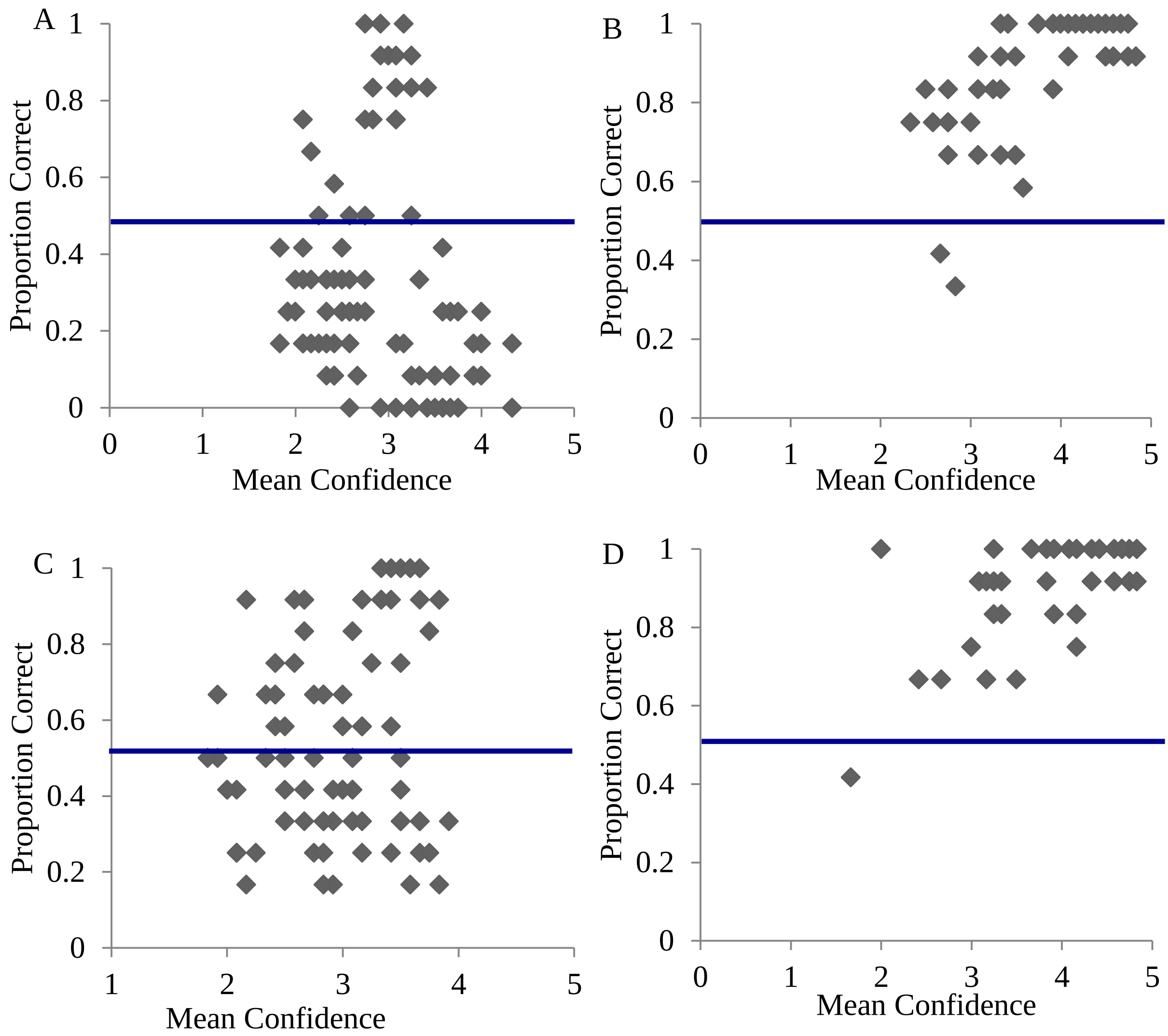

Figure 3.9. The proportion of correct responses on each trial plotted against the mean confidence rating for that item. Panels A and B show data for the low-skilled group and Panels C and D show data for the high-skilled group, on deception and normal trials, respectively.

Table 3.2.

Pearson's product-moment correlation coefficients (r) from Judgement Accuracy (JA) and Confidence Rating (CR) in normal and deception trials for high-skilled and low-skilled soccer players.

JA vs. CR	Normal	Deception
High-skilled	.605**	.205*
Low-skilled	.622**	-.185

$^{*}p < .05$, $^{**}p < .01$

3.9 Discussion

The aim of the two experiments was to examine high-skilled and low-skilled performers' susceptibility to deception when viewing (a) full video format and (b) point-light displays that isolate kinematic information. In addition to this, the present study sought to examine the relative importance of the upper-body and lower-body regions to perceiving deceptive intent and also examined the nature of the judgements being made through confidence ratings. The two experiments revealed that skill-level influenced the participants' ability to judge direction change, especially when the movement contained deceptive intent. In line with previous research, high-skilled performers were superior to their low-skilled counterparts at discriminating between genuine and deceptive movement. High-skilled performers were able to maintain this perceptual-cognitive advantage when viewing point-light videos of the deceptive and non-deceptive movements. There was a relatively small difference in performance across the three spatial occlusion conditions, suggesting that information-rich cues are conveyed in the movement of both of the upper and lower body.

3.9.1 Response accuracy. The results provide further evidence that, within their domain of expertise, high-skilled performers have a greater ability to discriminate between genuine and deceptive movement compared to low-skilled performers; a finding that supports previous research (Jackson et al., 2006; Rowe et al., 2009; Sebanz & Shiffrar, 2009; Cañal-Bruland & Schmidt, 2009; Dicks et al., 2010a; Smeeton & Williams, 2012). However, high-skilled players were also susceptible to deceptive movements, in agreement with findings in soccer (Dicks et al., 2010a) and tennis (Rowe et al., 2009). Overall, high-skilled performers demonstrated superior performance in both non-deceptive and deceptive trials compared to low-skilled performers.

In both experiments, low-skilled soccer players performed below chance level during the deception trials (Full video: *M* = 0.36, *SE* = 0.02; Point light: *M* = 0.32, *SE* = 0.02), whereas high-skilled performers continued to perform above chance level (Full video: *M* = 0.57, *SE* = 0.02; Point light: *M* = 0.57, *SE* = 0.02). The fact that low-skilled participants performed below chance level in some of the deception conditions represents clear evidence that the step-over motion was effective at deceiving the observer into making an incorrect judgement. Accordingly, the low-skilled participants were not simply guessing during the deception trials as performance would have regressed toward 0.50. In Experiment 1, performance for the high-skilled and low-skilled groups was better in the no deception condition than in the deception condition (*M* Difference = 0.36, *M* Difference = 0.49, respectively). These differences were similar to those for the high-skilled and low-skilled groups in Experiment 2 when viewing point-light video (*M* Difference = 0.35, *M* Difference = 0.55, respectively). The extent of this deterioration in low-skilled performers supports the finding that they are more susceptible to deception than high-skilled performers. Both experiments reported comparable findings, which indicated that performers were able to interpret the players' actions when presented with kinematics alone at a similar standard to that demonstrated in the full video trials.

There was a main effect of spatial occlusion, with the highest mean performance recorded in the NO condition, followed by LBO and UBO conditions in Experiment 1. Judgement accuracy was again highest in the NO condition in Experiment 2 with the LBO and UBO conditions yielding the same mean values. In both experiments, there was only a relatively small difference between the NO condition and UBO/LBO conditions, indicating that when either the upper or lower body was occluded performers were able to maintain their performance levels similar to that demonstrated in the NO condition. Once again in both experiments, there was a significant interaction between spatial occlusion and deception, which demonstrated that occluding the upper body resulted in greater susceptibility to deception.

The specific spatial differences between high- and low-skilled performers' information pick-up remain to be determined. Nonetheless, the present findings comparing performance across deception and no deception conditions under different types of spatial occlusion lead to a number of conclusions. First, the data indicate there are important visual cues located in both the upper and lower body that can deceive both the high-skilled and low-skilled observer. That is, both the low-skilled and high-skilled group performed considerably worse when viewing deceptive trials, irrespective of the type of spatial occlusion. Second, when information contained in the upper body region is occluded, both low-skilled and high-skilled performers become more susceptible to deception.

With regard to the specific temporal differences between high- and low-skilled performers' the present findings indicate that high-skilled participants were better able to extract important kinematic information from advance visual cues, allowing them to make correct judgements earlier than low-skilled participants. The data also indicates that participants were more susceptible to deception during the earlier temporal occlusion conditions, with a marked improvement occurring at the later time points due to the appearance of veridical information.

The data presented suggest that the ability to discriminate between genuine and deceptive movement is another hallmark of perceptual expertise. In both experiments, high-skilled participants demonstrated high levels of accuracy in picking up relevant information whilst viewing each trial. The ability to detect deceptive movement could be considered as an additional element of anticipation.

3.9.2 Confidence ratings. Analysis of the judgement confidence ratings revealed a significant difference between confidence in non-deceptive and deceptive trials, with both groups demonstrating higher confidence in non-deceptive trials. This finding differs from those found previously: Jackson et al. (2006) examined a one-on-one rugby tackle situation, wherein participants rated a higher confidence score on trials containing deceptive movement than on non-deceptive trials. However, this difference could simply be due to the nature of the skill presented in the video clips; for example, deceptive movement in rugby is conveyed by exaggerating the movement of certain parts of the body that are not mechanically related to the final running direction, and minimising the movements of the body parts that are related to final running direction (Brault et al., 2010). These types of movement are likely to facilitate cue-based judgements. A biomechanical comparison between the changing direction strategies (with and without deception) employed by soccer players is required to highlight the exaggerated and minimised biomechanical parameters associated with deception, in order to identify whether there are differences between a rugby side step and soccer step-over.

The distribution of situational probabilities revealed similar positive correlations between confidence and performance in normal trials for both the high-skilled and low-skilled group (see Table 3.1 and 3.2). In contrast, a significant linear relationship was only found for the high-skilled group in deceptive trials. Furthermore, response accuracy revealed a larger variance on deception trials in both the high- and low-skilled groups. This supports previous work, suggesting that deceptive actions are anticipated in a cue-based mode.

On non-deceptive trials, confidence increased from t1 to t4 in line with performance data. However, both experiments demonstrated that during the deceptive trials judgement confidence did not increase as much from t1 to t3, and judgement confidence actually decreased from t3 to t4. The highest mean confidence was recorded in the NO condition, which follows the performance data trends. However, the performance data only showed a small difference between the three spatial occlusion conditions, whereas the confidence ratings revealed a greater difference between the occluded and non-occluded trials. It is possible that the removal of such a large piece of the visual display (upper/lower body) led to a reduction in confidence in and of itself, independent of the specific area occluded.

3.10 Summary

Over the past 40 years, researchers have established that sport expertise is at least partly dependent upon the capability to anticipate an opponent's intentions and actions. Inferring others' intent is a common - and necessary - characteristic of human behaviour; hence it is surprising that the high-skilled advantage in discriminating between genuine and deceptive information has been largely overlooked in sport.

The results indicate that high-skilled players' superior ability to anticipate movement from advance cues extends to the detection of advance deceptive movement. The results indicate that there are visual sources present in the upper and lower body area that drive the high-skilled ability to discriminate between genuine and deceptive movement effectively even when other visual sources are occluded.

One possible implication is that perceptual training interventions may be better directed towards enhancing the ability to detect deception rather than training players to become attuned to non-deceptive movement. Further research is needed to assess the precise nature of differences between skilled and less-skilled performers, utilising other process tracing measures such as visual gaze behaviours and verbal reports.

Chapter 4

Study 2: The Effect of Top-Down Probability Information on Anticipation Skill

4.1 Introduction

Examining the factors that affect the decisions individuals make in time-constrained environments is important for understanding expertise in many activities, from driving to specialist activities in emergency or military operations (Ward, Suss, & Basevitch, 2009). Sport provides an excellent domain in which to study the human capacity for making judgements in highly time-constrained situations using participants who have invested many years of training to attain a high level of expertise. Researchers in sport have highlighted the ability of high-skilled performers to accurately anticipate the outcome of a situation based on advance visual information gleaned from their opponent (Müller & Abernethy, 2012). This ability to discriminate between subtle differences in early visual stimuli under severe time constraints is a defining characteristic of expertise in many sports (Mann, et al., 2010).

Research into human cognition has established that individuals actively interact with incoming sensory information, and judgements are therefore influenced by a variety of cognitive processes. For example, researchers have demonstrated that context enables participants to increase accuracy and reduce processing time across a number of domains, from chess to medicine (Chase & Simon, 1973; Verkoeijen, Rikers, Schmidt, van de Wiel, & Kooman, 2004). In the sport domain, there is currently very little empirical research concerning the use of strategic knowledge and how it interacts with a performer's ability to process advance visual information. Based on the limited evidence available, it appears that expert performers may be able to assign subjective probabilities to guide their future actions (Abernethy, et al., 2001; Alain & Proteau, 1980; Paull & Glencross, 1997).

Decision making is composed of two main components: first, the bottom-up data-driven component and, second, the top-down component which refers to the influence of a variety of factors, such as contextual information, expectations, prior knowledge, motivation, hope, and state of mind (Dror & Fraser-Mackenzie, 2008). The influence of top-down processing has been demonstrated in a number of studies, all confirming biased effects on perception and judgement (e.g., Dror, Charlton, & Péron, 2006; Eberhardt, Goff, Purdle, & Davies, 2004; Jones, Paull, & Erksine, 2002). Despite top-down processing being considered a sign of expertise, it can also contaminate the decision-making process through the loss of objectivity. For example, Dror and Fraser-Mackenzie found that when individuals examine information in light of prior top-down influences, they are more likely to select and focus on elements that validate and conform to prior information or expectations.

Posner and colleagues developed an experimental paradigm to examine top-down control over attention (Posner 1978, 1980; Posner, et al., 1980). In this paradigm, a target appears in one of two locations, and the observer is required to efficiently detect the target. Prior to the presentation of the stimulus, a cue indicates the probable location of the target with high validity (e.g., 80% of cues are valid). The typical finding from this paradigm is that performance (measured with response times or target detection accuracy) is better in the valid cue trials versus the invalid cue trials. Studies based on Posner’s paradigm indicate that performance in visual search tasks is facilitated by pre-cueing the location where the target stimulus will appear. This 'head start' for the attentional system is evidenced by improved response accuracy and faster response time in cases where the target appears in the expected location compared to when the target appears in an unexpected location. Furthermore, there is evidence from studies examining the manipulation of spatial attention that cueing non-relevant features typically elicits a deterioration in the performance of both experts and novices (Theeuwes, Kramer, & Atchley, 1999). Posner's spatial cueing paradigm can be used as a guide to design experimental sport tasks in order to further understand how 'top-down' and 'bottom-up' processes interact in time-constrained perceptual tasks.

Spatial pre-cues exert their influence on visual processing by directing the limited-capacity attentional system to the appropriate locations (Chun & Wolfe, 2001). However, as attentional resources are limited, allocation of attention to a cued location is accompanied by withdrawal of attentional resources from uncued locations. As a result, performance suffers when a target appears in an unexpected location (Theeuwes et al., 1999). One way in which this has been investigated is through the use of eye-movement registration systems whilst performing detection tasks using the cueing paradigm (Duc, Bays, & Husain, 2008).

In spite of the increasing availability and use of statistical information by athletes through the use of notational analysis there is a paucity of research examining the influence of top-down processing on the visual judgements underpinning anticipation skill in sport. Alain and colleagues reported findings that highlighted the ability of skilled racquet players to use their task-specific experience to assign probabilities to those events likely to occur with any given situation (Alain & Proteau, 1977; Alain & Sarrazin, 1990; Alain, et al., 1986). Similarly, Paull and Glencross (1997) found that expert and novice baseball batters improved their anticipatory performance when objective variables (i.e., ball and strike information) were added to a simulated batting task to provide strategic information. From these findings it was concluded that situational probability information plays such a key role during the task of baseball batting that all players use this information effectively (Paull & Glencross, 1997). However, only the strategic information for which there was a high level of agreement about what pitch would likely follow was selected for use in the experiment.

In light of increasing use of performance analysis in sport there has been a renewed interest in examining the contribution of situational probability information to anticipatory skill (McRobert et al., 2011; Farrow & Reid, 2012). For example, McRobert et al. manipulated contextual information during a simulated cricket batting task. Participants were required to anticipate ball destination during a low- and high-context condition. In the low-context condition they viewed randomised clips from different bowlers. In the high-context condition, they viewed a block of six trials from the same opponent that provided cumulative information on the bowler's performance tendencies. Skilled participants demonstrated superior performance, a more effective visual search strategy and provided more detailed verbal reports than less-skilled participants. All participants improved anticipation accuracy when contextual information was available. In addition, skilled batters altered their visual search strategy when additional context was available. McRobert et al. suggested that the absence of a group by context interaction was due to the high-context condition being too short in comparison to real-life sport competition and noted that the task only manipulated subjective information. Based on these findings McRobert et al. suggested researchers should increase the level of manipulation in order to more accurately mimic real-life competition.

Aside from this limited evidence demonstrating the benefits of contextual information for perceptual-cognitive performance, researchers in sport have yet to examine how specific top-down probability information affects the processing of advance visual information underlying anticipation skill (Williams, 2000). To date researchers have indicated that additional contextual information used in time-constrained tasks assists performers in improving their anticipatory performance (Abernethy et al., 2001; Buckolz, Prapaveis, & Fair, 1988; McPherson, 2000; McRobert et al., 2011; Paull & Glencross, 1997). These researchers have highlighted the difficulties in employing suitable paradigms to examine skill-based differences in anticipatory performance with the addition of situational probabilities. The common difficulty that has arisen in these studies revolves around the type of laboratory-based manipulation of contextual information (Paull & Glencross, 1997; McRobert et al., 2011). McPherson and Kernodle (2007) suggested that laboratory tasks examining performance must contain enough contextual information over a longer period of time to ensure that current event profiles can be examined. It has previously been proposed that the high-context conditions may have been too brief, providing limited information and no feedback (McRobert et al., 2011). The present study aims to overcome these common problems through employing a novel approach, based on an adaptation of the spatial cueing paradigm in a soccer prediction task.

The main objective of the study is to examine the influence of top-down probability information on the anticipatory judgements of high-skilled and low-skilled performers. In line with the notion of 'anticipatory bias' and response priming (Paull & Glencross, 1997), it is hypothesised that the addition of probability information will be more beneficial to high-skilled than low-skilled performers, and that this effect will be moderated by the degree of certainty conveyed in the probability information. Based on findings using the spatial cueing paradigm it is predicted that performers will have a faster response time during valid trials (expected) compared to invalid trials (unexpected), and that this difference will be more prominent in the high-skilled group.

4.2 Method

4.2.1 Participants. 30 male soccer players were recruited. Skilled participants (*n* = 15; *M* age = 20.6 years, *SD* = 2.4) were semi-professional soccer players, with nine having played at county level, and a further two having played at Premier League academy level. They had a mean of 14.2 years (*SD* = 2.8) playing experience and had been playing at a semi-professional level for a mean of 3.8 years (*SD* = 1.5). The low-skilled participants (*n* = 15; *M* age = 24.4 years, *SD* = 4.1) had a mean of 1.3 years (*SD* = 1.2) playing experience at recreational level (e.g., local Sunday league club). Participants provided informed consent and were free to withdraw from testing at any stage. All procedures were conducted according to the ethical guidelines of the institution.

4.2.2 Task design. The task was a two-choice prediction task in which the participant viewed life-size video sequences of an attacking player dribbling the ball towards them before changing direction to the left or right from the participant's perspective. Two male (*M* age = 18.5 years, *SD* = 0.7) Premier League academy soccer players were recruited to create the video-based test stimuli. A digital video camera (Canon HV40) was used to record the video stimuli from a first-person perspective. The camera was positioned on a tripod 11.5 m from the start point of the approaching player at a height of 1.4 m, so that it approximated an individual’s regular in-game viewing perspective. After a practice period, players were asked to run directly towards the camera and change direction at the execution point marked on the floor towards one of two targets located behind the camera at an angle of 45˚ to the left and right of the line of approach. On non-deceptive trials, players were instructed to run directly towards the camera before changing direction in one well-executed movement. On deceptive trials, the players were asked to perform a single step-over prior to changing direction in one well-executed movement. The players were instructed to perform each trial as they would in a match, running at pace directly towards the camera before changing direction, and maintaining close control of the ball. A panel of two UEFA 'B' and one UEFA 'A' licensed coaches rated each individual video clip under three categories: (1) smoothness of the approach run, (2) realistic game pace, (3) efficient execution of the change in direction. Each category was equally weighted and the mean score was taken from each coach to determine which 12 trials would be selected for each player.

The selected trials were entered into test protocols in E-Prime (v.2.0.1; Psychology Software Tools, Inc., Pittsburgh, Pennsylvania, US) to construct a two-choice prediction task that consisted of 144 trials. The final test footage was presented in 12 blocks of 12 trials. The test trials were blocked by player and player order was counterbalanced across participants. Within the six blocks corresponding to each player there were two sub-blocks of the three levels of probability conditions. These three probability conditions were also counterbalanced across participants. Three genuine levels of probability information were used, indicating the probability of the player changing direction to either the left or right. These were 50% - 50% (control condition), 67% [left/right] - 33% [right/left], and 83% [left right] - 17% [right left]. The order of the 12 individual trials within each block was randomised by the E-Prime software. The duration of each trial was approximately 2 s and was followed by a 5 s inter-trial interval. During the 5 s inter-trial interval a grey screen was projected for the first two seconds providing participants time to register their response, this was followed by another two second projection showing the next trial number and lastly a one second grey screen prior to the onset of the next trial. The test stimuli were projected (Optoma HD25, CA, USA) onto a 1.6 m (h) x 2.1 m (w) wall. As shown in figure 4.1, participants stood at a distance of 2.8 m perpendicular to the centre of the screen, with

0.72 m (l) x 0.39 m (w) response mats (Defender Security, Farnell, Leeds, UK) placed on the floor 0.1 m away from the participant's left and right feet. Participants were instructed to respond to the visual stimuli using pressure sensitive response mats that recorded response time and accuracy. Response time reflected both the individual's movement time and reaction time.

Figure 4.1. The experimental setup and the perceptual-cognitive soccer representative task simulation.

4.2.3 Procedure. Prior to testing, participants were given an overview of the experiment and presented with 16 practice trials in order to familiarise them with the experimental setup. These trials comprised eight trials from each player, presented with and without deception. No probability information was provided during the practice trials. Participants were given a 2-minute break prior to commencing the test trials and an opportunity to ask any further questions was provided. Prior to each block of test trials the relevant probability information was presented on the screen and read out by the experimenter (e.g., “In the next series of 12 video clips, the chance of the player changing direction to the left and right is 83% and 17%”). The probability information for both the left and right was presented on the corresponding side on the projection screen. There was a 20 s inter-block interval, where a grey screen was presented for 4 s, prior to a 1 s screen showing the next block number, which was immediately followed by the next block’s probability information for 13 s. The last 2 s of the inter-block interval showed a grey screen indicating that the next trial was about to begin. Participants were given a 2-minute rest period after every three blocks, which depicted video from one of the players shown in each of the three probability conditions. The practice and test trials took approximately 30 minutes in total.

