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THE IMPACT OF FIELD VISION ON PERFORMANCE WITHIN AN ENGLISH PREMIER LEAGUE ACADEMY SOCCER TEAM: A CASE STUDY

by

Daniel Spearritt

A Dissertation submitted in partial fulfillment of the requirements of the University of Chester for the degree of M.Sc. Sports Sciences (Performance Analysis)

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No portion of the work referred to in this Dissertation has been submitted in support of an application for another degree or qualification of this, or any other University or institute of learning.

The project was supervised by a member of academic staff, but is essentially the work of the author.

Signed ………………………………………………………….

Date ……30th September 2013……………………………………………………….

Abstract

Previous perceptual-cognitive skill research in sport has often applied laboratory-based protocols to examine differences amongst elite and sub-elite performers. Contemporary research within the area has started to move away from such protocols and has begun analysing visual search behaviours within competitive adult soccer matches. The purpose of the current study was to develop an understanding of visual search behaviour in relation to performance outcome amongst elite level youth soccer players, within competitive match performance. Thirteen matches from an English Premier League academy soccer team (under 15 age group) were analysed using a specifically designed notational analysis system created in Microsoft Excel. Visual explorations conducted by individual players were collated, followed by their subsequent action when in possession of the ball. The results show significant visual exploration differences between higher and lower ability elite level youth players (p=0.000). The results of a series of categorical logistic regression analyses also show a clear positive relationship exists between visual exploratory behaviours that are initiated prior to a player receiving the ball and performance with the ball. This relationship remains when assessed amongst several match conditions including overall pass completion, attacking third pass completion and forward pass completion. Practical implications for coaches, scouts and players are discussed.

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Introduction

Due to the unpredictable and dynamic nature of team sports, it is now accepted that perceptual and cognitive skills are a crucial aspect of expert performance alongside physical and motor capabilities (Burgess & Naughton, 2010; Williams, 2002). Although superior athletic performance is identifiable on observation, the perceptual-cognitive mechanics that contribute to expert performance are less evident (Mann, Williams, Ward & Janelle, 2007). Marteniuk (1976) referred to perceptual-cognitive skill as the ability to identify and acquire environmental information that is then integrated with existing knowledge, allowing appropriate responses to be selected and executed. These skills are pertinent within soccer, where players are confronted with a complex and rapidly changing environment. Players must gather information from the ball, teammates and opponents, before deciding on an appropriate response based upon current objectives (Williams, 2000). Using this information to make accurate decisions has been identified as being a significant factor in successful elite performance. This is certainly the case within soccer, a notoriously fast paced sport (Baker, Cote & Abernethy, 2003). Williams (2000) provided the example of talented defenders and their unhurried actions when intercepting a pass, suggesting that they have ‘all the time in the world’. This ability to ‘read the game’ often distinguishes skilled from less skilled soccer players.

As in other domains, experts within sport develop sophisticated knowledge structures that allow them to retrieve, encode and process information in a systematic and efficient manner. Research into perceptual and cognitive skills has focused on several key areas including pattern recognition, advance cue usage, situational probabilities and visual search behaviours (Williams, 2002). Stratton, Reilly, Richardson and Williams (2004) noted that, in lay terms, such skills are often labelled as ‘game intelligence’. Game intelligence, within soccer, relates to the ability to recognise and adapt to situations quickly in the high-pressure match environment. Up until recently the development of the intellectual capacities of youth soccer players has been scarce, often due to the authoritarian teaching style adopted by trainers or coaches. That is to say, frequently hinting or instructing players before and during a game is not sufficient to elevate players to the elite level (Wein, 2004). The importance of game intelligence within soccer has become recognised more widely, particular within the media, with the recent success of both the Spanish national soccer team and FC Barcelona. Both teams have adopted a style of soccer that, amongst other components, focuses upon technique and game intelligence. This is highlighted by Xavi Hernandez (midfielder for Spain and Barcelona) who when talking about FC Barcelona stated;

“Here they make you think from day one…It’s think, think, think, and it teaches you the responsibility of keeping the ball and the shame of losing it. You lift your head before you receive the ball, you look to see if you are in space, and who else is in space, and you play the ball first time. Modern football is so quick that two touches means too slow” (Xavi Hernandez, 2011).