4.2.4 Data analysis. The dependent measures were the mean proportion of correct judgements and response time. Prior to the main analysis, the data for the two models used to create the test stimuli were compared. Response accuracy and response time data were entered into separate 2 (Expertise: high-skilled, low-skilled) x 2 (Model: model A, model B) x 2 (Deception: deception, no deception) x 3 (Probability condition: 50:50, 66:34, 83:17) ANOVAs with repeated measures on the last three factors. The analyses revealed no significant main effect of model; nor any significant interactions between level of expertise and model factors. As a result, the data were collapsed across the two models for the main analysis.

Response accuracy and response time data were entered into separate 2 (expertise) x 2 (deception) x 3 (probability condition) ANOVAs, with repeated measures on the last two factors. For both dependent measures, a separate analysis was conducted to examine the differences between expected and unexpected trials based on prior knowledge. To do this, the response accuracy and response time data from the

66:34 and 83:17 conditions were entered into separate 2 (Expertise) x 2 (Deception) x (Probability condition) x 2 (Expectation: expected, unexpected) ANOVAs with repeated measures on the last three factors. For each analysis the assumptions relating to parametric analyses and the *F* distribution, such as normality, homogeneity of variances, independence of raw scores, and sphericity of the repeated measures values were evaluated. The univariate output was assessed with alpha set at .05 and a Greenhouse-Geisser correction was applied to the degrees of freedom in any instances in which the sphericity assumption was violated.

4.3 Results

4.3.1 Response accuracy. The ANOVA revealed significant main effects for expertise, $F(1, 28) = 35.69$, $p < .001$, $\eta_p^2 = .56$, and deception, $F(1, 28) = 89.47$, $p < .001$, $\eta_p^2 = .76$. The main effect of probability condition was non-significant, $F(2, 56) = 2.96$, $p = 0.06$, $\eta_p^2 = .09$. High-skilled players (*M* = 0.97, *SE* = 0.02) were more accurate anticipating the action of opponents compared to low-skilled players (*M* = 0.79 *SE* = 0.02). High-skilled players demonstrated superior performance in both normal and deception trials (*M* = 0.99, *SE* = 0.02; *M* = 0.95, *SE* = 0.03, respectively) compared to the low skilled players (*M* = 0.88, *SE* = 0.02; *M* = 0.69, *SE* = 0.03, respectively). There was also a significant interaction between expertise and deception, $F(1, 28) = 39.29$, $p < .001$, $\eta_p^2 = .58$, caused by the difference in performance between the high-skilled and low-skilled groups being greater in the deception trials than no deception trials, meaning that the high-skilled group were less susceptible to deception compared to the low-skilled group.

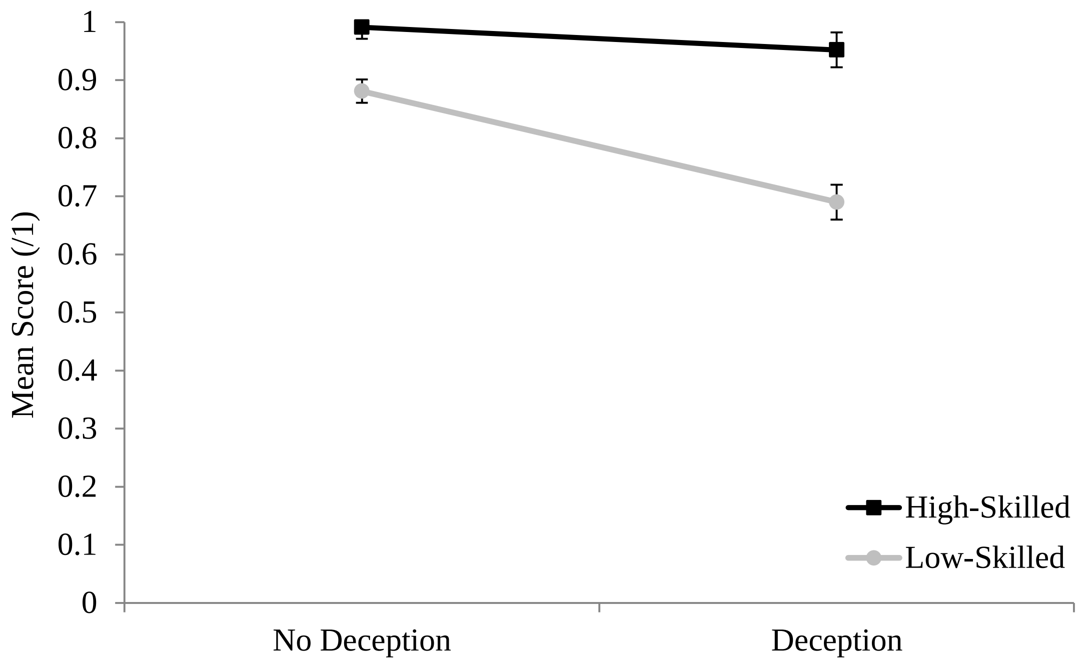

Figure 4.2. The mean proportion of correct judgements made by the high-skilled and low-skilled groups on non-deceptive and deceptive trials, with standard error bars.

There was a significant interaction between expertise and probability condition, $F(2, 28) = 4.68$, $p < .05$, $\eta_p^2 = .14$. High-skilled players outperformed low-skilled players in all probability conditions, with the greatest difference between the two groups occurring in the 50:50 condition (see Figure 4.3). The high-skilled group performed close to ceiling level across all three probability conditions, whilst the low-skilled group increased their judgement accuracy slightly across the three probability conditions, from 50:50 to 66:34 to 83:17 (see Figure 4.3). The probability condition by deception interaction was non-significant, $F(2, 56) = 2.56$, $p = .09$, $\eta_p^2 = .08$, as was the three-way interaction between probability condition, deception, and expertise, $F(2, 56) = 2.21$, $p = .12$, $\eta_p^2 = .07$.

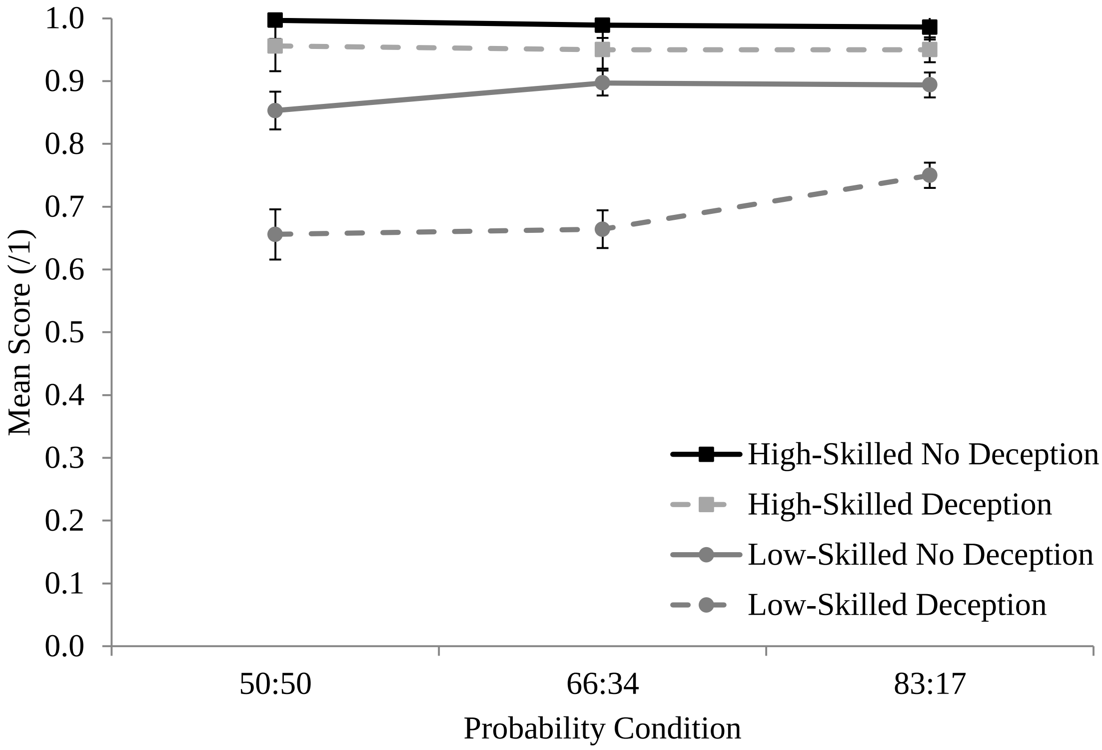

Figure 4.3. The mean proportion of correct judgements made by the high-skilled and low-skilled groups on deception and no deception trials across three probability conditions, with standard error bars.

4.3.2 Response accuracy and expectation. To check for the effect of model, response accuracy data from the 66:34 and 83:17 conditions were entered into a 2 (expertise) x 2 (deception) x 2 (probability condition) x 2 (expectation) x 2 (model) ANOVA with repeated measures on the last four factors. This revealed a significant main effect of model, $F(1, 28) = 5.72$, $p < .05$, $\eta_p^2 = .17$, and a significant three-way interaction between model, deception and expectation, $F(1, 28) = 9.43$, $p < .01$, $\eta_p^2 = .25$. The difference between performance on deceptive and non-deceptive trials was larger when the direction was unexpected; however, this effect was greater in Model B than in Model A. As these effects did not interact with expertise the data were collapsed across the two players for the main analysis.

The 4-way ANOVA revealed significant main effects for expertise, $F(1, 28) = 55.21$, $p < .001$, $\eta_p^2 = .64$, probability condition, $F(1, 28) = 5.96$, $p < .05$, $\eta_p^2 = .18$, expectation, $F(1, 28) = 60.35$, $p < .001$, $\eta_p^2 = .68$, and deception, $F(1, 28) = 93.81$, $p < .001$, $\eta_p^2 = .77$. Judgement accuracy was higher when the model moved in the expected direction ($M = 0.93$, $SE = 0.02$) than in the unexpected direction ($M = 0.74$, $SE = 0.02$). This was superseded by a significant interaction with expertise, $F(1, 28) = 11.86$, $p < .01$, $\eta_p^2 = .30$, caused by the low-skilled group having a greater difference in performance between expected and unexpected trials ($M = 0.86$, $SE = 0.02$; $M = 0.59$, $SE = 0.03$, respectively) than the high-skilled group ($M = 0.99$, $SE = 0.02$; $M = 0.89$, $SE = 0.03$, respectively). Thus, the effect of expectation was greater in the low-skilled group than the high-skilled group (see Figure 4.4).

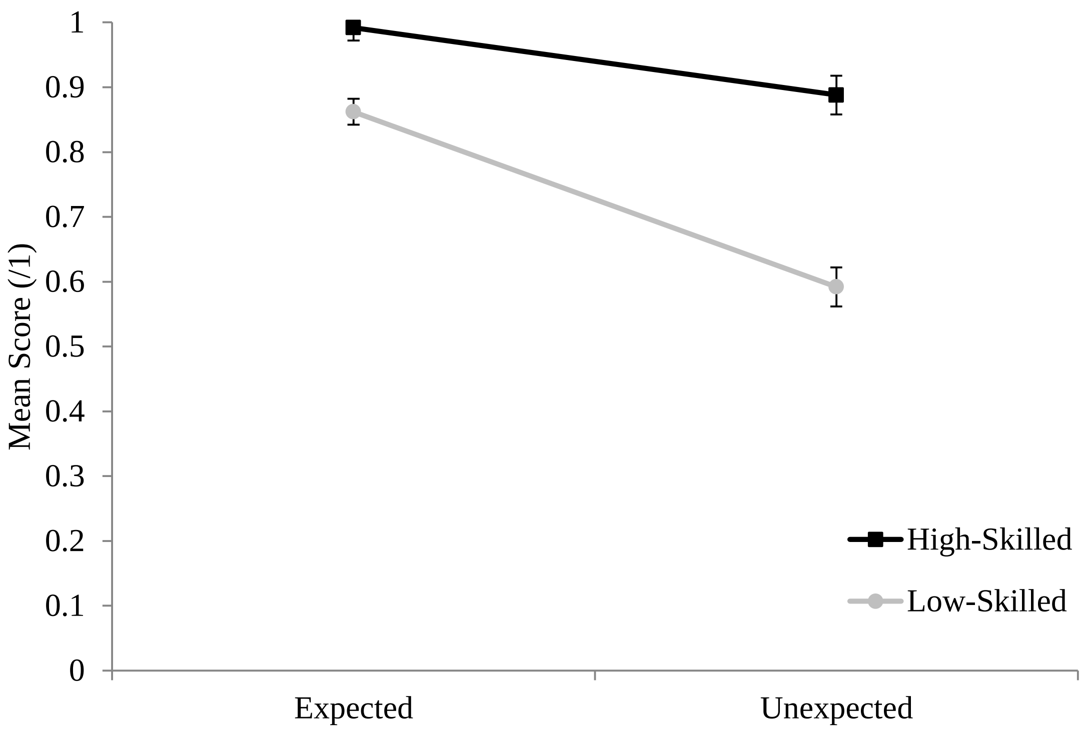

Figure 4.4. The mean proportion of correct judgements made by the high-skilled and low-skilled groups on expected and unexpected trials, with standard error bars.

The ANOVA also showed a significant interaction between probability condition and expectation, $F(1, 28) = 18.23$, $p < .001$, $\eta_p^2 = .39$. This was caused by the performance differential between expected and unexpected direction change being greater in the 83:17 condition than in the 67:33 condition, as shown for both expertise groups in figures 4.5 and 4.6. The three-way interaction between expectation, expertise and probability condition was non-significant, $F(1, 28) = 2.85$, $p = .10$, $\eta_p^2 = .09$.

Expectation also interacted significantly with deception, $F(1, 28) = 14.97$, $p < .01$, $\eta_p^2 = .35$, caused by the difference in performance between deceptive and non-deceptive trials being greater when the model moved in the unexpected direction. This effect was consistent for both groups, reflected in the non-significant higher-order interaction with expertise, $F(1, 28) = 1.42$, $p = .24$, $\eta_p^2 = .05$. All other interactions were non-significant ($p > .05$).

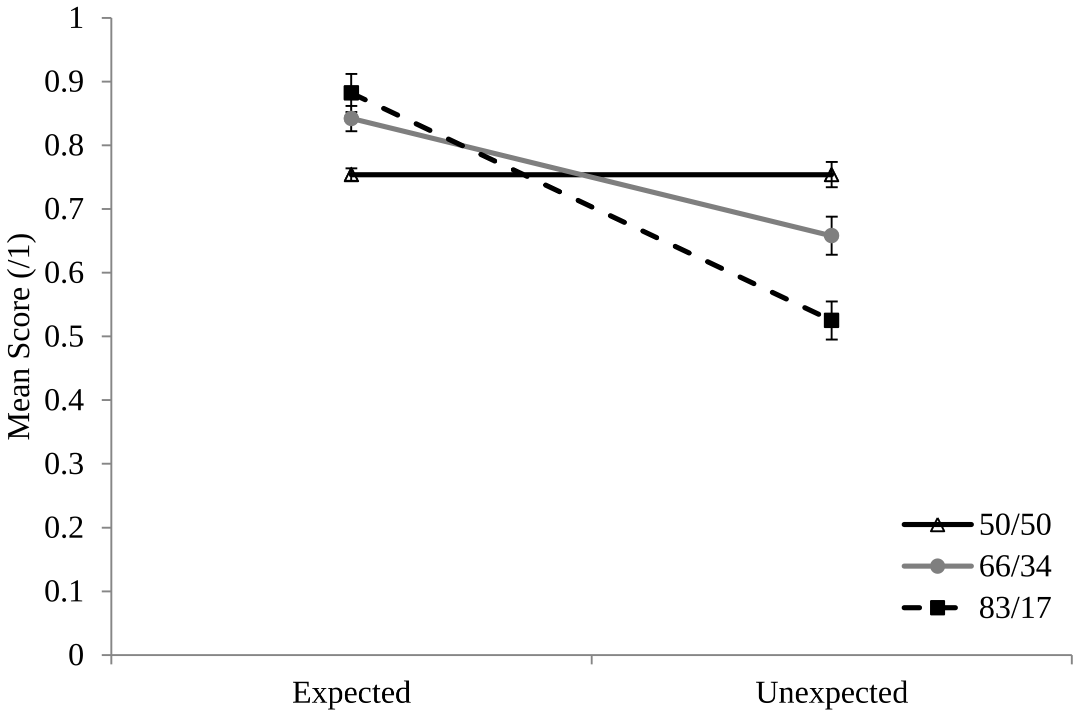

Figure 4.5. The mean score, expressed as the mean proportion of correct judgements made by the low-skilled group on expected and unexpected trials across three probability conditions, with standard error bars.

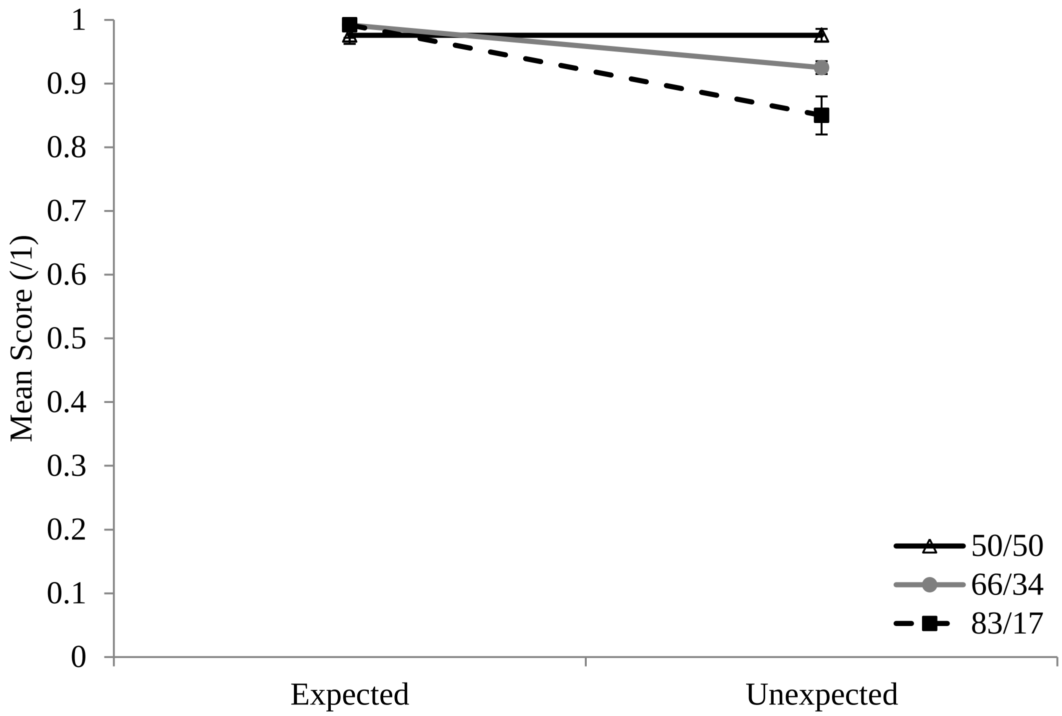

Figure 4.6. The mean score, expressed as the mean proportion of correct judgements made by the high-skilled group on expected and unexpected trials across three probability conditions, with standard error bars.

4.3.3 Response time. The ANOVA revealed a significant interaction between probability condition and deception, $F(2, 56) = 39.85$, $p < .001$, $\eta_p^2 = .59$. Participants had slower response times in the non-deceptive trials compared to deceptive trials in the 50:50 and 83:17 conditions. However, in the 66:34 condition slower response times were evident in the deceptive trials than in the non-deceptive trials. The main effect of expertise approached significance, $F(1, 28) = 3.87$, $p = .06$, $\eta_p^2 = .12$, reflecting slightly faster response times in the high-skilled group ($M = 1729.84$, $SE = 26.43$) than in the low-skilled group ($M = 1803.38$, $SE = 26.43$). All other main effects and interactions were non-significant ($p > .05$).

4.3.4 Response time and expectation. Data from the 66:34 and 83:17 conditions were first entered into a 2 (expertise) x 2 (deception) x 3 (probability condition) x 2 (expectation) x 2 (model) ANOVA with repeated measures on the last four factors. There were two significant interactions relating to model: model by deception, $F(1, 28) = 25.21$, $p < .05$, $\eta_p^2 = .47$, and a 3-way interaction between model, deception, and probability condition, $F(1, 28) = 69.54$, $p < .05$, $\eta_p^2 = .71$. The model by deception interaction reflected that response time was slightly faster in the non-deceptive trials compared to the deceptive trials for Model A, whereas the converse was true for Model B. The three-way interaction indicated that this effect was most pronounced in the 66:34 condition. Once again, as these interactions did not involve expertise, the data were collapsed across the two models for the main analysis.

The 4-way ANOVA revealed a significant main effect of expectation, $F(1, 28) = 11.05$, $p < .01$, $\eta_p^2 = .28$. Response time was faster when the model moved in the expected direction ($M = 1763.68$, $SE = 19.53$) than in the unexpected direction ($M = 1783.93$, $SE = 18.01$). This effect did not interact significantly with expertise, $F(1, 28) = 0.55$, $p = .47$, $\eta_p^2 = .02$, and all other main effects and interactions involving expectation were non-significant ($p > .05$).

4.4 Discussion

The primary aim of this study was to determine the impact of providing top-down (probability) information to the anticipatory performance of high-skilled and low-skilled soccer players. A one-versus-one soccer task was used to simulate a situation frequently encountered in matches, with ecological validity enhanced by the use of large projected video stimuli and the requirement for participants to make physical responses in 'real time'. Response accuracy and response time data were collected to examine skill-based differences during a two-choice prediction task. It was predicted that the addition of probability information would be more beneficial to high-skilled than low-skilled performers, and that this effect would be moderated by the degree of certainty conveyed. Consistent with research using Posner's spatial cueing paradigm, it was further predicted that response time would be faster when the model changed direction in the expected direction than in the unexpected direction, and that this effect would be greater for the high-skilled group compared to the low-skilled group.

Consistent with the findings reported in Chapter 3, high-skilled participants were more accurate in judging direction change, and were less susceptible to deception compared to their low-skilled counterparts on the one-versus-one soccer task. These findings support previous research that has measured anticipation skill and susceptibility to deception in sport (Rowe, Horswill, Kronvall-Parkinson, Poulter, & McKenna, 2009; Sebanz & Shiffrar, 2009).

The data were inconclusive as to whether the provision of probability information is more beneficial to high-skilled than low-skilled participants. High-skilled performers are more experienced in extracting visual information cues and anticipating an opponent’s movement from bottom-up visual stimuli, and the provision of ‘top-down’ information is considered to provide a ‘head start’ for the attentional system. Therefore, we predicted that the addition of probability information would be more beneficial to the high-skilled group, as they would be better able to integrate top-down probability information with bottom-up visual information. The data proved inconclusive in this regard, in part due to high-skilled performers' baseline level of performance. Specifically, the high-skilled group performed close to ceiling level in the 50:50 condition, therefore there was little scope for showing further improvement in the 67:33 and 87:13 conditions. By contrast, the low-skilled group’s performance at 50:50 left plenty of scope for improvement at the other two probability levels. The finding that the low-skilled group's judgement accuracy improved slightly from the 50:50 to the 67:33 and 87:13 conditions corroborates previous research demonstrating the ability of both high-skilled and low-skilled performers to benefit from provision of contextual information (McRobert et al., 2011; Paull & Glencross, 1997).