Whilst recent sporting achievements may have brought the importance of perceptual-cognitive skills (game intelligence) to the fore within the media, it has been a constant area of interest within research over the last few decades. Amongst the vast depth of previous literature within the area, a multitude of research protocols have been applied to elicit expertise differences in cognitive and perceptual skill. Although valuable, such a diverse research base has hindered the ability to compare effects across different protocols (Mann et al, 2007). One of the primary experimental approaches used within such research is the temporal occlusion paradigm. This involves the editing of dynamic visual images in order to provide selective vision to different events or time periods within the actions of an opposing player. Applied to many sports, including soccer, differences have been evident between experts and novices. Although somewhat dated, studies using the temporal occlusion paradigm (Abernethy & Russell, 1987; Goulet, Bard & Fleury, 1989) have consistently demonstrated that experts are able to anticipate more effectively than novices. Furthermore, studies have found that experts are capable of picking up useful anticipatory information from early events in their opponent's movement pattern, to which novices are not attuned. Despite the widespread use of the temporal occlusion paradigm, several issues exist regarding the validity of the conclusions reached using such an approach. The first relates to a potential confound in the paradigm, between effects due to actual anticipatory information pick up and effects due rather to inter condition variations in the length of the viewing period (Farrow, Abernethy & Jackson, 2005). The second issue relates to ecological validity, something that has long been acknowledged as a concern in academic research (Waldron & Worsfold, 2010). Farrow et al. (2005) question whether studies using the temporal occlusion paradigm approach can be considered ecologically valid. They allude to the film based approach and simple response modes used in the majority of temporal paradigm studies and question whether they accurately replicate the natural demands of the sporting task.

Jordet et al (2013) also question the extent to which laboratory simulations replicate the tasks and conditions that would logically seem critical to visual perception and subsequent actions in real competitive matches. They provide the example that video sequences only display information that is located in front of the participant, neglecting ambient information that is found in real world games (information from important events occurring behind a players back). Furthermore, due to the researchers' preoccupation with frontal vision, most visual search behaviour research has included eye movement monitoring (Canal-Bruland et al., 2011; Roca et al., 2011; Williams & Davids, 1998) thereby neglecting head and body movements. Filmed video sequences applied within previous studies often use edited sections of professional sporting performance or specific match simulations conducted by the researchers, neither of which meaningfully involve any of the participants (Jordet et al., 2013).

Effective anticipation (an aspect of 'game intelligence') requires that soccer players focus their visual attention on the most relevant sources of information at the appropriate time. Crucially, knowing 'when' and 'where' to look are important aspects of skilled performance (Williams, 2000). The current study will focus on visual search strategies (behaviours), which are defined as the ability to pick up advance visual cues or to identify patterns of play (Williams, 2000; Casanova, Oliveira, Williams & Garganta, 2006). It is important to make the distinction between visual search behaviour and cue usage, which has often been overlooked in previous literature. Visual search strategies reflect the way in which the eyes move around the display to extract relevant information, whereas cue usage refers to the specific source of information that a performer uses to guide their action (Williams, Janelle & Davids, 2004). To examine visual search behaviours, sophisticated eye movement registration techniques have been employed in sport settings to identify differences between expert and novice performers (Williams, 2002). These techniques allow researchers to examine both eye movements and the areas of display in which performers fixate their gaze (Williams, 2000).