Unlike previous studies examining the effect of contextual information on performance, the present study examined both the costs and benefits of receiving probability information on anticipation performance. During expected trials the high-skilled group maintained performance close to ceiling level, whilst the low-skilled group's performance increased from the 50:50 condition and, consistent with the general hypothesis, was moderated by the degree of certainty conveyed through the probability information. When viewing unexpected trials, both groups suffered a progressively greater decrement in performance from the 66:34 condition to 83:17 condition relative to their performance in the control (50:50) condition. This decrement in performance was greater for the low-skilled group who suffered a mean absolute decrease of over 31% in judgement accuracy compared to a mean decrease of just under 9% in the high-skilled group in the 83:17 condition. This finding indicates that the high-skilled group were better able to accommodate the probability information in so far as they were able to limit the costs of this knowledge when the model moved counter to expectation.

A common debate in the cognitive psychology literature is whether top-down processes can override bottom-up processes, and vice versa (Koelewijn, Bronkhorst, & Theeuwes, 2009). Dror and Fraser-Mackenzie (2008) claimed that individuals are more likely to select and focus on elements that conform to prior expectations, causing the allocation of attention to be selective and biased. Chen and Zelinsky (2006) also concluded that top-down guidance dominates bottom-up sources when the two sources of information are put in competition. In the present study, both skill groups anticipation performance was moderated by the degree of certainty conveyed by the probability information provided. However, due to the high-skilled group performing at ceiling-level it is impossible to accurately compare the costs and benefits associated with receiving probability information, and therefore no conclusions can be made regarding whether top-down information dominates bottom-up information during unexpected trials.

A growing body of research has shown that contextual information enhances anticipatory responses. However, the majority of these studies have focused on performers' ability to utilise contextual information to assign subjective probabilities (Paull & Glencross, 1997; McRobert et al., 2011; Farrow & Reid, 2012). It has been suggested that in some cases previous research designs have been limited due a lack of contextual information being provided over a short space of time (McPherson & Kernodle, 2007; McRobert et al., 2011). In order to develop such research, the current study developed a novel adaptation of Posner's spatial cueing paradigm, to examine the influence of top-down probability information on anticipatory performance. The current findings have implications for those interested in developing anticipation skill, and enhancing our understanding of how 'top-down' and 'bottom-up' processes interact in time-constrained perceptual tasks. It is widely accepted that an individual's perceptual judgements are influenced by the contextual information available; therefore it is vital that researchers and sport practitioners understand how top-down information, that drives a performer's expectations, interacts with the incoming bottom-up visual stimuli. The present findings provide one method in which to further examine the skill-based differences in anticipatory performance with the addition of top-down probabilistic information

4.4.1 Limitations. The absence of the predicted expertise by probability condition interaction in the response accuracy data could be due to the use of non-occluded stimuli in order to gather both response accuracy and response time data. Participants were encouraged to respond ‘as quickly and accurately as possible’; however, response time was not constrained as it would be in a real one-versus-one situation. Participants were therefore able to view the full video clip of the models changing direction, rather than attempting to ‘anticipate’ their on-screen opponent’s movement. In so doing, the high-skilled group performed close to ceiling level. In order to better compare the benefits, as well as costs, associated with providing probability information about likely events temporal occlusion might be employed to reduce the control (50:50) level of performance in the high-skilled group.

Future research should also attempt to examine the visual search behaviours employed by high-skilled and low-skilled participants when attempting to anticipate dynamic one-versus-one soccer simulations with the addition of probabilistic information. Previous research has indicated that high-skilled and low-skilled players employ different visual search strategies compared to low-skilled players. These findings have suggested that successful anticipation in soccer requires players to direct visual attention to the most informative locations in the visual display. However, it is currently unknown how the addition of probability information alters visual search strategies in sporting tasks.

4.4.2 Conclusion. In summary, high-skilled soccer players were more accurate at anticipating opponents’ actions and were less susceptible to deception compared to their low-skilled counterparts. This study employed an original approach that provided probability information to soccer players to examine its impact on anticipation. However, due to the ceiling effects experienced by the high-skilled group data were inconclusive as to whether top-down probabilistic information is more beneficial to high-skilled players. In order to further understand the costs and benefits associated with ‘top-down’ and ‘bottom-up’ processes on anticipation skill, time constraints relating to the stimuli presented should be introduced to mimic real-life sport situations, thereby affording some control over the levels of baseline performance. In addition, collecting visual search data will help better identify the mechanisms underpinning skilled performance, and the influence of top-down processing on visual search behaviours across skill groups.

Chapter 5

Study 3: The Effect of Top-Down Probability Information on Perceptual-Cognitive Processes during an Anticipation Task

5.1 Introduction

Despite the growing use of notational analysis in sport and the value that elite performers place on situational probability information (Farrow & Reid, 2012), there is a paucity of empirical research concerning the use of strategic knowledge and how it interacts with athletes' ability to process advance visual information. Based on the limited evidence available in the sport domain, it appears that situational probability information may help prime rapid responses when confirmatory information subsequently appears within (Paull & Glencross, 1997; Abernethy, et al., 2001; McRobert, et al., 2011; Farrow & Reid, 2012). Researchers have indicated that differences occur in perceptual-cognitive processes (e.g., visual search strategies) and performance measures (e.g., response accuracy) when contextual information about an opponent is available compared with when it is not available (MacMahon & Starkes, 2008; McRobert, et al., 2011).

An established cornerstone of human cognition is that individuals do not passively receive and encode information; they interact with the incoming sensory information. Consequently, an individual’s perception and judgement are influenced by a range of cognitive processes (Dror, et al., 2005). Yantis (1998) distinguished between top-down, goal driven and bottom-up, stimulus driven processes. Likewise, Corbetta and Shulman (2002) distinguished between two associated attentional systems: the goal-directed system influenced by expectation, knowledge and current goals and a stimulus-driven system influenced by salient stimuli. The goal-directed system is involved in the top-down regulation of attention, whereas the stimulus-driven system is involved in the bottom-up control of attention. In practice, these two systems frequently interact in their functioning (for a review, see Pashler, Johnston, & Ruthruff, 2001). For example, Dror et al., (2005) examined the effects of contextual top-down information on a student population's ability to match fingerprints. Their findings demonstrated that participants cued with emotionally charged contextual information, such as explicit disturbing crime scene photos and emotional background stories, were more likely to indicate a match between ambiguous fingerprints than uncued control participants. One key question that emerged from this study was whether experts are less susceptible to top-down interference, perhaps even being immune to such effects. More recently, researchers have replicated these findings across several forensic disciplines with detectives and forensic experts, concluding that experts rely on top-down information when conducting bottom-up processing of visual data. This reliance on top-down information has been evidenced by biased judgements (e.g., Dror, 2009; Dror & Cole, 2010).

The spatial cueing paradigm introduced by Posner and colleagues (Posner, 1980; Posner & Cohen, 1984; Posner, et al., 1980) has played a key role in understanding spatial attention. In the spatial cueing paradigm participants are presented one of two cues: informative cues, which can be either valid or invalid and non-informative cues. The valid cue gives the correct information about the upcoming location of the stimulus. The invalid cue gives misleading information about the upcoming location. A non-informative cue is non-predictive about the location of the stimulus to be presented. Following the presentation of the cue, participants have to identify a target as fast as possible. Cues come in various forms, e.g. the brightening of an object (Posner & Cohen, 1984), the appearance of simple stimuli (Posner, et al., 1980), or a symbol, such as an arrow, indicating where the target stimulus will appear (Posner & Cohen, 1984). Numerous studies have demonstrated that such attentional shifts to the cued location can produce faster and more accurate responses when stimuli are presented at attended locations (Posner, 1980; Posner & Cohen, 1984; Posner & Petersen, 1990). When individuals anticipate a stimulus to appear at a specific location, they are able to direct their attention to that location, which as a result enhances their perception of that stimulus at that location (Posner, 1980). Furthermore, there is evidence from studies examining the manipulation of spatial attention that cueing non-relevant features typically results in a deterioration of performance in both experts and novices (Theeuwes, Kramer, & Atchley, 1999).

It is important to recognise that the decision making process in sport is not only influenced by the visual information retrieved from an opponent's movement, but also the performer's prior knowledge, expectations and goals. Although there has been relatively little research on the role of probability information in soccer (Ward & Williams, 2003), research in other sports suggests that skilled performers are able to use their experience to effectively assign subjective probabilities to those events likely to occur (Alain & Proteau, 1980; Alain & Sarrazin, 1990; Paull & Glencross, 1997; Abernethy et al., 2001; McRobert et al., 2011). For example, Paull and Glencross found that expert and novice baseball batters improved their ability to predict the type of ball being pitched when count information was available. In squash, Abernethy et al. found that skilled players were able to utilise contextual information 620 ms before racquet-ball contact to support superior shot selections. These studies are linked in so far as the manipulations influence the participants' knowledge of the probability of likely events.

Research examining the perceptual processes underlying anticipation skill in sport has increased rapidly in recent years as researchers seek to understand better what governs the expert advantage. Researchers have highlighted that high-skilled players employ different visual search strategies compared to low-skilled players, using more extensive task-specific knowledge structures to focus on more relevant areas of interest (Williams, Ward, Knowles, & Smeeton, 2002). During one-versus-one tasks high-skilled performers typically use visual search strategies involving fewer fixations of longer duration. In contrast, low-skilled and novice performers typically display more fixations of shorter duration and fixate on more and potentially less informative locations (Helsen & Starkes, 1999; Savelsbergh et al., 2002). There have been a number of studies across different soccer tasks that have explored the visual search behaviours of performers with varying levels of expertise. Of particular relevance to the present study, Williams and Davids (1998) examined the visual search patterns of high-skilled and low-skilled soccer players when viewing defensive simulations in soccer (11 vs. 11, 3 vs. 3 and 1 vs. 1). In the one-versus-one situation, high-skilled players employed a greater number of fixations between the hip and ball-foot region compared with low-skilled players, who largely fixated on the ball. Their findings demonstrated that visual search behaviours alter as a function of skill level, with different search strategies and information sources becoming more pertinent in relation to the type of task.

A handful of researchers have examined how visual search behaviours during anticipation skill tasks are affected by the use of contextual information. For instance, McRobert et al. (2011) examined how the underlying processes used by skilled and less-skilled cricket batters when making anticipation judgements were affected by the provision of contextual information. In the low-context condition, the batsmen viewed a total of 36 random deliveries bowled by ten different bowlers, whereas in a the high-context condition batsmen were presented with an entire over from each of six bowlers who had delivered only one ball each in the first condition. Batsmen improved their judgement accuracy in the high-context condition, with the addition of contextual information compared to the random viewing condition. The analysis also revealed systematic differences in visual search behaviours between expertise groups and across the context conditions. During the high-context condition batters reduced their mean fixation duration, and batsmen also altered their gaze behaviours to spend more time fixating on more central (head-shoulder region) than peripheral (ball-hand region) areas. There was also a significant group main effect for the mean number of fixation locations, with skilled batters viewing significantly more locations compared to their less-skilled counterparts. This finding contrasts with previous research that has reported fewer fixations of longer duration by skilled performers in tasks that focus solely on the opponent’s postural orientation and movements (Ripoll, 1991; Savelsbergh et al., 2002; Vickers, 1996; Williams & Davids, 1998).

Presently, it is not known how visual search findings from anticipation skill tasks are affected by the processing of top-down, probability information. McRobert et al. (2011) relied on batsmen making accurate predictive inferences from contextual information, whereas the present study will provide participants with explicit probability information in order to examine the use of top-down probability information versus bottom-up visual stimuli during an anticipation task where improvement does not rely on the performers' long-term working memory. Accordingly, the primary objective of the present study is to analyse visual search data to make inferences about the allocation of visual attention during an anticipation task where top-down probability information is provided. It is predicted that high-skilled soccer players' superior anticipation skill will be underpinned by skill-based differences in visual search behaviours. With probability information above chance level, we predict that skilled performers will be more inclined to seek confirmatory cues associated with the expected event rather than search more broadly for predictive information. This is expected to result in progressively fewer fixations of longer duration as information becomes more definite. The second objective of the study is to extend the findings of Study 2 by using a temporal occlusion paradigm to lower mean judgement accuracy of high-skilled players so we can better ascertain the benefits as well as costs associated with participant expectations. In line with study 2, it is hypothesised that that the addition of probability information will be more beneficial to high-skilled than less-skilled performers, and that this effect will be moderated by the degree of certainty conveyed.

5.2 Method

5.2.1 Participants. Participants were 15 high-skilled (*M* age = 21.5 years, *SD* = 2.3) and 15 low-skilled (*M* age = 23.3 years, *SD* = 3.1) soccer players. High-skilled participants had a mean of 16.1 years (*SD* = 2.9) playing experience. They were currently playing at semi-professional level, with 12 having played at county level, and a further three players having played at Premier League academy level. The low-skilled participants had a mean of 1.8 years (*SD* = 1.5) playing experience at recreational level (e.g., local Sunday league club). Participants signed an informed consent form and reported normal or corrected to normal levels of visual function. The study was approved by the institution’s Ethics Committee and carried out under its ethical guidelines.

5.2.2 Test stimuli. Two right-footed adult male (*M* age = 18.5 years, *SD* = 0.7) Premier League academy soccer players were recruited to create the video-based test stimuli. Each player was filmed 'dribbling' the ball directly towards the camera then changing direction to the left and to the right, with and without a step-over. A digital video camera (Canon HV40, Tokyo, Japan) was used to record the stimuli from a defensive player's perspective. The camera was mounted on a tripod at a height of 1.4 m, approximating the eye height of a defensive player standing in a slightly crouched position. Players began their approach 11.5 m from the camera and changed direction approximately 5.3 m from the camera towards one of two targets placed at an angle of 45˚ to the initial approach. Two types of trials were filmed: ‘no deception’ and ‘deception’ trials. On non-deceptive trials, the players were instructed to run directly towards the camera and then to change direction in one well-executed movement. On deceptive trials, the players were asked to perform a step-over prior to changing direction. The players were instructed to perform each trial as they would in a match, running directly towards the camera whilst maintaining close control of the ball and changing direction in one smoothly executed movement. A panel of two UEFA ‘B’ and one UEFA ‘A’ licensed coaches independently rated each individual video clip under three categories: (1) smoothness of the approach run, (2) realistic game pace, (3) efficient execution of the change in direction. Each category was equally weighted and the mean score was taken from each coach to determine which 12 trials would be selected for each player.

The film sequences were edited (Pinnacle Studio 14) to create two occlusion conditions relative to foot-ball contact (0 ms, +80 ms). These conditions were selected based on the temporal occlusion findings from Chapter 3, and a pilot study that examined participants’ anticipatory performance across five temporal occlusion conditions (-240 ms, -160 ms, -80 ms, 0 ms , +80 ms). The two conditions selected were considered to be the time points most likely to reduce high-skilled anticipatory performance to approximately 75%. The two temporal occlusion conditions are depicted in Figure 5.1, both of which illustrate a step-over. The test trials comprised of 12 kicks from each of the two players (three left: no deception, three left: deception, three right: no deception, three right: deception), these 12 trials were repeated across both temporal occlusion conditions and the three probability conditions (the probability conditions were repeated once for each player). In total there were 144 trials. The test protocols were developed in E-Prime (v.2.0.1; Psychology Software Tools, Inc., Pittsburgh, Pennsylvania, US), with the two models and three probability conditions blocked separately. Block order was counterbalanced and the order of individual trial presentation within each block was randomised with respect to deception condition and temporal occlusion. Each trial lasted approximately 1.5 s and an inter-trial interval of 5 s was used for participants to register their response and prepare for the next trial. The test video stimuli were projected (Optoma HD25, CA, USA) onto a wall to create a 1.6 m (h) x 2.1 m (w) image. Participants stood central 2.8m away from the screen, with response mats placed on the floor next to the player's left and right feet (see Figure 5.2).

Normal

(No Deception)

Deception

Figure 5.1. A schematic representation of the two temporal occlusion conditions. One of the models is shown performing a normal (non-deceptive) trial and deceptive trial to the left from the viewer's perspective.

An eye-tracking system (Scene Camera ViewPoint Eye Tracker, Arrington Research, Scottsdale, AZ, USA) was used to collect participants' visual search data. The eye-tracking system uses infrared video with dark pupil tracking, which uses the relationship between the pupil and a reflection from the cornea to compute gaze within a scene. The accuracy ratings range between 0.25°-1.0° visual arc with a spatial resolution of 0.15° visual arc. Horizontal visual range is +/- 56° of visual arc while vertical is +/- 42° of visual arc. The data were analysed frame-by-frame using Anvil video annotation software (Kipp, 2001). A fixation was operationally defined as point-of-gaze being maintained on a location for a minimum of 120 ms (McRobert et al., 2011).

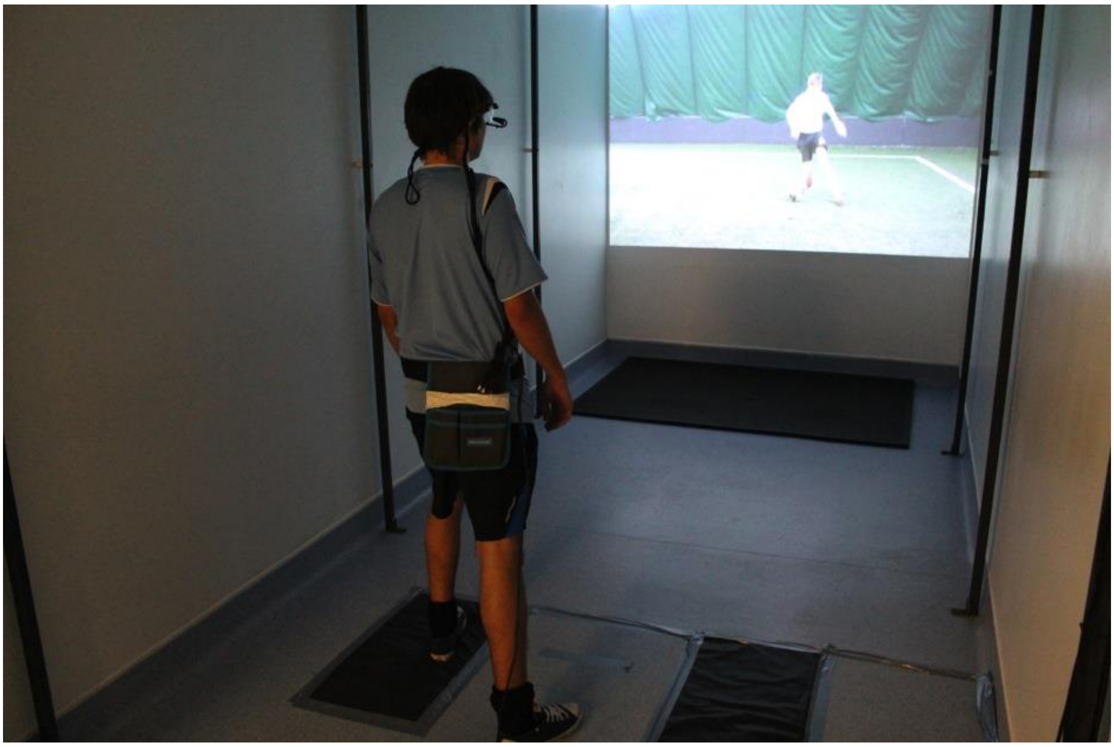

Figure 5.2. The experimental setup, with eye-tracking, and the perceptual-cognitive soccer representative task simulation.

5.2.3 Procedure. Prior to commencing the experimental task, the test procedure was explained and the eye-movement system fitted onto the participant's head. The eye-tracking device was fitted on the participant's head and they took position 2.8 m away from the screen. The system was calibrated using a reference of 9 points on the scene image. Periodic calibration checks were conducted after the 3rd, 6th and 9th block. Following the initial calibration of the eye-tracking system the participants were presented with 16 practice trials, depicting examples of deceptive and non-deceptive movement at the two occlusion conditions, in order to familiarise them with the experimental setup and response requirements.

For each trial, participants were instructed to take up their normal defending stance and to step on either the left or right response pad to indicate their response. Before each block of the test trials, the probability of the player changing direction to the left and right was provided to participants. Three genuine levels of probability were given: 50% - 50% (control condition), 67% [left/right] - 33% [right/left], and 83% [left right] - 17% [right left]. In the control condition participants were informed that in the upcoming block of 12 trials there was an equal chance of the player changing direction to the left and to the right. In the other two conditions participants were told the probability of the player changing direction to the left and to the right, expressed in percentage terms. For example, “In the next series of 12 video clips, the chance of the player changing direction to the left and right is 83% and 17%”, with the percentage figures displayed in large font on the respective sides of the screen. Participants viewed 12 blocks of 12 trials, with a 2-minute rest period after every third block. The experiment took approximately 40 minutes in total for each individual participant. Upon completion of the experiment participants were then thanked for their participation and debriefed. Following completion of the analysis, participants were later contacted to inform them regarding their performance.

5.2.4 Data analysis.

5.2.4.1 Performance data analysis. Prior to the main analysis, the judgement accuracy data for the two models were compared in a 2 (Expertise: high-skilled, low-skilled) x 2 (Model: model A, model B) x 2 (Deception: deception, no deception) x 3 (Probability Condition: 50:50, 66:34, 83:17) ANOVA with repeated measures on the last three factors. The analysis revealed a non-significant main effect of model, $F(1, 28) = 0.48$, $p = .50$, $\eta_p^2 = .02$ and a non-significant interactions between model and expertise, $F(1, 28) = 0.03$, $p = .86$, $\eta_p^2 = .00$. As a result, the data were collapsed across the two models and entered into a 2 (Expertise) x 2 (Deception) x 3 (Probability condition) ANOVA, with repeated measures on the last two factors.

In a separate analysis examining the effect of expectation on judgement accuracy, data from the 66:34 and 83:17 conditions were entered into a 2 (Expertise) x 2 (Deception) x 3 (Probability Condition) x 2 (Expectation: expected, unexpected) ANOVA with repeated measures on the last three factors.

For each analysis the assumptions relating to parametric analyses and the F distribution, such as normality, homogeneity of variances, independence of raw scores, and sphericity of the repeated measures values were evaluated. The univariate output was assessed with alpha set at .05 and a Greenhouse-Geisser correction was applied to the degrees of freedom in any instances in which the sphericity assumption was violated.

5.2.4.2 Visual search data analysis. Two separate analyses were conducted. First, visual search behaviour during the player’s approaching run were analysed up to the frame before the foot contacted or passed in front of the ball (0 ms) in order to examine search rate and mean percentage viewing time at each location. Second, visual search behaviours in the final 9 frames of all trials occluded at +80 ms were analysed in order to examine the location of the final fixation and the timing of the onset of the final fixation. Visual search data reliability was established using the intra-observer (97.6%) and inter-observer (96.8%) agreement methods. In total, 25% of the data were re-analysed to provide the agreement figures using the procedures recommended by Thomas, Nelson and Silverman (2005).

5.2.4.2.1 Search rate. Three measures of search rate were examined. These were the mean number of fixations, the mean number of fixation locations and the mean fixation duration (ms). These variables were analysed in separate 2 (expertise) x 2 (deception) x 3 (probability condition) ANOVAs.

The mean percentage of total viewing time spent fixating on various areas of the display was also measured. The display was initially divided into eight fixation locations: head; shoulders; trunk; hips; knees; shins/feet; ball; unclassified. The unclassified category was subsequently excluded because none of the participants' fixations fell outside any of the other seven locations. Percentage viewing time data were analysed in a 2 (expertise) x 2 (deception) x 3 (probability condition) x 7 (location) ANOVA, with the last three factors entered as repeated measures.

5.2.4.2.2 Final fixation. Final fixation location and the timing of the final fixation were recorded. Final fixation location referred to the last location point recorded at +80 ms. As the player was closer to the camera at the later time points we were able to discriminate between the left and right knees/feet. Therefore, the display was divided into nine fixation locations: head; shoulders; trunk; hips; left knee; right knee; left shin/foot; right shin/foot; ball. The final fixation location data were entered into a 2 (expertise) x 2 (deception) x 3 (probability condition) x 9 (location) ANOVA. The timing of the final fixation was recorded as the time point of the onset of the final fixation where the eye remained stationary for a period equal to, or in excess of, 120 ms.

The timing of the final fixation data were entered into a 2 (expertise) x 2 (deception) x 3 (probability condition) ANOVA. As in the performance data analysis, the assumptions relating to parametric analyses and the *F* distribution, such as normality, homogeneity of variances, independence of raw scores, and sphericity of the repeated measures values were evaluated for each visual search analysis. The univariate output was assessed with alpha set at .05 and a Greenhouse-Geisser correction was applied to the degrees of freedom in any instances in which the sphericity assumption was violated.

5.3 Results

5.3.1 Response accuracy. Significant main effects were observed for expertise, $F(1, 28) = 99.67$, $p < .001$, $\eta_p^2 = .78$, probability condition, $F(2, 56) = 36.72$, $p < .001$, $\eta_p^2 = .58$, and deception, $F(1, 28) = 203.40$, $p < .001$, $\eta_p^2 = .88$. As predicted, high-skilled players were more accurate than less-skilled players at anticipating their opponent's actions (*M* = 0.82, *SE* = 0.02 vs. *M* = 0.59, *SE* = 0.02). Performance improved across the three levels of probability condition from 50:50 (*M* = 0.66, *SE* = 0.02) to 66:34 (*M* = 0.69, *SE* = 0.01) to 83:17 (*M* = 0.76, *SE* = 0.01). Performers were also more accurate on non-deceptive trials (*M* = 0.90, *SE* = 0.02) than on deceptive trials (*M* = 0.52, *SE* = 0.02). In all cases, the maximum mean score was 1, with a score of 0.5 being equivalent to chance level.

In addition to the main effect of deception, there were significant interactions between deception and expertise, $F(1, 28) = 14.36$, $p < .01$, $\eta_p^2 = .34$, and deception and probability condition, $F(1.52, 42.66) = 13.40$, $p < .001$, $\eta_p^2 = .32$. As can be seen in Figure 5.3, the difference in performance between the high-skilled and low-skilled groups was greater in the deception trials (*M* = 0.68, *SE* = 0.03; *M* = 0.35, *SE* = 0.03, respectively) than in the no deception trials (*M* = 0.96, *SE* = 0.03; *M* = 0.84, *SE* = 0.03, respectively).

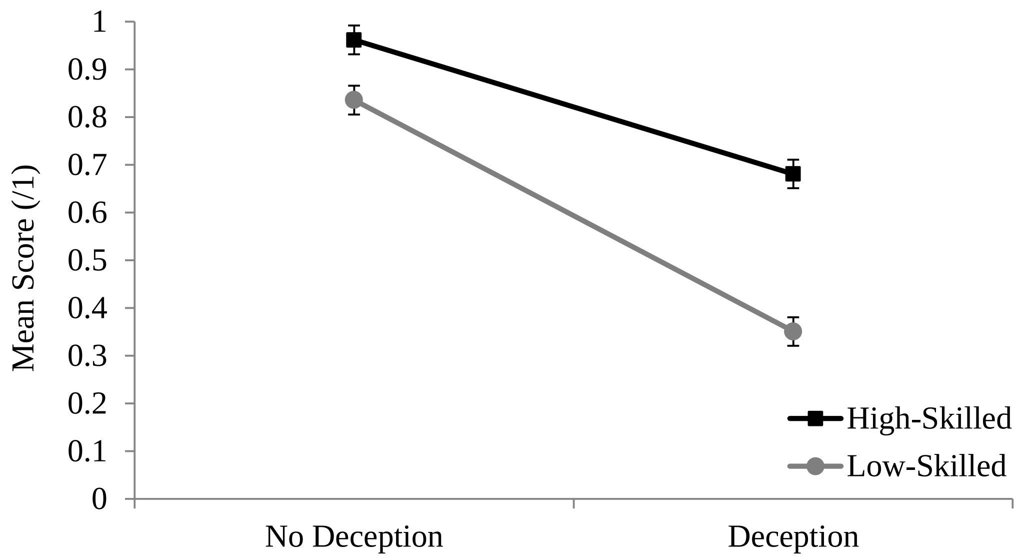

Figure 5.3. The mean proportion of correct judgements made by the high-skilled and low-skilled groups on non-deceptive and deceptive trials, with standard error bars.

The deception by probability condition interaction occurred due to the difference in judgement accuracy between deceptive and non-deceptive trials being notably greater in the 50:50 condition (*M* = 0.45) and the 66:34 condition (*M* = 0.41) than in the 83:17 condition (*M* = 0.29) (see Figure 5.4)**.**

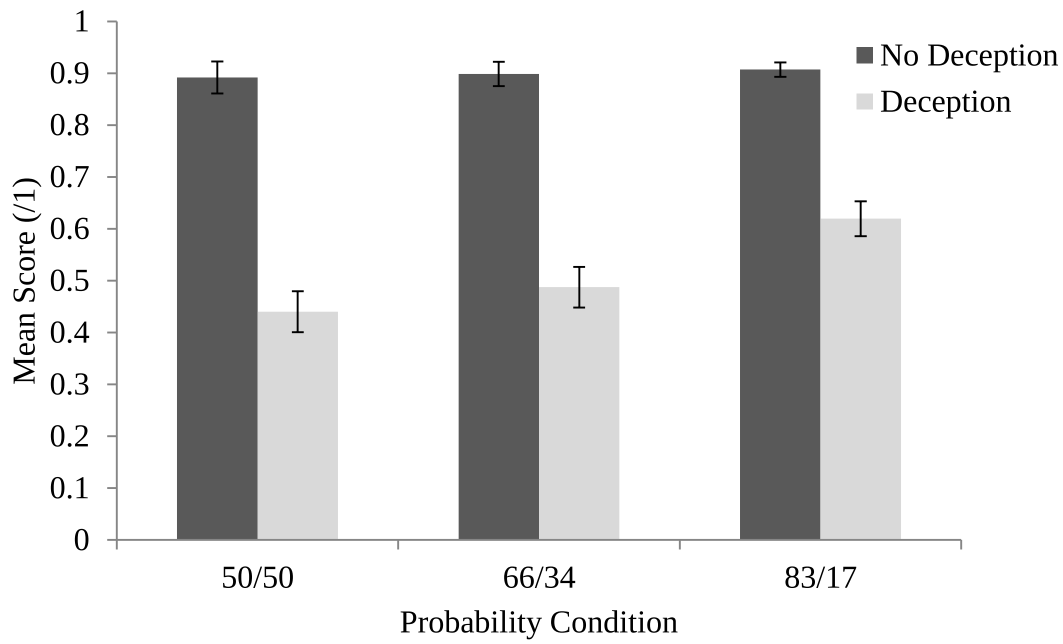

Figure 5.4. The mean proportion of correct judgements in deceptive and non-deceptive trials for the three levels of probability, with standard error bars.

As well as the main effect of probability condition, the analysis revealed a significant interaction between probability condition and expertise, $F(2, 56) = 7.52$, $p < .01$, $\eta_p^2 = .21$, illustrated in Figure 5.5. High-skilled participants outperformed low-skilled participants in all levels of probability condition. However, the extent of the expert advantage differed across the three probability conditions, with the greatest difference occurring in the 50:50 (*M* difference = 0.26) and 66:34 (*M* difference = 0.29) conditions compared to the 83:17 condition (*M* difference = 0.18). The 3-way interaction between probability condition, deception and expertise was non-significant, $F(1.52, 42.66) = 0.38$, $p = .63$, $\eta_p^2 = .01$.

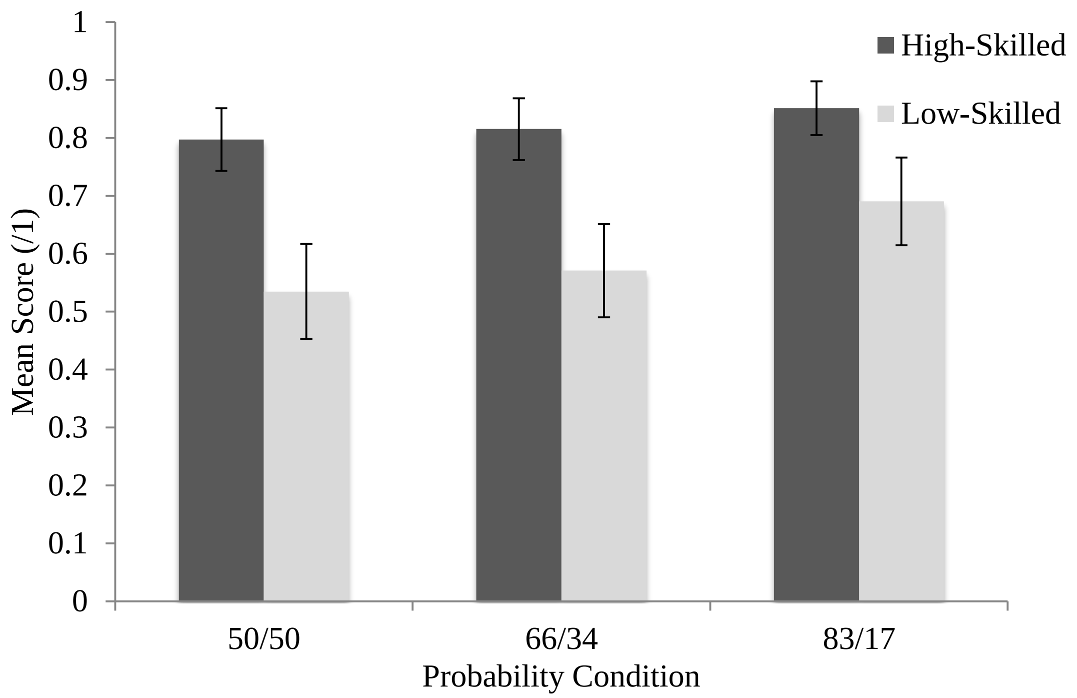

Figure 5.5. The mean proportion of correct judgements made by the high-skilled and low-skilled groups at each level of probability, with standard error bars.

5.3.1.1 Expectation. The analysis of the 66:34 and 83:17 data revealed a significant main effect for expectation, $F(1, 28) = 55.14$, $p < .001$, $\eta_p^2 = .66$. Performance was better when the model moved in the expected direction ($M = 0.76$, $SE = 0.01$) than in the unexpected direction ($M = 0.60$, $SE = 0.02$). The main effect of expectation was superseded by a significant probability condition by expectation interaction, $F(1, 28) = 20.14$, $p < .001$, $\eta_p^2 = .42$, which was caused by the difference in performance between the expected and unexpected directions being greater in the 83:17 condition ($M = 0.23$) than in the 66:34 condition ($M = 0.09$). There was a non-significant interaction between expertise and expectation, $F(1, 28) = 0.56$, $p = .46$, $\eta_p^2 = .02$, presented in Figures 5.6 and 5.7 for visual comparison.

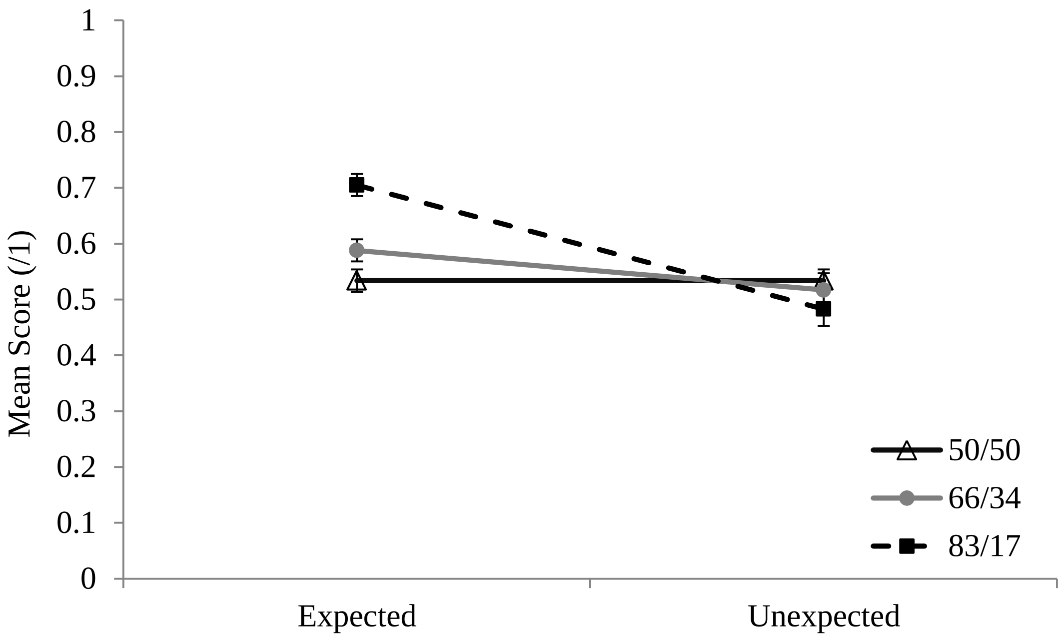

Figure 5.6. The mean score, expressed as the mean proportion of correct judgements made by the low-skilled on expected and unexpected trials across three probability conditions, with standard error bars.

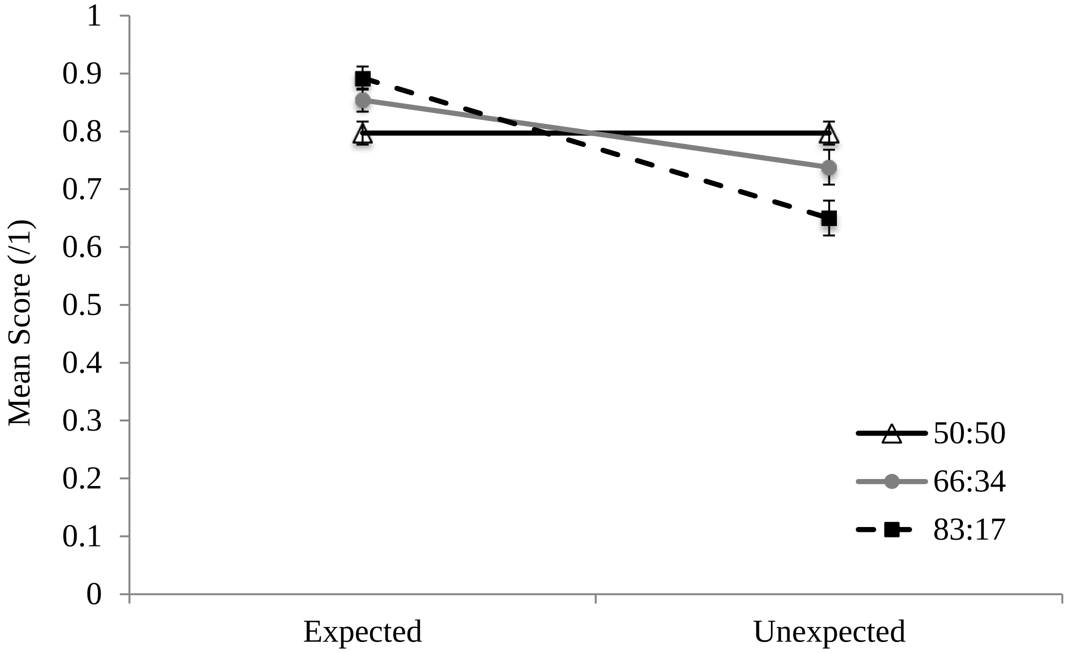

Figure 5.7. The mean score, expressed as the mean proportion of correct judgements made by the high-skilled on expected and unexpected trials across three probability conditions, with standard error bars.

5.3.2 Visual Search Data

5.3.2.1 Search rate. The results are presented in Table 5.1. There was a significant main effect of expertise for the mean number of fixations, $F(1, 28) = 129.25$, $p < .001$, $\eta_p^2 = .82$, mean duration of fixations, $F(1, 28) = 21.88$, $p < .001$, $\eta_p^2 = .44$, and the mean number of fixation locations per trial, $F(1, 28) = 34.15$, $p < .001$, $\eta_p^2 = .55$.

Table 5.1.

Mean (SE) Number of Fixations, Number of Fixation Locations, and Fixation Duration per Trial Across Expertise Groups.

	Group	
Search Rate	High-Skilled	Low-Skilled
No. of fixations	2.22 (0.04)	2.90 (0.04)
No. of fixation locations	1.99 (0.05)	2.43 (0.05)
Fixation duration (ms)	356.14 (9.75)	291.58 (9.84)

For the mean number of fixations there was also a significant main effect of deception, *F*(1, 28) = 6.38, *p* < .05, η_p^2 = .19, caused by a slightly higher mean number of fixations in the deception trials (*M* = 2.61, *SE* = 0.04) than in the no deception trials (*M* = 2.51, *SE* = 0.04). In addition to the main effect of deception, there was a significant deception by expertise interaction, *F*(1, 28) = 5.09, *p* < .05, η_p^2 = .15, caused by a greater increase in the number of fixations from no deception to deception trials in the high-skilled group (*M* = 0.20) compared to the low-skilled group (*M* = 0.12). The main effect of probability condition was non-significant, *F*(2, 56) = 0.82, *p* = .45, η_p^2 = .03, as was the probability condition and expertise interaction, *F*(2, 56) = 0.11, *p* = .93, η_p^2 = .04 and expertise by probability condition by deception, *F*(2, 56) = 1.14, *p* = .45, η_p^2 = .04.

Analysis of the data for mean number of fixation locations revealed significant main effects for probability condition, *F*(2, 56) = 182.47, *p* < .001, η_p^2 = .87, deception, *F*(1, 28) = 4.77, *p* < .05, η_p^2 = .15, and location, *F*(2.65, 74.15) = 24.20, *p* < .001, η_p^2 = .46. The mean number of fixation locations was greatest in the 50:50 probability level (*M* = 2.74, *SE* = 0.05), followed by 83:17 (*M* = 2.01, *SE* = 0.04) then 66:34 (*M* = 1.88, *SE* = 0.05). The number of fixation locations was also higher in deceptive trials (*M* = 2.25, *SE* = 0.04) compared to non-deceptive trials (*M* = 2.16, *SE* = 0.04). A greater number of fixations were made on the hips (*M* = 3.71, *SE* = 0.27), knees (*M* = 3.49, *SE* = 0.29) and feet (*M* = 3.11, *SE* = 0.35).

With respect to mean fixation duration, there were no significant main effects for probability condition, $F(2, 56) = 0.97$, $p = .39$, $\eta_p^2 = .03$, or deception, $F(1, 28) = 2.49$, $p = .13$, $\eta_p^2 = .08$. Similarly, there were no additional two- or three-way interactions ($p > .05$).

5.3.2.2 Percentage viewing time. The ANOVA revealed a significant main effect for fixation location, $F(2.95, 82.52) = 16.44$, $p < .001$, $\eta_p^2 = .37$, and interaction between expertise and fixation location, $F(2.95, 82.52) = 14.40$, $p < .001$, $\eta_p^2 = .34$ (see Figure 5.8). The low-skilled participants spent more time fixating on the knees (*M* = 30.0%, *SE* = 3.74) and feet (*M* = 36.5%, *SE* = 5.11) than did the high-skilled participants (*M* = 19.9%, *SE* = 4.01 and *M* = 4.2%, *SE* = 1.68, respectively). In contrast, high-skilled participants spent more time fixating on the shoulders (*M* = 19.9%, *SE* = 4.01), trunk (*M* = 21.9%, *SE* = 3.84) and hips (*M* = 33.5%, *SE* = 5.64) than did the low-skilled participants (*M* = 6.5%, *SE* = 1.66, *M* = 6.1%, *SE* = 2.13 and *M* = 14.5%, *SE* = 1.94, respectively).

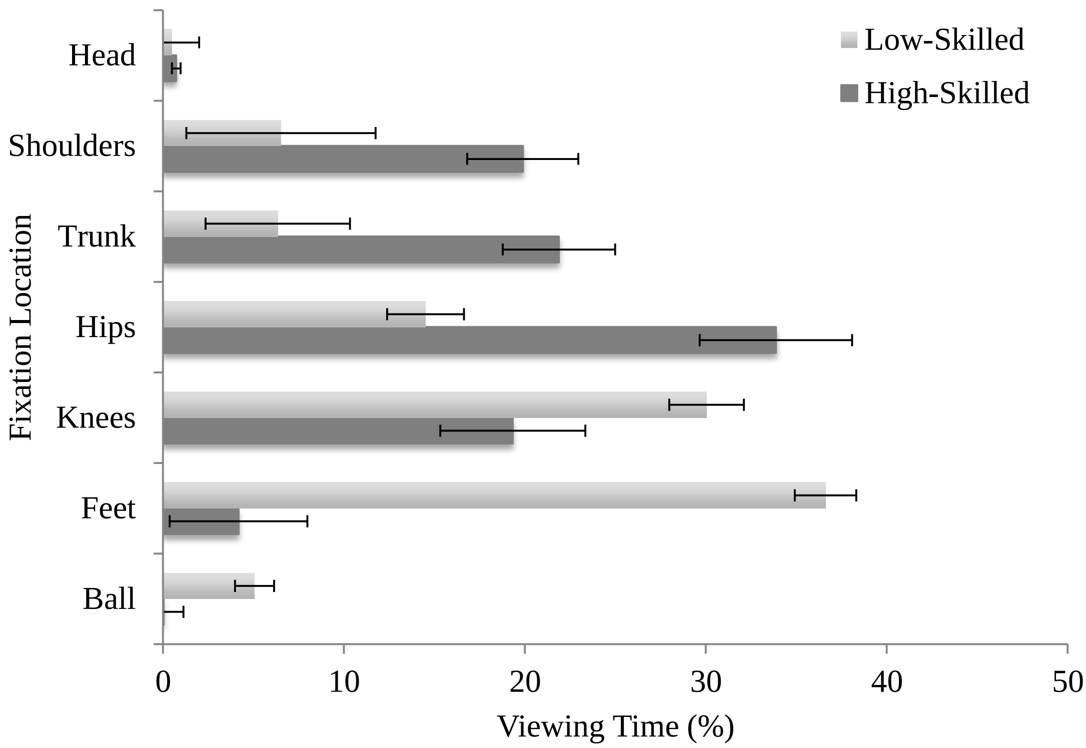

Figure 5.8. The mean percentage of time spent viewing each fixation location across expertise groups, with standard error bars.

The ANOVA revealed a significant probability condition by deception interaction, $F(2, 56) = 5.66$ $p < .01$, $\eta_p^2 = .17$. Participants' mean percentage viewing time across the seven locations decreased from non-deceptive trials to deceptive trials in the 50:50 and 83:17 probability conditions, compared to an increase in the 66:34 condition. This interaction was superseded by significant three-way interaction with expertise, $F(2, 56) = 3.74$ $p < .05$, $\eta_p^2 = .12$. High-skilled participants' mean percentage viewing time across the seven locations decreased from non-deceptive trials to deceptive trials in the 50:50 and 83:17 conditions, compared to an increase in the 66:34 condition. Whereas low-skilled participants' mean percentage viewing time increased from non-deceptive to deceptive trials in the 50:50 and 66:34 conditions, and decreased from non-deceptive to deceptive trials in the 83:17 condition. There was no significant main effect of probability condition, $F(2, 56) = 1.53$, $p = .23$, $\eta_p^2 = .05$, nor were there any other significant two- or three-way interactions ($p > .05$).