Previous research suggests that skilled soccer players show more pertinent search strategies than their less skilled counterparts. Skilled players generally perform fewer fixations but with longer durations, and often fixate more on informative areas of display, thus allowing them to anticipate future actions skilfully (Williams, 2000; Helsen & Pauwels, 1992; Williams & Davids, 1998). Canal-Bruland et al. (2011) found that skilled soccer players do not use a larger visual span than less skilled players. They concur with previous research that skilled players perform fewer fixations but with longer durations. However, in contrast to previous findings, Roca, Ford, McRobert and Williams (2011) found that skilled soccer players employed a visual search strategy involving more fixations of shorter durations than the less skilled players. Skilled players also searched in a different sequential order and toward more disparate and informative locations in the display, in comparison with their less skilled counterparts. Whilst previous studies have taken place within a laboratory setting, methodological differences between studies may explain the disagreements in previous research. That is to say, some studies have adopted the use of static photographs whereas other research has used filmed match sequences (Jordet, Bloomfield & Heijmerikx. 2013).

Perceptual-cognitive skills, including visual search behaviours, have been examined in several sports, including soccer. An extensive search strategy involving many fixations of relatively short duration is required in order for players to make themselves aware of the positions and movement of players, and the passing opportunities presented to the player in possession of the ball (Williams, Davids, Burwitz & Williams, 1994). Conversely, when the ball is nearer to the goal, in smaller match situations (such as 3 vs

3 on the edge of the penalty area), lower search rates seem preferable owing to the increased role of peripheral vision (Williams & Davids, 1998). The majority of researchers have employed the expert-novice paradigm to isolate key differences between skilled and less skilled individuals (Williams, Ward, Knowles & Smeeton, 2002). Generally, researchers have examined players that differentiate in both skill level and playing experience. Using such participants has proved problematic, specifically when attempting to determine the relative contribution of innate talent and experience on the task in fostering expert performance. These issues are compounded by the apparent absence of adequate control groups differentiated on the experience and skill continuum (Abernethy, Thomas & Thomas, 1993). Therefore it is questionable whether previous paradigms are able to discriminate effectively among players of varying skill level, but with a similar amount of soccer experience (Williams et al., 1999). Moreover, the more dated research focused heavily on using adult sample groups during testing. Recent research, therefore, has begun to assess differences amongst youth soccer players. Vaeyens et al. (2007) examined differences in visual search behaviours and decision-making skills across different microstates of offensive play in soccer (2 vs 1, 3 vs 1, 3 vs 2 etc), amongst youth participants. Their findings state that playing experience, skill level and differing task constraints determined both the observed search behaviour and processing requirements imposed on players.

The increase in perceptual-cognitive skill research examining youth soccer players has coincided with the rising importance of identifying, developing and nurturing talented young soccer players. Soccer teams are placing a greater emphasis on producing players through their own academy due to the spiralling costs of purchasing players through the transfer market (Williams, 2000). Historically, identifying talent and selecting individual players has been linked to a coach or scout's subjective opinion based on their image of the ideal player (Unnithan et al., 2012). Talent may not be evident at an early age, but there will be some indicators that enable trained individuals to identify its presence. Often soccer clubs will adopt certain acronyms such as TABS (Technique, Attitude, Balance and Speed) and SUPS (Speed, Understanding, Personality and Skill) to subjectively assess players (Williams & Reilly, 2000). However, due to the multidimensional structure of soccer the 'right' and 'wrong' qualities needed to excel within the sport are not easily identifiable through a selection of single factors but through a multifaceted set of characteristics (Christensen, 2009). Whilst the ability of coaches and scouts to interpret such criteria should not be underestimated, the addition of sport science allows a more objective approach to be taken when assessing such criteria (Williams & Reilly, 2000). Without the inclusion of sport science support, it is now accepted that such methods can lack consistency and repetitive misjudgements can be made (Meylan, Cronin, Oliver & Hughes, 2010; Unnithan, White, Georgiou, Iga & Drust, 2012). Moreover, there has been a recent emphasis upon the use of science-based support systems that provide a more holistic approach to identifying and developing talent (Unnithan et al., 2012).