5.3.2.3 Location of Final fixation. The ANOVA revealed a significant main effect for location, $F(3.09, 86.64) = 22.65$, $p < .001$, $\eta_p^2 = .45$. In addition to the main effect there was a significant interaction between expertise and location, $F(3.09, 86.64) = 59.90$, $p < .001$, $\eta_p^2 = .68$. This occurred due to low-skilled participants spending more time fixating on the left foot ($M = 28.0\%$, $SE = 1.98$), right foot ($M = 27.2\%$, $SE = 1.94$), and ball ($M = 18.6\%$, $SE = 2.60$) compared to the high-skilled participants ($M = 1.7\%$, $SE = 0.71$, $M = 1.3\%$, $SE = 0.53$ and $M = 0.2\%$, $SE = 0.19$, respectively). In contrast, high-skilled participants spent more time fixating on the shoulders ($M = 11.7\%$, $SE = 2.60$), trunk ($M = 25.0\%$, $SE = 3.15$) and hips ($M = 45.0\%$, $SE = 5.10$) compared with their less-skilled counterparts ($M = 0.0\%$, $SE = 0.00$, $M = 0.7\%$, $SE = 0.43$ and $M = 4.8\%$, $SE = 0.83$, respectively). There was no significant main effect of deception, $F(1, 28) = 1.69$, $p = .21$, $\eta_p^2 = .06$, nor was the interaction between expertise and deception, $F(1, 28) = 2.00$, $p = .53$, $\eta_p^2 = .02$. There were no other significant main effects or interactions ($p > .05$).

5.3.2.3 Timing of the final fixation. There were significant main effects for expertise, $F(1, 28) = 54.09$, $p < .001$, $\eta_p^2 = .66$, probability condition, $F(1.58, 44.34) = 3.47$, $p < .05$, $\eta_p^2 = .11$, and deception, $F(1, 28) = 261.43$, $p < .001$, $\eta_p^2 = .90$. High-skilled players made their final fixation at an earlier time point compared to low-skilled players ($M = -228.99$, $SE = 9.28$ vs. $M = -132.46$, $SE = 9.28$). The timing of the final fixation became earlier as the degree of certainty conveyed increased from 50:50 ($M = -170.73$, $SE = 6.72$) to 66:34 ($M = -183.45$, $SE = 8.57$) to 83:17 ($M = -188.00$, $SE = 7.53$). The time of the final fixation occurred earlier on non-deceptive trials ($M = -274.96$, $SE = 11.83$) than on deceptive trials ($M = -86.49$, $SE = 3.77$). In addition to the main effect of deception, there was a significant deception by expertise interaction, $F(1, 28) = 117.05$, $p < .001$, $\eta_p^2 = .81$. The high-skilled group made their final fixation earlier than the low-skilled group on no deception trials (*M* = -386.28, *SE* = 16.73; *M* = -163.64, *SE* = 16.73, respectively); however, in the deception trials the high-skilled group made their final fixation later than the low-skilled group (*M* = -71.70, *SE* = 5.33; *M* = -101.30, *SE* = 5.33, respectively). There were no other two- or three-way significant interactions ($p > .05$).

5.4 Discussion

The aim of this study was to examine the processes underlying anticipation skill when probability information is available using a representative soccer task. It was predicted that the addition of probability information would be more beneficial to high-skilled than less-skilled performers, and that this effect would be moderated by the degree of certainty conveyed. It was further predicted that superior performance of high-skilled participants would be caused by systematic differences in visual search behaviours compared with low-skilled participants. More specifically, it was predicted that when probability information was provided skilled performers would be more inclined to seek confirmatory cues associated with the expected event rather than search more broadly for predictive information. This was expected to result in progressively fewer fixations of longer duration, with the onset of the final fixation occurring earlier as information becomes more definite.

High-skilled soccer players were more accurate in their judgements than the less-skilled players and, consistent with previous research, demonstrated a greater ability to discriminate between genuine and deceptive movement (Jackson, et al., 2006; Rowe, et al., 2009; Sebanz & Shiffrar, 2009; Cañal-Bruland & Schmidt, 2009; Dicks, et al., 2010a; Smeeton & Williams, 2012). However, high-skilled players were also susceptible to deceptive movements, in agreement with the findings in chapters three and four.

The data were inconclusive as to whether the addition of probability information is more beneficial to high-skilled than low-skilled participants. It was originally predicted that high-skilled players would be better able to integrate top-down probability information with bottom-up visual information, and that the provision of top-down information would enhance judgement accuracy. Contrary to our prediction, the interaction between expectation and expertise was non-significant, with both groups showing an increase in judgement accuracy when the model moved in the expected direction and a decrease in judgement accuracy when the model moved counter to expectations. However, the low-skilled group’s baseline performance was at chance level (see Figure 5.6), making it less likely that performance would decrease further in the 'unexpected' condition. An alternative interpretation is that both high-skilled and low-skilled participants are equally adept at utilising contextual information to improve performance (Paull & Glencross, 1997; McRobert et al., 2011).

The findings in Chapter 4 indicated a ceiling effect in the high-skilled group, with the present study indicating a potential floor effect for the low-skilled group. However, it is worth making a visual comparison between Figure 4.5 from Chapter 4 and Figure 5.7, which illustrate the low-skilled group’s performance in Chapter 4 and the high-skilled group’s performance in the present chapter, both of which are not restricted by ceiling or floor effects and baseline performance is of similar level. This comparison demonstrates that during expected trials there are positive benefits associated with receiving probability information, which is similar for both the high-skilled and low-skilled group. However, when comparing response accuracy during unexpected trials the costs of receiving the probability information is greater for the low-skilled group compared to the high-skilled group. Due to the skill-based differences in the present anticipation task it is difficult to directly compare how probability information affects judgement accuracy for both high-skilled and low-skilled players as their baseline performance levels are significantly different. Therefore, the comparison with data from Chapter 4 is informative as it allows for comparison of performance on the same task with a similar baseline performance for both skill groups. Specifically, the comparison between the high-skilled group's performance in the present study with the low-skilled group's performance in Study 2 provides some evidence towards our prediction that the high-skilled players would be better able to integrate top-down probability information with bottom-up visual information. The low-skilled group suffered a greater decrement in performance from baseline level during unexpected trials, indicating that they are less able to integrate top-down information with bottom-up information compared to the high-skilled group. As suggested by Dror and colleagues (Dror, 2009; Dror & Cole, 2010) it is possible that the low-skilled group were more reliant on top-down information leading to more biased responding during the unexpected trials.

Consistent with Study 2, judgement accuracy was moderated by the degree of certainty conveyed through the probability information. Both groups recorded an increase in judgement accuracy across the three levels of probability, with high-skilled participants outperforming low-skilled participants at each level. The improvement in accuracy from the 50:50 to 83:17 levels was greatest for the low-skilled group; however, it should be noted that they performed around chance level in the 50:50 probability trials. Again, through comparison of the high-skilled group's performance in the present study and the low-skilled group's performance in Study 2, it is apparent that both groups improved their judgement accuracy to a similar level across the three probability conditions, suggesting that the probability information was of benefit to both skill groups.

The eye-movement data revealed several differences in visual search behaviour between high-skilled and low-skilled participants. It was hypothesised that skilled performers would be more inclined to seek confirmatory cues associated with the expected event rather than search more broadly for predictive information, resulting in fewer fixations of longer duration as information becomes more definite. As predicted, the search rate analysis indicated that high-skilled participants made fewer fixations of longer duration and on significantly fewer locations in the visual display compared with low-skilled participants. Differences in visual search rate were comparable to those presented in previous work using eye-movement recording and one-versus-one film based situations (Savelsburgh et al., 2002; Williams & Davids, 1998), confirming that high-skilled performers employed a more efficient visual search strategy indexed by fewer fixations of longer duration. Other researchers have typically found that when the ball is nearer the goal (e.g., 3-vs-3), or during one-versus-one tasks, lower search rates appear to be preferable due to the increased role of peripheral vision, with players needing to extract information from relatively fewer areas of interest (Vaeyens, et al., 2007; Williams & Davids, 1998).

The data demonstrated that high-skilled participants altered their visual search strategy when observing deceptive trials. Both groups fixated on significantly more locations when viewing deceptive trials compared to non-deceptive trials; however, this difference was greater in the high-skilled group. This finding suggests that the visual system of high-skilled participants was more attuned than low-skilled participants to seeking the confirmatory visual information that would enable successful discrimination between a 'genuine' change in direction as opposed to a step-over.

Overall, low-skilled players extracted information from more location sources, primarily from peripheral lower body regions (e.g., the feet and knees). In contrast, high-skilled players extracted information from fewer sources located more centrally. Previously, researchers have suggested that relative motion is picked up more effectively through peripheral vision, and the use of ‘visual pivots’ or 'anchoring' by expert performers has been proposed in a number of sports (Poulter, Jackson, Wann, & Berry, 2005; Ripoll et al., 1995; Savelsbergh et al., 2002; Williams & Davids, 1998; Williams & Elliot, 1999). These differences in fixation location were also demonstrated in the final fixation location analysis.

With respect to the discrimination between genuine and deceptive motion, the data for the timing and locus of the final fixation may be considered. The high-skilled group made their final fixation approximately 223 ms before the low-skilled group on non-deceptive trials; however, they were approximately 40 ms after the low-skilled group on deceptive trials. This interaction was driven by the change in the high-skilled group's visual search behaviour from non-deceptive to deceptive trials. Specifically, the high-skilled group made a much later final fixation on deceptive trials than on non-deceptive trials; however, this was rarely an additional fixation (mean increase = 0.20) and the increase was only slightly higher than that of the low-skilled group (mean increase = 0.12). Nor did the locus of fixations change from non-deceptive to deceptive trials for either group. If one takes the timing of the final fixation as indicative of identifying confirmatory information, it seems that the high-skilled group were (a) able to identify a 'genuine' movement at an earlier point than the low-skilled group, and (b) are delayed in identifying such information when an opponent performs a step-over. Also, in line with our prediction, the final fixation occurred earlier as the degree of certainty conveyed by the probability information increased; presumably, this occurred because the additional information encouraged them to seek confirmatory cues associated with the expected event rather than search more broadly for predictive information. These findings provide further evidence that high-skilled participants employed a more efficient search strategy.

One of the aims of this study was to extend the findings of Study 2 by using a temporal occlusion paradigm to lower mean judgement accuracy of high-skilled players so we could better ascertain the benefits as well as costs associated with participant expectations. As shown in the control condition (50:50) the high-skilled group’s judgement accuracy was successfully lowered from ceiling level to 80%. In Study 2 the low-skilled group’s mean judgement accuracy in the control condition was 75%, which provided an opportunity to compare the high-skilled data from the present study to that of the low-skilled group in Study 2. Although we have successfully presented some evidence to demonstrate that the addition of probability information influences anticipation judgements and that high-skilled performers employ more efficient visual search strategies, future research should try to further mimic the real-life demands of sport competition (e.g., during high-pressure situations). The debilitative effects of high anxiety on sports performers are only too familiar, and researchers have sought to explain the relationship between anxiety, attention and performance. In recent years researchers in sport have tested the predictions of ACT in an effort to examine how anxiety influences performance effectiveness and efficiency. ACT assumes that anxiety decreases the influence of the goal-directed attentional system, which is likely to have a significant impact on the influence of top-down probability information.

In summary, we manipulated the probability information available to soccer players to examine its impact on anticipation and the visual search behaviours associated with expert performance. In comparison to low-skilled soccer players, high-skilled players demonstrated superior anticipation skill, were less susceptible to deceptive movement, and employed a more efficient visual search strategy. In both groups, anticipation performance was moderated by the degree of certainty conveyed by the probability information provided.

This study demonstrates the importance of probability information on anticipation performance in both high-skilled and low-skilled players. The use of probability information through performance analysis feedback plays a prominent role across a number of sports for expert performers. It is therefore essential that researchers and practitioners continue to work towards further understanding the costs and benefits associated with using such information.

Chapter 6

Study 4: The effects of anxiety and top-down (probability) information on anticipation skill and visual search in soccer

6.1 Introduction

The ability to perform under pressure is a key component of an athlete's repertoire in competitive sport. It is therefore perhaps not surprising that the influence anxiety exerts on sports performance has been a key area of interest for both sport psychology researchers and practitioners. Researchers have increasingly examined the role of attention in explaining the effects anxiety has on sports performance (Beilock, 2008; Eysenck, et al., 2007; Pijpers, Oudejans, Bakker, & Beek, 2006). Anxiety is considered to be an aversive emotional state that occurs as a result of threat and is related to the subjective evaluation of a situation (Eysenck & Calvo, 1992). One of the earliest models related to attentional control and anxiety was developed by Easterbrook (1959). The cue utilisation hypothesis predicts that arousal causes attentional narrowing, facilitating or maintaining performance on central tasks at the expense of performance on peripheral tasks. With a narrowing of the attentional field, it is proposed that performance on central tasks will be facilitated at the expense of peripheral tasks (Janelle, 2002).

A more recent theory that has been developed to account for the effects of anxiety on cognitive performance is attentional control theory (ACT; Eysenck, et al., 2007). ACT was developed as an extension of the processing efficiency theory (PET), which has received empirical support in both cognitive psychology (Eysenck et al., 2007) and sport psychology (see Wilson, 2008, for a review). The main hypothesis of PET is that cognitive anxiety disrupts the attentional system rather than directly impacting task performance. Consequently, PET predicts that performance effectiveness may be maintained in spite of impaired processing efficiency (Causer, et al., 2011). PET predominantly makes predictions about the general effect of anxiety on processing efficiency, and as a result has been criticised for lacking precision and explanatory power (Eysenck et al., 2007). PET predicts that anxiety will impair the processing efficiency of the central executive; however, the central executive is argued to conduct five specific functions. These are: switching attention between tasks, planning subtasks, selective attention and inhibition, updating the working memory, and coding representations in the working memory for time and place of appearance.

In outlining his case for ACT, Eysenck et al. (2007) noted that PET does not specify which of these is negatively affected by anxiety and sought to address this limitation. The main prediction of ACT is that impaired attentional control is attributed to a disruption in the balance between two attentional systems: (a) a top-down (goal-directed) system, influenced by current goals, knowledge and expectations, and (b) a bottom-up (stimulus-driven) system, influenced by salient stimuli (Corbetta & Shulman, 2002). ACT predicts that elevated levels of anxiety lead to an increased influence of the stimulus-driven attentional system and a decreased influence of the goal-directed attentional system (Eysenck et al.). In addition, ACT predicts that the central executive functions most impaired by anxiety will be the inhibition and shifting functions. These functions both involve attentional control. The inhibition function involves using 'negative attentional control' to prevent attentional resources being allocated to task-irrelevant stimuli and to prevent incorrect prepotent responses from interfering with the task (Derakshan et al., 2009). The shifting function refers to a positive attentional control process by which the allocation of attention shifts between relevant task stimuli (Derakshan & Eysenck, 2009). ACT provides a valuable framework within which to consider the effects of anxiety on tasks involving cognitive processing. Studies based on

ACT found that anxiety caused disruptions in gaze behaviour and a significant drop in performance effectiveness (Causer, et al., 2011; Nibbeling, Oudejans, & Daanen, 2012; Wilson, Vine, & Wood, 2009a; Wilson, Wood, & Vine, 2009b), thus supporting the predictions of ACT.

There is significant research evidence in cognitive psychology indicating that the inhibition and shifting functions are affected by anxiety, leading to a reduced ability to inhibit incorrect prepotent responses, greater susceptibility to distractions, and impaired shifting of attention (for a review see Eysenck, et al., 2007; Eysenck & Derakshan, 2011). Much of this research has been concerned with the effects of anxiety on cognitive task performance as these tasks tend to place significant demands on working memory. However, researchers have also found evidence in support of ACT in perceptual-motor tasks, predominantly in far aiming tasks and penalty kicks (Causer et al., 2011; Nieuwenhuys & Ouejans, 2011; Noël & van der Kamp, 2012; Wilson, et al., 2009a; Wilson, et al., 2009b). For example, Wilson et al. (2009a) examined the predictions of ACT by measuring gaze patterns of participants taking penalty kicks under low and high pressure. The pressure manipulation involved a monetary reward and a leader board with the scores was circulated among participants. Under high pressure participants taking the penalty fixated for significantly longer towards the goalkeeper, which resulted in a more centralised shot within the goalkeeper’s reach. Thus, in line with the predictions of ACT, during the high-pressure condition attention became more stimulus driven, with kickers focusing more on the 'threatening' stimulus, in this case the goalkeeper.

6.1.1 Visual search and ACT. Visual search behaviours are commonly employed as indicators of visual attention (e.g., Behan & Wilson, 2008; Nibbeling et al., 2012). Research across a range of sports tasks has demonstrated that experts tend to employ more efficient gaze strategies compared to novices, predominantly focusing on the information deemed most useful to the specific task (see Mann, et al., 2007 for a review). Although a number of studies have successfully identified skill-based differences in visual search strategies in sport, there is a paucity of research examining the effects of anxiety on visual search behaviour. However, the handful of studies that have examined the effects of anxiety of visual search behaviour have demonstrated that visual search behaviours are disrupted under heightened levels of anxiety, leading to inefficient and often ineffective search strategies (Janelle, 2002; Janelle, Singer, & Williams, 1999; Williams, Vickers, & Rodrigues, 2002; Wilson, Smith, Chattington, Ford & Marple-Horvat, 2006). With respect to ACT, there is some evidence in sport for an attentional bias towards threatening stimuli under high-pressure that comes at the expense of the goal-driven (task-relevant) stimuli (Causer et al., 2011; Nieuwenhuys, Pijpers, Oudejans, & Bakker, 2008; Wilson et al., 2009a). For example, Causer et al. examined how anxiety affected performance effectiveness and performance efficiency of elite shotgun shooters. They found that elite shooters had a significantly shorter quiet eye period during the high-pressure condition compared with the low-pressure condition. This and similar studies have provided support for the predictions of ACT if one accepts the premise that the quiet eye period is an index of goal-directed attention (Niewenhuys & Oudejans, 2011; Vickers & Williams, 2007; Vine, et al., 2011; Vine & Wilson, 2011).

Despite several studies having examined ACT in far-aiming sports tasks, researchers have yet to test the predictions of ACT during simulated anticipation tasks either with respect to performance or visual search. While not specifically examining ACT there are relevant findings from Williams and Elliott’s (1999) study of karate players in which they examined the visual search strategies employed by expert and novice karate performers under high and low-anxiety. The performance results showed that expert performers exhibit superior anticipation skill, with both groups performing better during high-anxiety compared to low-anxiety conditions. There were no statistically significant differences in the visual search behaviours of the two groups; however, Williams and Elliott reported that heightened anxiety led to reduced mean fixation duration in novice performers but longer fixation duration in expert performers. This difference in search behaviour was also accompanied by an increase in the number of fixations and in the total number of fixation locations employed by novices compared with experts under the high-anxiety conditions. These findings suggest that the anxiety manipulation had a greater effect on the novice participants' visual search behaviours. The researchers suggested that these changes in search strategy were caused by a narrowing of the perceptual field, resulting in increased search activity to compensate for peripheral narrowing (Williams & Elliott). Another possible explanation is that changes in visual search behaviours under heightened anxiety are caused by the performers focusing on threatening / irrelevant stimuli, referred to as hypervigilance (Eysenck, 1992). Hypervigilance is viewed as compatible with attention narrowing in so far as performers are able to focus narrowly on distracting threatening or irrelevant cues (Janelle, Singer, & Williams, 1999).

In this study, the main objectives are to replicate the findings of Williams and Elliot (1999), and to test the predictions of ACT in relation to the provision of top-down probability information, and the visual search behaviours employed under heightened anxiety. With regard to the findings of Williams and Elliot, we hypothesise that anxiety will result in reduced efficiency of visual search evidenced by an increased number of fixations of shorter duration, and that these effects will be more pronounced in the low-skilled group than the high-skilled group. In line with ACT, we hypothesise that the effect of probability information on performance will be suppressed in the high-pressure condition. Also consistent with ACT, we hypothesise that the timing of the onset of the final fixation prior to execution will shorten under conditions of high anxiety.

6.2 Method

6.2.1 Participants. A total of 30 (15 high-skilled and 15 low-skilled) adult male soccer players participated. High-skilled participants (*M* = 19.8 years, *SD* = 3.8) were semi-professional players, with six having played at international youth level and nine for a Premier League Academy. They had a mean of 14.1 years (*SD* = 2.1) playing experience. Low-skilled players (*M* = 20.9 years, *SD* = 3.1) had a mean of 2.3 years (*SD* = 1.5) playing experience at recreational level (e.g., local Sunday league club). Participants provided informed consent and were free to withdraw from testing at any stage. All procedures were approved by the institution's Ethics Committee and carried out under its ethical guidelines.

6.2.2 Test design. Participants completed a two-choice prediction task, in which they were required to judge from video sequences whether the player running towards the camera was going to change direction towards the left or right of the screen. The test trials presented an attacking player dribbling the ball towards the camera and executing a change in direction (left/right), viewed from the first-person perspective of a defending player. A digital video camera (Canon HV40, Tokyo, Japan) was used to record the stimuli. The camera was positioned on a tripod 11.5 m from the player's starting position, mounted at a height of 1.4 m. Players began their approach from a standardised position and changed direction at the execution point, 5.3 m from the camera towards one of the two targets placed at an angle of 45° to the line of approach. Two types of trials were presented to participants: 'normal' and 'deception' trials. In the normal condition the filmed player ran directly towards the camera and changed direction in one well-executed movement to either the left or right of the camera. In the deception trials the filmed player performed a single step-over prior to changing direction. All trials were subsequently edited to create temporal occlusion conditions of 0 ms and +80 ms relative to foot-ball contact. A panel comprising two UEFA ‘B’ and one UEFA ‘A’ licensed coaches rated each individual video clip under three categories: (1) smoothness of the approach run, (2) realistic game pace, (3) efficient execution of the change in direction. Each category was equally weighted and the mean score was taken from each coach to determine which 12 trials would be selected for each player.

The final test film included 96 trials, each lasting approximately 1.5 s followed by a 5 s interval for participants to respond, report their judgement confidence and prepare for the next trials. The test stimuli were projected using a video projection system (Optoma HD25, CA, USA) onto a 1.6 m (h) x 2.1 m (w) wall. Participants stood at a marker located 2.8 m from the screen, approximating a real-life environment. Participants were free to move in response to the action as they would normally do when playing in a real soccer match.

6.2.3 Measures.

6.2.3.1 The Mental Readiness Form-3 (MRF-3). The MRF-3 (Krane, 1994) was developed as an alternative to the Competitive State Anxiety Inventory-2 (CSAI-2; Martens, Burton, Vealey, Bump, & Smith, 1990). The MRF-3 is a practical alternative to the CSAI-2, allowing for anxiety to be reported during tasks with temporal constraints. The form is comprised of three items (somatic anxiety; cognitive anxiety; self-confidence) with bipolar 11-point Likert-type scales (worried/not worried; tense/not tense; confident/not confident). Validation work revealed correlations between the MRF-3 and CSAI-2 subscales of 0.76 for cognitive anxiety, 0.69 for somatic anxiety, and 0.68 for self-confidence. The MRF-3 has proved to be a sensitive measure in previous research examining the impact of anxiety on sport performance (Wilson, Smith, & Holmes, 2007; Vine & Wilson, 2010; Causer, et al., 2011; Vine, et al., 2011).

6.2.3.2 Visual search behaviour. The visual search behaviour employed by participants was recorded using an eye-tracking system (Scene Camera ViewPoint Eye Tracker, Arrington Research, Scottsdale, AZ, USA). The Arrington eye tracker is head mounted, meaning that it follows head movements and thereby allow the subject unrestricted movements. The device uses infrared video with dark pupil tracking, which uses the relationship between the pupil and a reflection from the cornea to compute gaze within a scene. The accuracy ratings range between 0.25°-1.0° visual arc with a spatial resolution of 0.15° visual arc. Horizontal visual range is +/- 56° of visual arc while vertical is +/- 42° of visual arc. The data were analysed frame-by-frame using Anvil video annotation software (Kipp, 2001). A fixation was defined as a gaze maintained on a location for a minimum of 120 ms (McRobert, et al., 2011).

6.2.4 Procedure. Prior to collecting data the eye-tracking device was attached and calibrated using a reference of nine points on the scene image, 2.8 m away from the viewing screen. Periodic calibration checks were conducted after the 2nd and 6th block. Following the initial calibration of the eye-tracking system the participants were presented with 16 practice trials in order to familiarise them with the experimental setup. For each trial, participants were instructed to take up their normal defending stance and were required to indicate their judgement by stepping to the left or right. In addition, participants were asked to provide a verbal response ('left' or 'right') and rated their confidence in their judgement on a 5-point scale (1 = *not at all confident*, 5 = *extremely confident*).

During the test trials probability information regarding the likely direction change in the observed player was provided to participants. Two genuine levels of information were given - 50:50 (control condition), and 75:25. In the 50:50 condition participants were informed that there was an equal chance of the player changing direction to the left or to the right. In the 75:25 condition participants were given specific probability information (e.g., “In the next series of 12 video clips, the chance of the player changing direction to the left and right is 75% and 25%”). The probability information for both the left and right was presented on the corresponding side on the projection screen. In total, participants viewed 8 blocks of 12 test trials, with a 2-minute rest period after the 2nd and 6th block.

Participants performed under low- and high-pressure conditions, using an ABA design (low, high, low). In the low-pressure conditions (Blocks 1, 2, 7 and 8), non-evaluative instructions were provided to participants, asking them to do their best and to respond as quickly and accurately as possible. Participants completed the MRF-3 immediately after the first two low-pressure blocks. After completing the MRF-3 participants were informed that their response accuracy score was either 18/24 (75%) or 17/24 (71%). Prior to the high-pressure blocks (3-6) participants were told that they could earn a monetary bonus (£10) if they and a (fictional) partner achieved a performance criterion (≥ 80% correct) over the next four blocks of 48 trials (Beilock & Carr, 2001). They were then informed that their partner had already completed the experiment and had reached the performance criterion, so the participant’s partner was relying on him to receive the reward. Each participant was told that they would be informed of their final results and whether they had achieved the criterion performance once all participants had completed the study. The MRF-3 was again issued during a 2-minute break in the middle of the high-pressure condition (after Block 4). The manipulation instructions were then reiterated before completing the final two high-pressure blocks. The MRF-3 was completed after the final high-pressure block (Block

6) and after the final low-pressure blocks (Block 8) during the 2-minute breaks. The block order of the two probability conditions was counterbalanced across participants. The entire testing session took approximately 25 minutes in total.

6.2.5 Data Analysis.

6.2.5.1 Performance data analysis. Prior to the main analysis, the data for the two model players used to create the test stimuli were compared in a 2 (expertise) x 2 (model) x 2 (deception) x 2 (probability condition) ANOVA with repeated measures on the last three factors. The analysis revealed a non-significant main effect of model; nor did model interact with expertise. As a result, the data were collapsed across the two models and entered into a 2 (expertise) x 2 (pressure) x 2 (deception) x 2 (probability condition) ANOVA, with repeated measures on the last three factors. A separate analysis was conducted to examine the differences between expected and unexpected trials based on prior knowledge. Data from the 75:25 condition were entered into a 2 (expertise) x 2 (pressure) x 2 (deception) x 2 (expectation) ANOVA with repeated measures on the last three factors.

6.2.5.2 Visual search data analysis.

6.2.5.2.1 Search rate. Three measures relating to search rate were examined: the mean number of fixations, the mean number of fixation locations and the mean duration of each fixation. A fixation was defined as a period of at least 120 ms in which the eye remained stationery within 1.5˚ of movement tolerance (Williams & Davids, 1998). The search rate variables were analysed by way of separate 2 (expertise) x 2 (pressure) x 2 (deception) x 2 (probability condition) ANOVAs. Visual search data reliability was established using the intra-observer (98.4%) and inter-observer (97.9%) agreement methods. In total, 25% of the data were re-analysed to provide the agreement figures using the procedures recommended by Thomas, Nelson and Silverman (2005).

6.2.5.2.2 Fixation location. The percentage of total viewing time spent fixating on different areas of the display was also measured. The display was initially divided into eight locations: head; shoulders; trunk; hips; knees; shins and feet; ball; unclassified. The unclassified category was excluded because none of the participants' fixations fell outside of the other seven locations. Percentage viewing time data were analysed in a 2 (expertise) x 2 (pressure) x 2 (deception) x 2 (probability condition) x 7 (location).

6.2.5.2.3 Final fixation location and timing. Final fixation location and the timing of the final fixation were recorded. As the player was closer to the camera at the later time points we were able to discriminate between the left and right knees/feet. Therefore, the display was divided into nine fixation locations: head; shoulders; trunk; hips; left knee; right knee; left shin/foot; right shin/foot; ball. The data were entered into a 2 (expertise) x 2 (pressure) x 2 (deception) x 2 (probability condition) x 9 (location) ANOVA. The timing of the final fixation was recorded as the time point of the onset of the final fixation where the eye remained stationary for a period equal to, or in excess of, 120 ms. Data were entered into a 2 (expertise) x 2 (pressure) x 2 (deception) x 2 (probability condition) ANOVA. As in the performance data analysis, the assumptions relating to parametric analyses and the *F* distribution, such as normality, homogeneity of variances, independence of raw scores, and sphericity of the repeated measures values were evaluated for each visual search analysis. The univariate output was assessed with alpha set at .05 and a Greenhouse-Geisser correction was applied to the degrees of freedom in any instances in which the sphericity assumption was violated.

6.3 Results

6.3.1 Anxiety manipulation check. To test whether the pressure manipulation was successful a repeated measures multivariate analysis of variance (MANOVA) was performed with the cognitive anxiety, somatic anxiety and self-confidence sub-scale scores of the MRF-3 as dependent variables. The multivariate analysis indicated a significant overall effect of pressure $F(3, 26) = 221.10$, $p < .001$, Wilks Lambda = .04, $\eta_p^2 = .96$. The univariate analyses revealed significant effects of pressure for cognitive anxiety, $F(1, 28) = 14.36$, $p < .01$, $\eta_p^2 = .34$, somatic anxiety, $F(1, 28) = 658.87$, $p < .001$, $\eta_p^2 = .96$ and self-confidence, $F(1, 28) = 145.69$, $p < .001$, $\eta_p^2 = .84$. An inspection of the mean scores revealed increases from low pressure to high pressure for cognitive anxiety (M = 2.62 to 6.92) and somatic anxiety (M = 2.27 to 6.62), and a decrease in self-confidence from low pressure to high pressure (M = 6.63 to 3.73).

6.3.2 Performance Data.

6.3.2.1 Response accuracy. Significant main effects were observed for expertise, $F(1, 28) = 383.00$, $p < .001$, $\eta_p^2 = .93$, pressure, $F(1, 28) = 15.42$, $p < .01$, $\eta_p^2 = .36$, probability condition, $F(1, 28) = 11.42$, $p < .01$, $\eta_p^2 = .29$, and deception, $F(1, 28) = 1235.36$, $p < .001$, $\eta_p^2 = .98$. As predicted, high-skilled players (M = 0.81, SE = 0.01) were more accurate than less-skilled players (M = 0.59, SE = 0.01) and judgement accuracy decreased from low-pressure (M = 0.72, SE = 0.01) to high-pressure conditions (M = 0.68, SE = 0.01). Performance improved as the degree of certainty moderated by the probability condition increased from 50:50 (M = 0.68, SE = 0.01) to 75:25 (M = 0.72, SE = 0.01), and performers were more accurate on non-deceptive trials (M = 0.90, SE = 0.01) than on deceptive trials (M = 0.50, SE = 0.01). In all cases, the maximum mean score was 1, with a score of 0.5 being equivalent to chance level.

The main effect of deception was superseded by significant interactions with expertise, $F(1, 28) = 51.16$, $p < .001$, $\eta_p^2 = .65$, and pressure, $F(1, 28) = 4.79$, $p < .05$, $\eta_p^2 = .15$. The difference in performance between the high-skilled and low-skilled groups was greater in the deception trials ($M = 0.83$, $SE = 0.01$; $M = 0.35$, $SE = 0.01$, respectively) than in the non-deceptive trials ($M = 0.97$, $SE = 0.01$; $M = 0.83$, $SE = 0.01$, respectively).

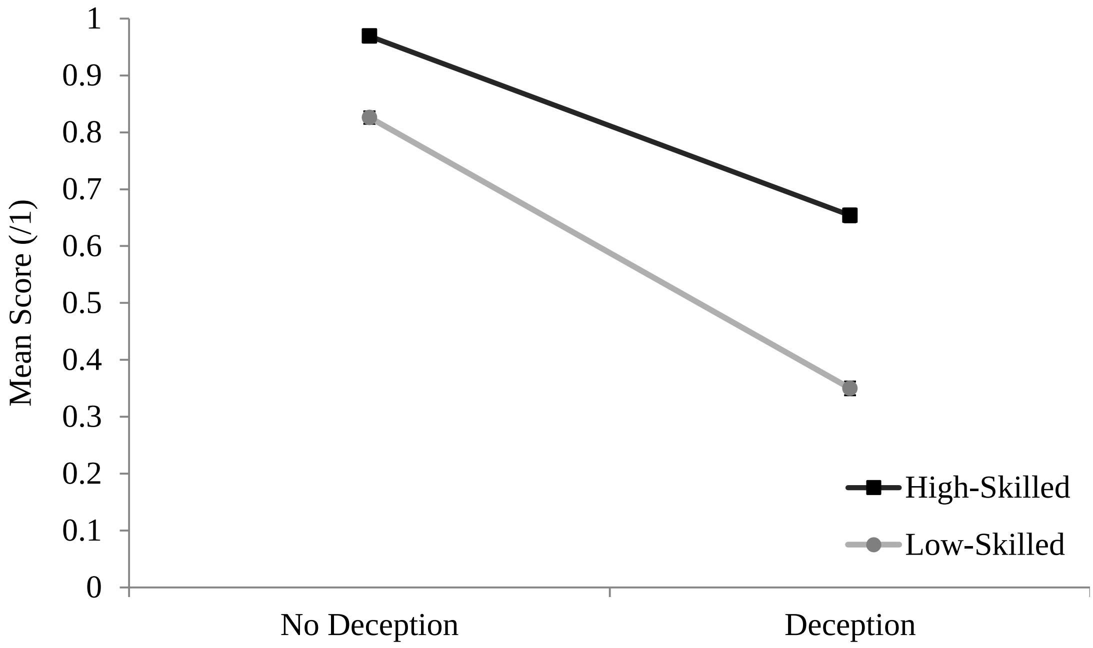

Figure 6.1. The mean proportion of correct judgements made by the high-skilled and low-skilled group in non-deceptive and deceptive trials, with standard error bars.

The deception by pressure interaction was caused by the judgement accuracy difference between non-deceptive and deceptive trials being greater in the high-pressure condition ($M = 0.42$) than in the low-pressure conditions ($M = 0.37$, see Figure 3). There was no significant interaction between probability condition and pressure, $F(1, 28) = 2.52$, $p = .12$, $\eta_p^2 = .08$, or between pressure and expertise, $F(1, 28) = 2.04$, $p = .16$, $\eta_p^2 = .07$. All other three-way interactions, along with the four-way interaction, were non-significant ($p > .05$).

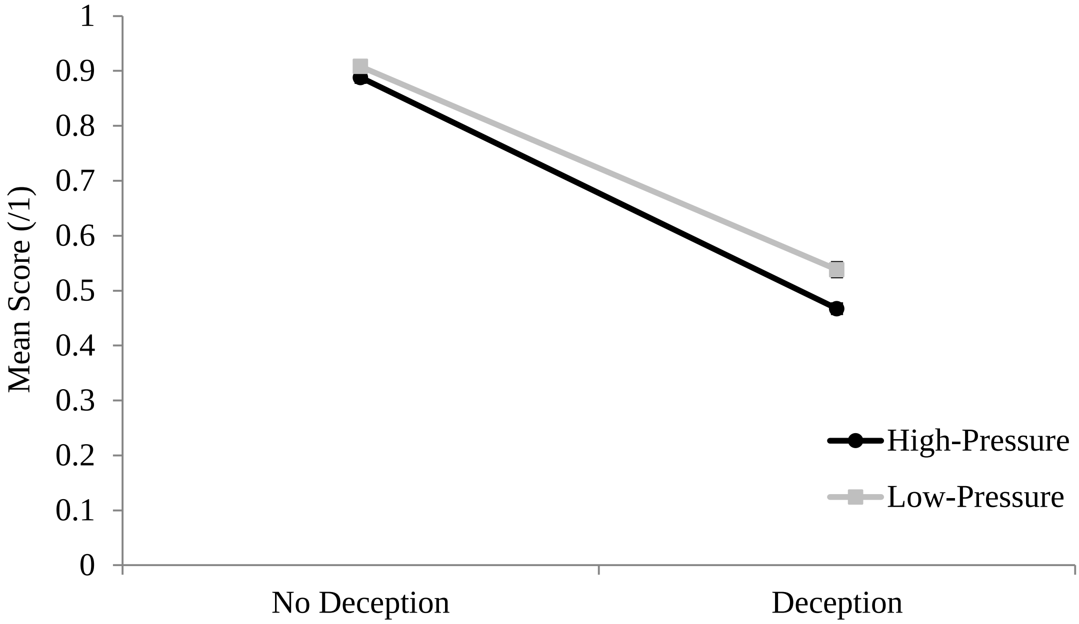

Figure 6.2. The mean score expressed as the mean proportion of correct judgements in no deception and deception trials under low-pressure and high-pressure, with standard error bars.

6.3.2.2 Expectation. The separate analysis of the 75:25 condition data revealed a significant main effect of expectation, $F(1, 28) = 25.08$, $p < .001$, $\eta_p^2 = .47$. Judgement accuracy was greater when the player moved in the expected direction ($M = 0.75$, $SE = 0.01$) than in the unexpected direction ($M = 0.63$, $SE = 0.02$). Expectation also interacted significantly with pressure, $(1, 28) = 11.03$, $p < .01$, $\eta_p^2 = .28$, caused by a smaller difference in performance between 'expected' and 'unexpected' trials in the high-pressure condition ($M = 0.04$) than in the low-pressure condition ($M = 0.20$), as shown in Figure 6.3. There was a non-significant interaction between expectation and expertise, $F(1, 28) = 0.01$, $p = .91$, $\eta_p^2 = .00$, expectation and deception, $F(1, 28) = 0.80$, $p = .38$, $\eta_p^2 = .03$, and pressure by expertise by expectation, $F(1, 28) = 0.12$, $p = .73$, $\eta_p^2 = .00$.

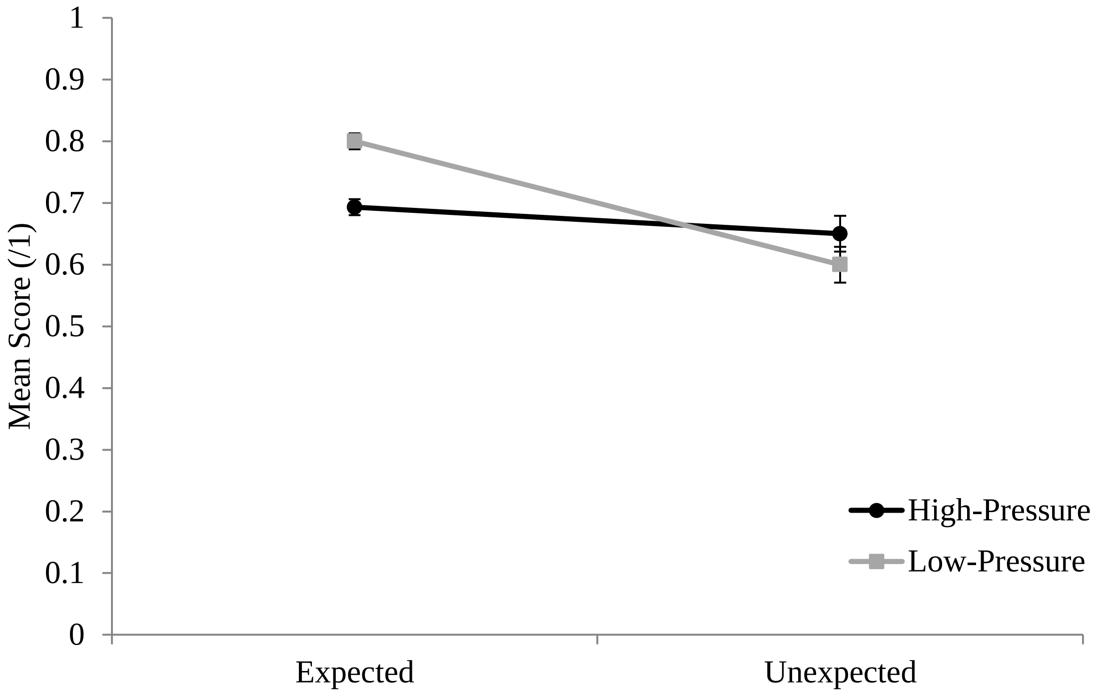

Figure 6.3. The mean proportion of correct judgements in the 75:25 condition when the model moved in the expected and unexpected direction, under low pressure and high pressure, with standard error bars.

6.3.3 Judgement Confidence. Significant main effects were observed for expertise, $F(1, 28) = 52.33$, $p < .001$, $\eta_p^2 = .65$, pressure, $F(1, 28) = 135.02$, $p < .001$, $\eta_p^2 = .83$, and deception, $F(1, 28) = 354.45$, $p < .001$, $\eta_p^2 = .93$. As predicted, high-skilled players ($M = 3.70$, $SE = 0.04$) were more confident in their judgements than less skilled players ($M = 3.28$, $SE = 0.04$). Judgement confidence was higher for low-pressure trials ($M = 3.69$, $SE = 0.04$) than high-pressure trials ($M = 3.29$, $SE = 0.02$). Participants were also more confident about their judgements on non-deceptive trials ($M = 3.75$, $SE = 0.03$) than on deceptive trials ($M = 3.23$, $SE = 0.04$). There was a non-significant effect for probability condition, $F(1, 28) = 0.55$, $p = .47$, $\eta_p^2 = .02$.

There were additional interactions between deception and expertise, $F(1, 28) = 354.45$, $p < .001$, $\eta_p^2 = .93$, and between probability condition and deception, $F(1, 28) = 32.25$, $p < .001$, $\eta_p^2 = .54$. The high-skilled group recorded a greater decrease in confidence from non-deceptive to deceptive trials (*M* = 0.97) than did the low-skilled group (*M* = 0.07, see Figure 5). The difference between judgement confidence in deceptive and non-deceptive trials was greater in the 75:25 condition (*M* = 0.66) than in the 50:50 condition (*M* = 0.39). All other two-, three- and four-way interactions were non-significant ($p > .05$).

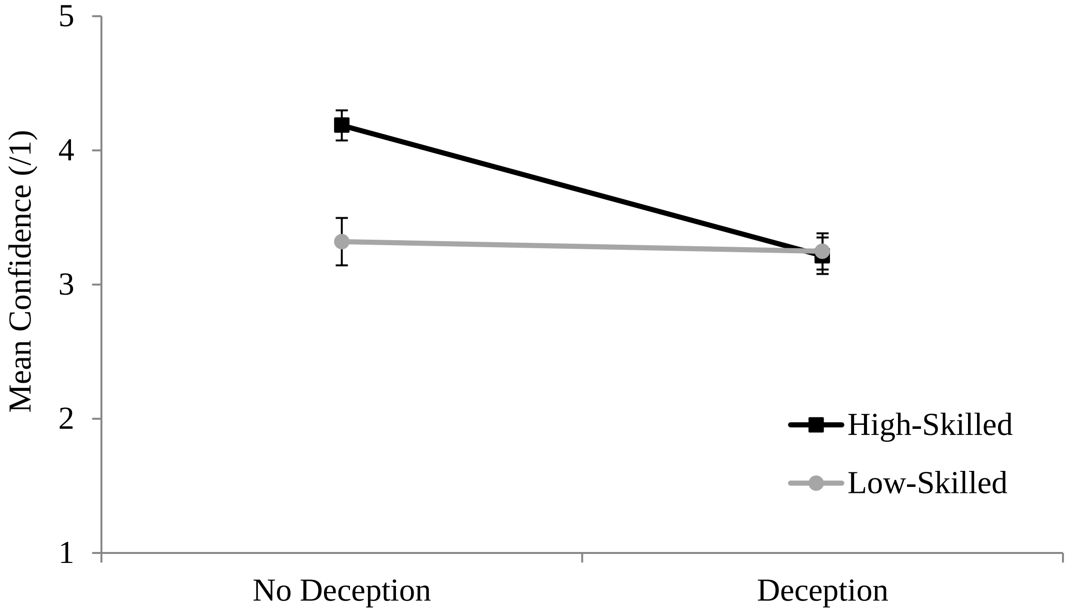

Figure 6.4. Mean judgement confidence ratings for the high-skilled and low-skilled groups on non-deceptive and deceptive trials, with standard error bars.

6.3.3.1 Expectation. The analysis of the 75:25 condition confidence data revealed a significant main effect for expectation, $F(1, 28) = 141.44$, $p < .001$, $\eta_p^2 = .84$. Confidence ratings decreased from 'expected' trials (*M* = 3.60, *SE* = 0.03) to 'unexpected' trials (*M* = 3.12, *SE* = 0.04). In addition there was a significant pressure by expectation interaction, $F(1, 28) = 8.94$, $p < .01$, $\eta_p^2 = .24$. As with judgement accuracy, this was caused by a smaller difference in confidence between 'expected' and 'unexpected' trials in the high-pressure condition (*M* = 0.34) than in the low-pressure condition (*M* = 0.61). Expectation also interacted significantly with expertise, $F(1, 28) = 68.73$, $p < .001$, $\eta_p^2 = .71$, caused by a greater difference in judgement confidence between 'expected' and 'unexpected' trials for the high-skilled group (*M* = 0.81) than for the low-skilled group (*M* = 0.14). All other interactions were non-significant ($p > .05$).

6.3.3 Visual Search Data.

6.3.3.1 Search rate. The search rate data are presented in Table 6.1 in which it can be seen that the high-skilled group made fewer fixations of longer duration to fewer locations than the low-skilled group. The analyses revealed a significant main effect of expertise with respect to the number of fixations, $F(1, 28) = 117.43$, $p < .001$, $\eta_p^2 = .81$, mean duration of fixations, $F(1, 28) = 36.96$, $p < .001$, $\eta_p^2 = .57$, and mean number of fixation locations per trial, $F(1, 28) = 175.20$, $p < .001$, $\eta_p^2 = .86$.

Table 6.1.

Mean Number of Fixations, Number of Fixation Locations, and Fixation Duration per Trial Across Expertise Groups.

	Group	
Search Rate	High-Skilled	Low-Skilled
No. of fixations	2.74 (0.04)	3.41 (0.04)
No. of fixation locations	1.76 (0.05)	2.69 (0.05)
Fixation duration (ms)	343.65 (4.63)	306.52 (4.32)

Analysis of the mean number of fixations further revealed significant main effects for pressure, $F(1, 28) = 117.77$, $p < .001$, $\eta_p^2 = .81$, probability condition, $F(1, 28) = 13.11$, $p < .01$, $\eta_p^2 = .32$, and deception, $F(1, 28) = 51.56$, $p < .001$, $\eta_p^2 = .65$. The mean number of fixations was greater in the high-pressure (*M* = 3.38, *SE* = 0.05) than low-pressure trials (*M* = 2.78, *SE* = 0.03), was lower on the 75:25 trials (*M* = 3.02, *SE* = 0.04) than on the 50:50 trials (*M* = 3.13, *SE* = 0.03), and was greater for deceptive trials (*M* = 3.28, *SE* = 0.04) than non-deceptive trials (*M* = 2.88, *SE* = 0.04). In addition, expertise interacted significantly with pressure, $F(1, 28) = 7.09$, $p < .05$, $\eta_p^2 = .20$, probability condition, $F(1, 28) = 4.77$, $p < .05$, $\eta_p^2 = .15$, and deception, $F(1, 28) = 59.08$, $p < .001$, $\eta_p^2 = .68$. The interaction between pressure and expertise was caused by a greater increase in the number of fixations from low- to high-pressure in the low-skilled group (*M* = 0.75) than in the high-skilled group (*M* = 0.46). The interaction with probability condition was caused by a greater decrease in the number of fixations from 50:50 to 75:25 in the low-skilled group (*M* = -0.18) compared to the high-skilled group (*M* = -0.05). Lastly, the interaction with deception was caused by a greater increase in the number of fixations from no deception to deception trials in the high-skilled group (*M* = 0.83) compared to the low-skilled group (*M* = 0.03).

The fixation duration ANOVA also revealed a significant main effect of pressure, $F(1, 28) = 17.77$, $p < .001$, $\eta_p^2 = .39$, with mean fixation duration lower on low-pressure trials (*M* = 343.36, *SE* = 6.09) than on high-pressure trials (*M* = 306.81, *SE* = 4.38). There were no other significant main effects or interactions ($p > .05$).

Analysis of the mean number of fixation locations revealed a significant main effect of pressure, $F(1, 28) = 51.89$, $p < .001$, $\eta_p^2 = .88$, deception, $F(1, 28) = 15.19$, $p < .01$, $\eta_p^2 = .35$, and location, $F(4.27, 119.47) = 142.86$, $p < .001$, $\eta_p^2 = .84$. The number of fixation locations was greater in the high-pressure condition (*M* = 2.69, *SE* = 0.05) than in the low-pressure condition (*M* = 1.76, *SE* = 0.05). The number of fixation locations was also higher in deceptive trials (*M* = 2.35, *SE* = 0.04) than in non-deceptive trials (*M* = 2.16, *SE* = 0.04). With respect to location, the greatest number of fixations was on the knees (*M* = 3.82, *SE* = 0.09), feet (*M* = 3.06, *SE* = 0.11), hips (*M* = 2.88, *SE* = 0.11), shoulders (*M* = 2.33, *SE* = 0.12), trunk (*M* = 2.13, *SE* = 0.11), with the fewest number of fixations occurring at the head (*M* = 0.26, *SE* = 0.05) and ball (*M* = 1.08, *SE* = 0.11). The analysis also revealed significant interactions between expertise and location, *F*(6,

168) = 102.19, $p < .001$, $\eta_p^2 = .76$, and between pressure and location, $F(6, 168) = 5.80$, $p < .01$, $\eta_p^2 = .12$. The high-skilled group made more fixations to the shoulders, trunk and hips, in comparison to the low-skilled group who made more fixations to the head, knees, feet and ball. Performers fixated on more locations in the high-pressure condition than in the low-pressure condition, with the greatest increase occurring at the ball (M = 1.29), trunk (M = 1.29) and knees (M = 1.12). This pressure by location interaction was superseded by a three-way interaction with expertise, $F(6, 168) = 6.08$, $p < .001$, η_p^2 = .18. These data are illustrated in Figures 6.5 and 6.6 in which it can be seen that the high-skilled group's increase in the mean number of fixations from low- to high-pressure was mostly restricted to the knees, hips, trunk, and feet (Figure 6.5), whereas the low-skilled group's increase occurred across all seven locations (Figure 6.6).

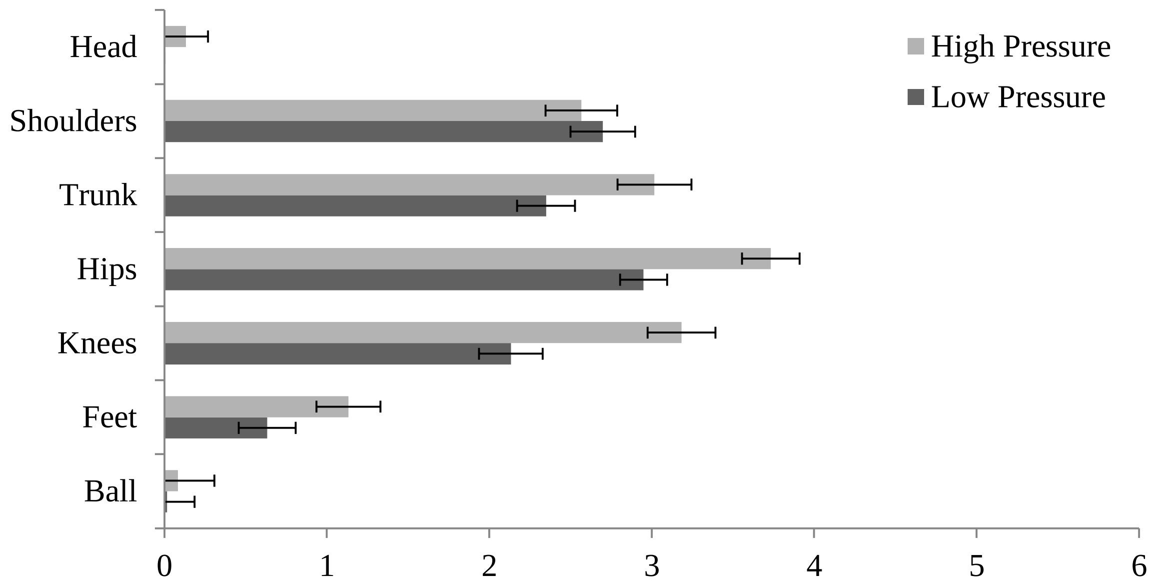

Figure 6.5. The mean number of fixations at each location made by the high-skilled group in the low-pressure and high-pressure conditions, with standard error bars.

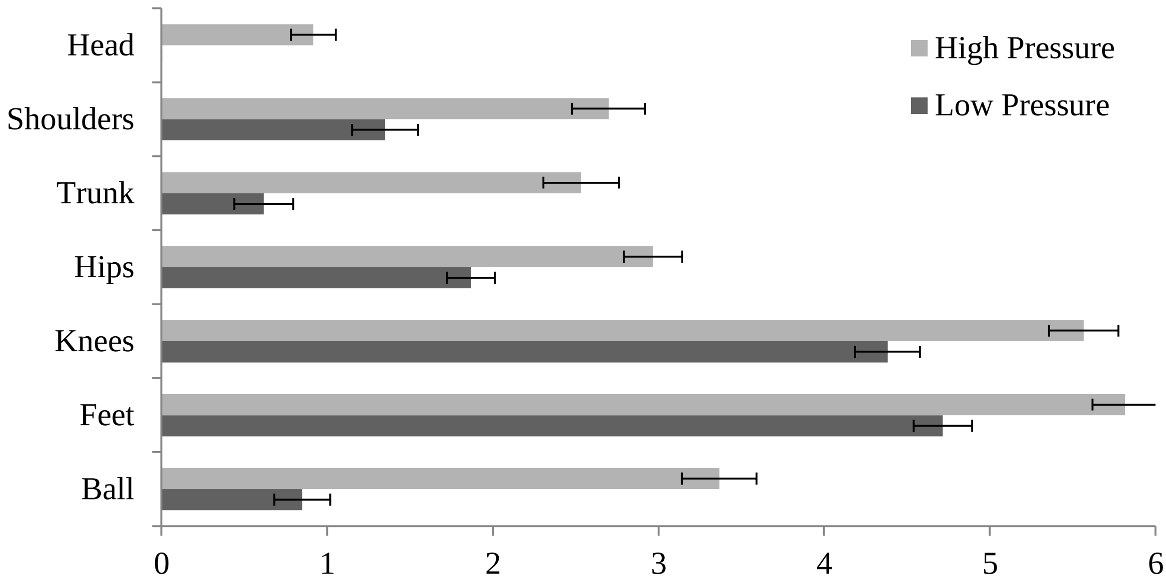

Figure 6.6. The mean number of fixations at each location made by the low-skilled group in the low-pressure and high-pressure conditions, with standard error bars.

6.3.3.2 Percentage viewing time. The ANOVA revealed significant main effects for expertise, $F(1, 28) = 76.12$, $p < .001$, $\eta_p^2 = .73$, pressure, $F(1, 28) = 8.59$, $p < .01$, $\eta_p^2 = .24$, deception, $F\ (1, 28) = 8.56$, $p < .01$, $\eta_p^2 = .23$, and fixation location, $F(2.96, 82.89) = 17.16$, $p < .001$, $\eta_p^2 = .38$. Less time was spent fixating on the head and ball compared to any other location. In addition, location interacted with expertise, $F(2.96, 82.89) = 16.34$, $p < .001$, $\eta_p^2 = 0.37$, and pressure, $F(6, 168) = 2.72$, $p < .05$, $\eta_p^2 = 0.08$. This interaction with expertise was caused by low-skilled players spending more time fixating on distal cues such as the feet and ball compared to high-skilled players who spent more time fixating on more proximal cues such as the shoulders and trunk. The interaction with pressure was caused by participants spending longer fixating on more proximal cues in the low-pressure condition than in the high-pressure condition whereas there was a tendency to spend slightly longer viewing distal cues in the high-pressure condition than in the low-pressure condition. There was no significant main effect of probability condition, $F(2, 56) = 1.53$ $p = .23$, $\eta_p^2 = .05$, nor were there any other significant two- or three-way interactions ($p > .05$).

6.3.3.3 Final fixation. Analysis of the final fixation data revealed a significant main effect for location, $F(3.13, 87.67) = 22.79$, $p < .001$, $\eta_p^2 = .49$. There were a greater number of final fixations to the hips (*M* = 24.54) than to any other location (*M* range = 0.23 - 14.35). In addition, the analysis revealed a significant interaction between expertise and location, $F(3.31, 87.67) = 64.54$, $p < .001$, $\eta_p^2 = 0.70$, indicating that low-skilled participants made more final fixations on the left foot (*M* = 27.13, *SE* = 1.33), right foot (*M* = 26.39, *SE* = 1.49), and ball (*M* = 20.74 *SE* = 1.71) compared with the high-skilled participants (*M* = 1.57, *SE* = 1.33, *M* = 1.39, *SE* = 1.49 and *M* = 0.28, *SE* = 1.71, respectively). High-skilled participants made more final fixations on the trunk (*M* = 25.74, *SE* = 2.01) and hips (*M* = 43.98, *SE* = 3.46) compared with their less skilled counterparts (*M* = 0.65, *SE* = 2.10 and *M* = 5.09, *SE* = 3.46, respectively). There were no other significant main effects or interactions ($p > .05$).

6.3.3.4 Timing of final saccade. Analysis of the point at which the final saccade was made revealed significant main effects for expertise, $F(1,28) = 136.05$, $p < .001$, $\eta_p^2 = .83$, pressure, $F(1, 28) = 36.96$, $p < .001$, $\eta_p^2 = .57$, and deception, $F(1, 28) = 104.11$, $p < .001$, $\eta_p^2 = .49$. High-skilled players made their final saccade at an earlier time point compared to low-skilled players (*M* = -220.63 ms, *SE* = 6.58 vs. *M* = -112.10 ms, *SE* = 6.58). The final saccade occurred earlier in the low-pressure condition (*M* = -193.57, *SE* = 7.80) than in the high-pressure condition (*M* = -139.15 ms, *SE* = 4.75), and occurred earlier on non-deceptive trials (*M* = -216.73 ms, *SE* = 8.43) than on deceptive trials (*M* = -115.99 ms, *SE* = 4.58). In addition the analysis revealed significant interactions between expertise and deception, $F(1, 28) = 17.68$, $p < .001$, $\eta_p^2 = .39$, and between expertise and pressure, $F(1, 28) = 20.61$, $p < .001$, $\eta_p^2 = .42$. The expertise by deception interaction was caused by the difference in timing of the final saccade between non-deceptive and deceptive trials being greater in the high-skilled group (*M* difference = 190.38 ms) than in the low-skilled group (*M* difference = 11.10 ms). The expertise by pressure interaction was caused by the high-skilled group data being consistent across low and high pressure conditions (*M* = -227.52 ms, *SE* = 11.03, *M* = -213.74 ms, *SE* = 6.72, respectively), whereas the low-skilled group made an earlier final fixation in the low-pressure condition compared to the high-pressure condition (*M* = -159.63 ms, *SE* = 11.03, *M* = -64.57 ms, *SE* = 6.72, respectively). There were no other two- or three-way significant interactions (*p* > .05).

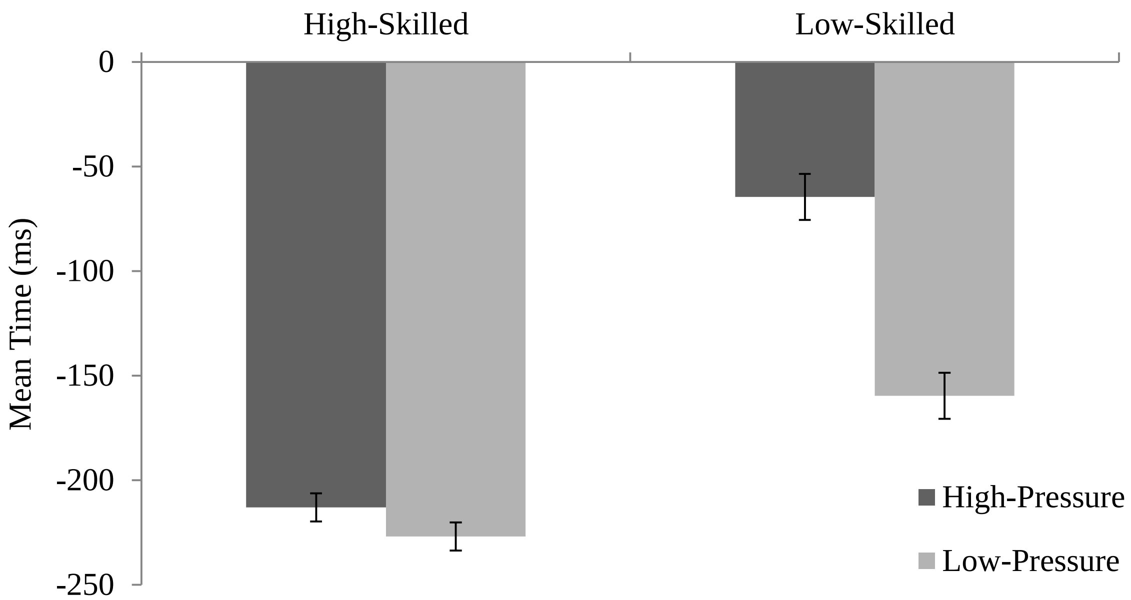

*Figure 6.7.*The mean timing of the onset of the final fixation for high-skilled and low-skilled groups during low- and high-pressure conditions, with standard error bars.

6.4 Discussion

In this study, we aimed to test the predictions of ACT (Eysenck et al., 2007) in a test of anticipation skill incorporating the perception of deception and the manipulation of prior probabilistic knowledge about likely actions. The predictions of ACT have been tested across a range of visuo-motor tasks such as climbing (Nieuwenhuys et al., 2008), basketball free-throw shooting (Wilson et al., 2009b) and police firearms response (Nieuwenhuys & Oudejans, 2009). However, this is the first study that has attempted to test the predictions of ACT in an anticipation task where precise top-down probability information is provided. In Experiments 2 and 3, we demonstrated the effects of top-down information on anticipation performance in the absence of pressure. Specifically, we found that anticipation performance was moderated by the degree of certainty conveyed by the probability information provided for both high-skilled and low-skilled performers. In addition, high-skilled players refined their visual search strategy when probability information was provided. The main objectives of this study were to replicate the findings of Williams and Elliot (1999) and to test the predictions of ACT. In line with the predictions of ACT, we hypothesised that in the high-pressure condition (1) participants would employ a less efficient visual search behaviour indexed by more fixations of shorter duration (increased distractibility), which would be more pronounced in the low-skilled group, (2) the effect of probability information on visual search behaviours and task performance would be suppressed, and (3) the timing of the onset of the final fixation would be earlier.

We were successful in our attempt to create two distinct levels of anxiety. Participants reported significantly higher levels of cognitive and somatic anxiety and lower levels of self-confidence in the high-pressure condition as opposed to the low-pressure condition. Even though it is likely that levels of anxiety reported during actual sport competition would exceed those reported in this study, the results from the MRF-3 were successful in creating two distinct levels of pressure. The reported anxiety levels are similar to those reported in other laboratory studies (Wilson et al., 2009a; Wilson et al., 2009b).

6.4.1 Performance. The high-pressure condition had a negative impact on both visual search behaviour and performance effectiveness. Williams and Elliot (1999) revealed an increase in performance during high-anxiety conditions, which was not replicated in the present study. In the current study, impairments in gaze behavior during the high-pressure condition were accompanied by impaired performance. This supports findings demonstrated in far aiming tasks and driving tasks, suggesting that there is a critical interdependence between attention and performance (Behan & Wilson, 2008; Vickers & Williams, 2007; Wann, Swapp, & Rushton, 2000; Wilson et al., 2009a). The performance and visual search findings are discussed in greater detail throughout this section.

The skill-based differences in judgement accuracy replicated those observed in Chapters 3, 4, and 5. High-skilled participants were more accurate in judging direction change, and were less susceptible to deception compared to their low-skilled counterparts (as per; Rowe, et al., 2009; Sebanz & Shiffrar, 2009). In accordance with the findings from Chapters 4 and 5, judgement accuracy was again shown to be worse when the model moved in the unexpected as opposed to expected direction. There was no significant interaction between expectation and expertise, as both groups displayed equivalent increases in judgement accuracy when the model moved in the expected direction compared to the unexpected direction. This supports the findings from Chapters 4 and 5 along with previous research indicating that both high-skilled and low-skilled performers are able to make effective use of contextual information (Paull & Glencross, 1997; McRobert et al., 2011).

Consistent with our hypothesis, the impact of providing probability information was reduced in the high-pressure condition. Specifically, for both groups the costs and benefits associated with the provision of probability information were greater in the low-pressure condition than in the high-pressure condition. In accordance with ACT this indicates suppressed input from the goal-directed attentional system. By inference, if top-down attentional control is required to effectively complete a task, the overriding stimulus-driven attentional control will likely impair task performance. With regard to our second prediction, players were significantly more susceptible to deceptive movement during the high-pressure condition. These findings are consistent with ACT, in that anxious performers have difficulty disengaging from distractions and the shift in attentional control to stimulus-driven bottom-up control causes players to focus solely on the visual stimuli. ACT precisely states that the central executive functions most impaired by anxiety are the inhibition and shifting functions. It has been suggested that under high anxiety individuals take longer to process threatening stimuli and take longer to disengage from them (Derakshan & Eysenck, 2009).

6.4.2 Confidence Ratings. After each trial participants indicated their perceived confidence of their judgement on a scale of 1-5 (1 = not at all confident; 5 = extremely confident). Overall, high-skilled players reported higher confidence ratings than low-skilled players. Confidence ratings decreased from non-deceptive to deceptive trials as shown in Chapter 3, which suggests that players were aware of possible deceptive cues from advance visual information. Moreover, the perceived confidence ratings of both skill groups significantly decreased during the high-pressure condition. This provides additional support for the success of anxiety manipulation. In addition to this finding, there was also a greater drop in confidence ratings from expected to unexpected trials in the low-pressure condition compared to the high-pressure condition, providing further support to our prediction that the effect of probability information would be suppressed in the high-pressure condition.

6.4.3 Visual Gaze Behaviours. The findings from visual search data largely replicated those found in Chapter 5 and observed in other studies (Ripoll et al., 1995; Williams & Davids, 1998; Williams & Elliot, 1999). High-skilled players made significantly fewer fixations of longer duration on fewer locations within the visual display compared to low-skilled players. In comparison to Chapter 5's findings, both groups made fewer fixations in the 75:25 probability condition compared to the 50:50 condition; however, this reduction in fixations was greater for the high-skilled players. It is likely that the provision of probability information guided the high-skilled players to extract relevant information more effectively. Further evidence for this finding was demonstrated by the high-skilled players making their final fixation at an earlier time point compared to low-skilled players, which aligns with findings from research examining quiet eye (Behan & Wilson, Wilson et al., 2009a; Wilson et al., 2009b).

The systematic differences in visual search behaviours employed in this study provide support for an increased influence of the stimulus-driven attentional system. In keeping with the initial prediction, anxiety caused an increased number of fixations of shorter duration indicating a reduced efficiency of attention control. The high-pressure condition revealed an increase in the mean percentage viewing time on more distal cues (e.g., head and ball), which suggests that players experienced a narrowing of the perceptual field, resulting in enhanced search activity to compensate (Williams & Elliot, 1999). These search differences help to explain the increased susceptibility to deception during high-pressure. The findings provide further evidence that anxiety causes attentional narrowing of peripheral vision, which leads to participants employing compensatory fixations in order to discriminate between relevant and irrelevant peripheral cues. Support for an increased influence of stimulus-driven attentional control is reinforced by the time of the final fixation data, which demonstrated that a later final fixation was made during the high-pressure condition. The data suggests that players employed an enhanced search strategy, directing their attention to an increased number of locations for shorter periods. Research on far-aiming tasks have typically found that a decrease in the ‘quiet eye’ period leads to a reduction in performance effectiveness (Causer et al., 2011; Vickers & Williams, 2007; Wilson et al., 2009a). Together, these findings provide support for the predictions of ACT.

6.4.4 Summary. The current findings have practical and theoretical implications. The present study helps to further our understanding of how attentional processes and anticipation skill respond under heightened anxiety induced by performance pressure. Our findings reported changes in both performance effectiveness (as indicated by a decrease in judgement accuracy) and processing efficiency (as inferred from an increased number of fixations, alterations in search locations and reductions in the time of the final fixation) under high-pressure. In line with the predictions of ACT, anxiety caused a reduction in the goal-directed attentional system, as indexed by the systematic differences in visual gaze behaviours. As a result there was a significant decrement in performance effectiveness. Previous research has demonstrated the importance of situational probability information on performers anticipatory performance. Despite the increasing use of performance analysis methods in elite sport, the use of such information is still poorly understood, particularly in environments that artificially recreate high-pressure environments experienced during real-life competition. Findings from the current study indicate that the use of top-down probability information was suppressed in the high-pressure condition. On a practical level, these findings highlight the importance of considering how context and probabilities are used by performers under low- and high-pressure conditions, and how these should be considered when researchers or practitioners seek to develop perceptual training protocols.

It is evident that ACT provides a useful theoretical framework to examine attentional control in high-pressure environments. Even in the cognitive psychology literature, there have been relatively few studies that have tested the main predictions of ACT (Derakshan, et al., 2009). Research from the sport literature which has examined ACT has revealed that differences in visual attentional control lead to a deterioration in performance, which has not been shown in ‘process pure’ tasks in cognitive psychology. In moving forward, researchers should examine the specific predictions of ACT in anticipation tasks with respect to the shifting and inhibition functions and should further examine the potential for visual attentional training to aid performance under pressure.

Chapter 7: General Discussion

7.1 Introduction

The present chapter provides a detailed summary of the main findings presented in this thesis and outlines its implications for both theory and practice. The limitations of the present research are considered, and potential directions for future research are discussed.

7.2 Aims of the Thesis

The aims of the present thesis were to examine expertise effects with regard to anticipation skill and, in particular, the perception of deceptive movement. In addition, it aimed to increase understanding how 'top-down' and 'bottom-up' processes interact in time-constrained perceptual tasks, and to extend understanding of how anxiety impacts anticipation skill, especially the perception of deception, and associated attentional processes. In Study 1, the expert advantage in anticipation skill and susceptibility to deception was examined by testing high-skilled and low-skilled soccer players in a time-constrained perceptual task, in normal and point-light video footage. A combination of performance and process measures, comprising of judgement accuracy and confidence ratings, was employed. The aim of Study 2 was to examine the influence of 'top-down' probability information on the anticipatory judgements of high-skilled and low-skilled soccer players. Expanding further on this work, Study 3 aimed to further understand how 'top-down' and 'bottom-up' processes interact during a time-constrained perceptual task and its impact on the visual search behaviours associated with expert performance. Lastly, Study 4 tested the predictions of ACT in relation to the provision of top-down probability information, and the visual search behaviours employed under heightened anxiety.

7.3 Summary of Research Findings

Despite a proliferation of research examining expert effects in anticipation skill, there is a lack of consensus regarding the processes underlying expert judgements of deceptive intent. In Study 1, the aim of the two experiments was to examine high-skilled and low-skilled performers' susceptibility to deception when viewing (a) full video format and (b) point-light displays that isolate kinematic information. In addition to this, the two experiments sought to examine the relative importance of the upper-body and lower-body regions to perceiving deceptive intent and also examined the nature of the judgements being made through confidence ratings. Study 1 presented a two-choice prediction task in which the participants viewed video sequences of an attacking soccer player dribbling the ball towards them before changing direction to the left or right.

The results provided further evidence that high-skilled performers have a greater ability to discriminate between genuine and deceptive movement compared to low-skilled performers. High-skilled performers were able to maintain the perceptual-cognitive advantage when viewing point-light displays. These findings support the original hypothesis in showing that the expert advantage in anticipation skill extends to judgements of deceptive intent, with high-skilled players less susceptible to deception than low-skilled players; thus supporting previous research (Dicks et al., 2010a; Rowe et al., 2009). Also in line with previous research, Study 1 provides further evidence that information extracted from advance visual cues is largely kinematic, such that the expert advantage was demonstrated in both full video and point light display. Overall, across the two experiments there was only a small difference between the no occlusion condition and the upper/lower body occlusion conditions, indicating that even when the upper or lower body was occluded performers were able to maintain their performance levels similar to that in the no occlusion condition. However, both experiments revealed that when occluding the upper body there was a greater disruption in judgement accuracy during deceptive trials, resulting in both groups being more susceptible to deception. This finding suggests that there are important visual cues located in the upper body that are more effective in assisting performers discriminate between genuine and deceptive cues, compared to the lower body.

Study 2 was conducted to gain an insight into the influence of top-down processing on the anticipatory judgements of high-skilled and low-skilled performers. A novel approach, based on an adaptation of the spatial cueing paradigm, was adopted in Study 2. This involved a two-choice prediction task identical to the task employed in Study 1; however, participants were presented with probability information prior to each block of trials indicating the probability of the player changing direction to the left or right. Consistent with the findings reported in Study 1, high-skilled participants were more accurate in judging direction change, and were less susceptible to deception compared to their low-skilled counterparts. It was predicted that the addition of probability information would be more beneficial to the high-skilled group; however, findings proved inconclusive. This was primarily because the high-skilled group performed close to ceiling level in the 50:50 condition, leaving little scope for further improvement in the 67:33 and 87:13 conditions. In contrast, the low-skilled group's performance in the 50:50 condition left plenty of scope for improvement at the other two probability levels.

The low-skilled group's performance improved from the 50:50 condition and, consistent with the general hypothesis, was moderated by the degree of certainty conveyed through the probability information. During unexpected trials, both groups suffered a progressively greater decrement in performance from the 66:34 condition to

83:17 condition relative to their performance in the control (50:50) condition. However, during unexpected trials the low-skilled group suffered a much greater decrement in performance from the 50:50 to 83:17 condition (23%) compared to the high-skilled group (12%). This finding suggests that the high-skilled players were better able to integrate the top-down probability information with bottom-up visual stimuli, as they were able to limit the costs of this prior knowledge when the model moved counter to expectation. Due to the ceiling effects in the high-skilled group data were inconclusive with regard to the differences during expected trials. Overall, both groups were equally adept at using probability information to improve performance. However, the findings during unexpected trials suggest that high-skilled players were better able to integrate the top-down probability information with the bottom-up visual stimuli.

In light of the findings of Study 2, it was deemed necessary to introduce the temporal occlusion paradigm to lower the mean judgement accuracy of high-skilled players in order to better ascertain the costs and benefits associated with receiving top-down probability information. Therefore, in Study 3 an identical perceptual task was presented to that in Study 2, with each trial occluded at one of two temporal occlusion conditions. Furthermore, visual search behaviours were examined to enable inferences to be made about the allocation of visual attention during the task.

As in Study 2, there was no expertise by probability condition interaction meaning the data were once again inconclusive as to whether the addition of probability information is more beneficial to high-skilled than low-skilled participants. The interaction between expertise and expectation was non-significant, with both groups improving their judgement accuracy when the model moved in the expected direction and displaying a decrease in judgement accuracy when the model moved counter to expectations. In Study 2 a ceiling effect occurred in the high-skilled group’s judgement accuracy results, whereas in Study 3 there was a potential floor effect for the low-skilled group. The selection of participants and experimental trials were identical across Study 2 and 3; therefore, we compared the low-skilled group's results in Study 2 and the high-skilled group's results in Study 3, as baseline performance was at a similar standard. The comparison revealed that during expected trials the benefits associated with receiving probability information were similar for the high-skilled and low-skilled groups. However, when comparing response accuracy during unexpected trials the costs of receiving the probability information were greater for the low-skilled group compared to the high-skilled group. This offers some support for our prediction that the high-skilled players would be better able to integrate top-down probability information with bottom-up visual information.

Systematic differences in visual search behaviour were observed between high-skilled and low-skilled participants. High-skilled participants made fewer fixations of longer duration on significantly fewer locations in the visual display in comparison to low-skilled participants. In addition, high-skilled participants fixated on different locations of the display (e.g., hips and trunk), whereas the low-skilled participants fixated on information sources primarily from peripheral lower body regions (e.g., feet and knees). These data were comparable to studies using representative tasks in one-versus-one film simulations (Savelsbergh et al., 2002; Williams & Davids, 1998). High-skilled participants also made a much later final fixation on deceptive trials than on non-deceptive trials; however, this was rarely an additional fixation (mean increase = 0.20). Nor did the locus of fixations change from non-deceptive to deceptive trials for either group. This finding indicates that the high-skilled group were able to identify a 'genuine' movement at an earlier point than the low-skilled group, and were delayed in identifying such information when an opponent performs a step-over. The final fixation also occurred earlier as the degree of certainty moderated by the probability information increased, which implies that the additional information encouraged participants to seek confirmatory cues associated with the expected event. It is likely that these visual search differences are indicative of a more efficient visual search strategy employed by high-skilled participants for this particular type of task. The absence of the predicted expertise by probability condition interaction across a number of analyses in Study 2 and 3 provides further evidence that both high-skilled and low-skilled performers are equally adept at utilising top-down information to improve performance (McRobert et al., 2011; Paul & Glencross, 1997).

In Study 4, the implications of the previous studies' findings were explored under heightened anxiety. According to ACT, anxiety negatively affects performance by disrupting goal-directed, top-down attentional control and causing attention to become more stimulus-driven. The results of the final study added strong support for this and the predictions of ACT (Eysenck et al., 2007). As in Studies 2 and 3, both high-skilled and low-skilled participants were able to make effective use of the probability information. Consistent with our prediction, the influence of probability information was suppressed in the high-pressure condition, indicating that the use of top-down information was restricted due to the overriding stimulus-driven system. The findings also demonstrated that participants in both groups were more susceptible to deceptive movement during the high-pressure conditions, suggesting that anxious performers have difficulty disengaging from the stimulus-driven bottom-up system. Participants' confidence ratings significantly decreased during the high-pressure condition, which provides additional support for the success of the anxiety manipulation. There was also a greater drop in confidence ratings from expected to unexpected trials in the low-pressure condition compared to the high-pressure condition, providing further support that the effect of probability information was suppressed under increased pressure.

The visual search findings provided additional support for an increased influence of the stimulus-driven attentional system. In line with the initial prediction, increased anxiety caused participants to make more fixations of shorter duration indicating a reduced efficiency of attentional control. The high-pressure condition caused participants to increase their mean percentage viewing time on more distal cues (e.g., head and ball), which implies that participants experienced a narrowing of the perceptual field. These differences assist in explaining the increased susceptibility to deception during high-pressure, as the increased dependence on the feet and ball as a source of visual information direct the participants attention to the location of where the step-over action takes place. Furthermore, the time of the final fixation provides additional support for an increased influence of the stimulus-driven system, as participants made their final fixation at a later time point under heightened anxiety. This suggests that participants employed an enhanced search strategy, fixating on more locations prior to making a final judgement.

7.4 Implications of Research Findings

The studies within this thesis have made a significant addition to the perceptual-cognitive expertise literature. These additions include: 1) a greater understanding of the effect of expertise on the perception of deception, 2) evidence to support the use of contextual information, 3) evidence to support the use of both visual and contextual perceptual training interventions and 4) evidence to support the use of ACT as a theoretical framework for understanding the influence of anxiety upon visual attentional control. The purpose of this section is to appraise the main findings and highlight the possible implications.

7.4.1 Perceptual-cognitive expertise. In order to better understand the expertise effects associated with anticipation skill and, in particular, the perception of deceptive movement, judgement accuracy and confidence ratings were recorded to infer skill-based differences. Researchers have consistently demonstrated across a number of sports that skilled performers are able to anticipate an opponent's action through pick up of early visual cues in time-constrained tasks (Abernethy & Russell, 1987; Bishop, et al., 2013; Crognier & Féry, 2005; Müller & Abernethy, 2006; Müller et al., 2006; Shim et al., 2005; Williams, 2000) and the present research programme has provided results in-line with this notion.

As predicted and in line with previous research (e.g., Dicks et al., 2010a; Rowe et al., 2009), high-skilled participants were less susceptible to deception across all four studies, compared to their low-skilled counterparts. Across the four experimental chapters in this thesis high-skilled players consistently demonstrated that their superior ability to anticipate movement from advance cues extends to the detection of advance deceptive movement. These findings have consistently demonstrated that expertise effects are much greater during deceptive trials compared to normal trials and are a key distinguishing feature between skill groups, providing strong evidence for the use of deceptive movement when examining expert performance.

The findings in Studies 3 and 4 revealed that when viewing deceptive trials high-skilled players employed significantly different visual search strategies, in comparison to low-skilled players whose search strategy remained similar for normal and deceptive trials. High-skilled participants made a much later final fixation on deceptive trials than on non-deceptive trials; however, this was rarely an additional fixation (mean increase = 0.20). This finding suggests that the visual system of high-skilled players is more attuned than low-skilled participants to seeking the confirmatory visual information that would enable successful discrimination between a 'genuine' change in direction as opposed to a step-over.

If the timing of the final fixation is indicative of identifying confirmatory information, it appears that high-skilled players identify 'genuine' movement at an earlier point than the low-skilled players, and are delayed in identifying such information when an opponent performs a step-over. Similar findings have been reported in studies examining ‘quiet-eye’ (QE) during aiming tasks. The QE is considered to be a period of cognitive pre-programming, whereby experts display longer fixations to extract critical information and programme accurate movement responses. Researchers have yet to attempt to define the specific QE period for other non-aiming sporting tasks. The data from this thesis indicates that there are significant expertise differences in the timing of the final fixation, which requires further research to uncover why an earlier onset of the final fixation promotes superior performance, and how this finding alters during the perception of deception.

7.4.2 Influence of contextual information of anticipation performance. As outlined in Chapter 4, previous research has indicated that differences occur in perceptual-cognitive processes (e.g., visual search strategies) and performance measures (e.g., response accuracy) when contextual information about an opponent is available compared with when it is not available (MacMahon & Starkes, 2008; McRobert, et al., 2011). Previous work on the moderating effects of contextual information were extended through examination of how 'top-down' and 'bottom-up' processes interact in time-constrained perceptual tasks in relation to expertise in Chapters 4, 5 and 6. Unlike previous research on contextual information, there were no significant interactions for response accuracy between expertise and probability information (McPherson & Kernodle, 2007; Verkoeijen et al., 2004). However, in other studies researchers have reported similar improvements in anticipatory performance across high-skilled and low-skilled groups when context-specific information was available (McRobert et al., 2011; Paull & Glencross, 1997).

In Chapters 4 and 5 judgement accuracy was moderated by the degree of certainty conveyed through the probability information. In line with previous research, the present results suggest that both groups are equally adept at utilising contextual information to improve performance (Paull & Glencross, 1997; McRobert et al., 2011). Through comparison of the low-skilled group's performance in Chapter 4 and the high-skilled group's performance in Chapter 5, there is some evidence to support our prediction that high-skilled players were better able to integrate top-down information with bottom-up stimuli. Therefore it is reasonable to suggest that the use of probability information in lower-skilled players is associated with greater costs when viewing unexpected trials. The visual search data presented in Chapters 5 and 6 revealed that the timing of the final fixation became earlier as the degree of certainty conveyed through the probability information as the degree of certainty conveyed through the probability information increased.

These studies have significant implications for the manner in which researchers examine how top-down information interacts with bottom-up visual stimuli in order to further understand the costs and benefits of prior knowledge on anticipation skill. The adaptation of the spatial cueing paradigm used in Chapters 4-6 provides an opportunity to understand the interaction between the top-down and bottom-up attentional systems in time-constrained perceptual tasks, and contribute to the evidence base associated with using notational analysis in sport. The task design employed in this thesis differed to previous work in that there was more control over the amount of information provided. Limitations highlighted in previous research that employed high- and low-context conditions suggest that the high-context conditions may have been too brief and did not provide a sufficient amount of information to generate probabilistic expectations (McPherson & Kernodle, 2007; McRobert et al., 2011).

In summary, these findings help provide a more complete representation of the processes mediating superior anticipation and decision making expertise during a one-versus-one attacking soccer task. These studies have demonstrated the importance of probability information on anticipation performance and visual search behaviours in both high-skilled and low-skilled soccer players. Performance analysis in soccer, and several other sports, plays a prominent role in expert performance. As highlighted in this research there are clear benefits from receiving probability information, however, there are also significant costs. It is vital that researchers and sports practitioners continue to work towards further understanding the costs and benefits associated with using such information.

7.4.3 The influence of anxiety on visual attentional control. Sport psychology is ideally situated to test cognitive psychological theories in real anxiety-inducing environments such as competition. Janelle (2002) claimed that attentional control is one of the most critical psychological skills to perform effectively in sports. Chapter 6 tested the predictions of ACT (Eysenck et al., 2007) in a one-versus-one soccer situation to further our understanding of how attentional control and anticipation performance are affected by pressure. Compared to PET (Eysenck & Calvo, 1992), ACT provides further explanation of the attentional mechanisms that are impaired by anxiety (i.e., disruption in inhibition, shifting and updating functions of the central executive). It is vital that researchers testing the predictions of ACT in sports setting take into consideration what independent variables can be measured to assess disruptions in one or more of these functions. For example, in Chapter 6 response accuracy and visual search data were used as an indicator of disruption to the inhibition function of the central executive.

ACT also provides a useful framework, as evidenced in Chapter 6, for examining the relationship between anxiety, top-down information and anticipation performance in sport. Findings from the current study indicate that the use of top-down probability information was suppressed in the high-pressure condition. The earlier Chapters in this thesis demonstrated the importance of situational probability information on anticipatory performance. Chapter 6 is the first study to our knowledge to examine the use of such information in environments that artificially replicate high-pressure environments experienced during real-life competition. The findings offered support for ACT as shifts in attentional control from a goal-directed attentional strategy (top-down), to a stimulus-driven strategy (bottom-up) supressed the influence of top-down probability information, which significantly reduced performance and caused changes in processing efficiency.

From a theoretical perspective Chapter 6 clearly demonstrates that ACT provides a useful framework whereby visual attentional control can be examined under heightened anxiety. Research in sport has revealed that disruptions in visual attentional control lead to a deterioration in performance. In contrast, studies in cognitive psychology adopting ‘process pure’ tasks (e.g., anti-saccade tasks) have indicated that disruptions in visual attentional control does not tend to lead to deteriorations in performance (Derekshan et al., 2009). Further research in sport is required to examine the specific predictions of ACT in anticipation tasks with respect to the shifting and inhibition functions.

7.4.5 Practical implications. The findings across all four studies have further practical implications for researchers designing perceptual training protocols. These studies demonstrate that the perceptual and cognitive processes supporting performance alter according to the task constraints and it is vital that these processes are identified prior to the development of a training intervention. A key implication is that perceptual training interventions may be better directed towards enhancing the ability to detect deception rather than training players to become attuned to non-deceptive movement. Furthermore, in Chapters 3, 5 and 6 it is evident that certain cues and visual search strategies are more efficient for successful performance.

Most training interventions have been designed to improve a very specific perceptual-cognitive process (e.g., advance cue utilisation), often within a narrow or restricted context. In this study, evidence suggests that the different perceptual-cognitive skills (e.g., visual search behaviours, advance cue utilisation, situational probabilities) all interact during anticipation performance. Therefore, designing tasks that test and develop a combination of these skills (i.e., visual search and contextual information) in a similar manner to that which is experienced during actual sporting performance is likely to be important in designing effective training of perceptual-cognitive skills.

7.5 Limitations and Directions for Future Research

To date the majority of studies assessing perceptual-cognitive performance have used a representative laboratory-based task. Despite the widespread use of laboratory-based tasks the issue of how best to capture skilled perceptual-cognitive performance in the laboratory setting remains an important topic (Farrow & Abernethy, 2005; Williams & Ericsson, 2005). In Chapters 3-6 an attempt was made to develop a dynamic one-versus-one representative soccer using the most realistic replication of that environment that is currently feasible under controlled conditions in the laboratory. However, despite improved realism, functional limitations still remain. One particular concern is that visual simulation tasks, in some cases, fail to represent the selection of stimuli available for perception and action in a performer's natural environment (Farrow & Abernethy, 2003). Researchers have provided some evidence in support of the expert-novice differences found in laboratory-based tasks being replicable during real-life tasks (Abernethy et al., 2001; Farrow & Abernethy, 2003, Mann et al., 2010).

The present studies are limited to time-constrained, soccer tasks. While there are direct implications for soccer, there are a number of sports that comprise of similar skill characteristics where tentative predictions could be made from these findings. For example, it is likely that the findings regarding the influence of top-down probability on anticipatory performance could be used to predict the outcomes in sports and even other domains of a similar nature.

The method used to manipulate the degree of pressure individuals experienced during high pressure trials in Chapter 6 was based on established methods used in previous studies (Beilock & Carr, 2001) and demonstrated increased feelings of cognitive and somatic anxiety. Yet despite the advantages of manipulating pressure in a laboratory-based setting the problem of ecological validity is still inherent by design. The pressure manipulation in Chapter 6 attempted to replicate real-life sources of pressure (e.g., peer pressure and money incentives), it is unlikely that the pressure induced through laboratory manipulations are at the same level of that experienced in real-life settings.

A further limitation of the studies within this thesis is that portions of the findings in Chapters 4 and 5 were inconclusive as to whether high-skilled players are better able to integrate top-down probability information compared to low-skilled players. It is possible that this lack of interaction between expertise and probability condition could be due to not being fully immersed in a real-life game scenario. The methods employed to provide participants with probability information in the laboratory setting is different to how they would typically receive information in a real-life scenario. It is likely that players are provided with contextual information over a longer period of time, obtain prior knowledge/expectations from previous experiences and receive in-competition feedback used to update, and possibly strengthen, their expectations. These findings reinforce the recommendations that the examination of expertise, wherever feasible, should take place in a situation that closely mimics the natural performance environment (Farrow & Abernethy, 2003; Mann et al., 2007).

The findings demonstrate the importance of contextual information on anticipation performance. Furthermore, it is evident that the perceptual system needs to extract information from different cues when viewing deceptive movement and becomes more efficient at extracting the information when contextual information is available. Also, based on the findings presented in this thesis, future gaze-based interventions should attempt to combat anxiety-induced attentional disruptions.

7.6 Conclusion

The present series of studies examined the visual information and processes underlying expert judgements of deceptive intent, and how ‘top-down’ and ‘bottom-up’ processes interact during time-constrained perceptual tasks. Furthermore, it aimed to extend the theoretical understanding of how anxiety impacts anticipation skill and associated attentional processes indexed by visual search behaviour and the interaction between ‘top-down’ and ‘bottom-up’ processes. High-skilled participants demonstrated superior anticipation skill and were less susceptible to deception across all studies, whilst employing a more refined and effective visual search strategy. Both high-skilled and low-skilled participants' anticipation performance improved when top-down probability information was provided, demonstrating the importance of probability information on anticipation performance in both high-skilled and low-skilled soccer players.

The findings in this thesis provide support for the predictions of ACT, as indexed by the systematic differences in visual gaze behaviours there was a reduction in the goal-directed attentional system. As a result there was a significant decrement in performance effectiveness. Furthermore, the use of top-down probability information was suppressed in the high-pressure condition. In future, researchers and sport practitioners should continue to work towards further understanding the costs and benefits associated with using top-down information. The development of perceptual training programmes should also consider how contextual information is used by performers under heightened anxiety. Overall, this thesis has extended the perceptual-cognitive expertise literature, and offers theoretical and practical implications regarding the moderating affects of top-down information on anticipation performance.

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Appendices

List of Publications Emanating from the Present Programme of Research

Barton, H., & Jackson, R. C. (2010). Anticipation skill and susceptibility to deceptive movement in female football players. Paper presented at the annual meeting of the Division of Sport and Exercise Psychology, London, UK.

Barton, H., Jackson, R. C., & Bishop, D. T. (2013). Knowledge of player tendencies: The effect on anticipation skill and susceptibility to deception. Paper presented at the annual meeting of the North American Society for the Psychology of Sport and Physical Activity, New Orleans, LA. (Abstract: *Journal of Sport and Exercise Psychology*, *35*, S18).