In order to select suitable candidates for talent development programs, research has adopted a multi-disciplinary approach. This often includes objectively measuring elements of performance such as physiological, psychological, anthropometric and game specific skill variables in order to ascertain certain criterion values that represent elite youth populations (Reilly, Bangsbo & Franks, 2000; Vaeyens et al., 2006). Such measures are advocated for use within longitudinally designed research in order to distinguish between elite and sub-elite samples. Previous research has reported that fine motor-skills, such as dribbling, occur most frequently as a significant difference between elite and sub elite sport performers. Specifically in soccer, (Reilly, Williams, Nevill & Franks, 2000; Huijgen, Elferink-Gemser, Post & Visscher, 2009) research has supported the notion of skill testing as a discriminating factor between elite and sub-elite playing levels, using additional gross motor skills such as shooting and passing within the respective test batteries (Waldron & Worsfold, 2010).

One discipline within sport science that is becoming more common within professional soccer teams and can analyse performance in an ‘open’ skilled environment, is performance analysis (O’Donoghue, 2005)|. When analysing sport performance information provides the key link between application and theory. That is to say sport coaches will aim to influence future actions and decisions of their athletes by providing them with information gathered from observations based on past performances (McGarry, 2009). The failings of the human observer as a recording instrument, together with understanding the importance of providing accurate information in the form of augmented feedback for skill learning, encouraged the systematic introduction of objective methods to document and quantify sport performance (McGarry, 2009). Performance indicators are adopted within performance analysis to define and measure successful and unsuccessful performance. They are often made up of a selection or combination of action variables to help explain outcomes of performance (O’Donoghue, 2005). Depending on the specific needs of coaches or players, performance indicators enable the assessment of individual, team or an opponent’s performance (Hughes & Bartlett, 2002). Performance analysis methods have also been applied to assess the differences amongst youth soccer players. Waldron and Worsfold (2010) analysed the performance of 71 elite and sub-elite soccer players, using O'Donoghue's (2005) performance profiling method. The authors report how the elite group are significantly higher performers in 9 out of the 18 performance indicators selected, including shooting, dribbling and passing.

It has been suggested that future performance (notational) analysis systems should aim to incorporate all facets of performance, and most importantly, how they all impact on each other (James, 2006). Despite the importance of decision-making skills in sport, (and the components previously discussed that enable correct decisions to be made) very few notational analysis methods exist to assess this ability in competitive match situations (Lorains, Ball & MacMahon, 2013). Hughes and Franks (2004) highlighted that whilst performance analysis is often used to inform coaches and players on a variety of performance measures, the cognitive components of decision-making are not included as a performance measure.

With the aforementioned limitations surrounding previous studies' ecological validity and the dearth of performance analysis research that examines the 'cognitive components' of decision-making, Jordet et al. (2013) conducted a study to assess visual scanning during competitive match performance in soccer. They alluded to the urgent need to examine athletes' perception in real-world competitive situations. Analysing performances of elite soccer players from the English Premier League, the authors report that a 'clear positive relationship' exists between exploratory behaviours that are initiated before receiving the ball and performance with the ball (Jordet et al., 2013). Whilst a positive relationship exists amongst elite adult soccer players no such studies to date have used similar methods to examine elite youth soccer players. Therefore there is a need to establish the distinguishing characteristics of elite youth players (LeGall, Carling, Williams & Reilly, 2010). Due to the introduction of the ‘Financial Fair Play’ licensing scheme and the increased emphasis on clubs to produce a ‘home grown’ quota of players, the ability to foresee the ‘elite’ within their academy is even more important (UEFA). The following study will apply similar methods to that of Jordet et al. 2013, to assess visual search behaviour amongst elite youth soccer players. The study will assess if visual search behaviour affects sporting performance, specifically in relation to passing performance and the number of touches player’s take. Furthermore, with the previous acknowledgements that elite soccer player’s perceptual-cognitive skills differ to sub-elite soccer players, the current study will assess if visual search behaviours are significantly different amongst elite youth soccer players. The current study hypothesises that:

1) Individual players who are of higher ability will conduct a greater amount of visual explorations than players of lower ability.
2) When individual players conduct visual explorations they will perform more successful actions than unsuccessful actions.
3) When players perform a greater amount of visual explorations they will possess a greater percentage of successful passes.
4) When players perform a greater amount of visual explorations they will possess a greater percentage of successful forward passes and attacking third passes (often considered more important to successful overall performance than sideward/backward passes and defensive third/middle third passes).
5) When players take between 0-2 touches and perform a pass, they are more likely to be successful if they perform a greater amount of visual explorations.

Literature Review

The psychological theory underpinning perceptual-cognitive skills within sport has often directed previous research. It has also influenced the methodology applied within studies, which has predominately involved laboratory based tests allowing for easily measureable and controlled settings. The majority of studies have examined differences amongst sport performers of different overall skill levels (i.e elite vs sub elite). Recent studies have attempted to merge disciplines of sport science to provide a greater understanding of the relationship between performance outcome and the processes that underpin the decisions made by performers.

Over the past two decades a considerable amount of research has been conducted to examine expert performance in sport (Williams, Ward & Chapman, 2003). The study of expertise has its historical roots in mainstream psychology and originated from the work of De Groot (1965) who examined the complex thoughts and mechanisms that mediated the selection of moves by elite chess players. De Groot reported that expert chess players were able to perceive good chess moves within seconds, and that these perceptions were mediated by their extensive knowledge of meaningful game configurations. Decades later Smith and Ericsson (1991) had considered previous research on expertise and proposed their own descriptive and inductive framework, which they referred to as the expert performance approach. Their empirical analysis enabled the authors to identify three important stages of expert performance. The framework provided a timely impetus to guide empirical studies relating to expertise over the ensuing decade, however few researchers may be deemed to have completely embraced its philosophical underpinning (Ericsson & Lehmann, 1996).

Within any domain, including sport, tasks must be developed to enable researchers to identify expertise within the area of perceptual-cognitive skills. Such tasks should produce precise and reproducible measurements so that the development of performance can be evaluated objectively. This may be straightforward in tasks such as running or swimming events where there are often clear and measureable performance outcomes that can define levels of achievement based on the time taken to complete a set course. However, behavioural constructs are more difficult to measure in a field setting and to isolate for systematic investigation and evaluation under laboratory conditions. Therefore researchers aiming to examine perceptual-cognitive expertise in sport face a challenge to design tasks that characterise such skills (Williams & Ericsson, 2005).

Abernethy (1990) conducted one of the earliest studies within perceptual-cognitive skills in sport. Applied to the sport of squash Abernethy (1990) compared expert and novice performance using two experiments. In the first experiment, participants were required to predict the direction and force of an opponent's stroke from a film display. The filmed sequence was designed to accurately simulate the normal display available to a defending squash player. Abernethy reported systemic differences in the information pick-up of the experts and novices on the film task, however such differences were achieved with only relatively minor between group variances in visual search strategy. The second experiment conducted within the study, set in a natural field setting, found no expert-novice differences in fixation order, distribution or duration. Therefore Abernethy (1990) concluded that the limiting factor in the perceptual performances of novice athletes is not an inappropriate search strategy but rather an inability to utilize the information available from fixated display features. With no significant difference between expert and novices regarding visual search strategy in a ‘field setting’ within the sport of squash, Abernethy attempted to determine the area of expert advantage in relation to perceptual-cognitive skills within another sport, snooker.

Abernethy, Neal and Koning (1994) selected seven expert snooker players, seven intermediate players and 15 novice players to participate in the study. Participants were tested on a range of visual tests and sport-specific perceptual and cognitive tests. Regarding standard optometric tests of acuity, ocular muscle balance, colour vision and depth perception no significant differences were evident between expert and novice performers. However, experts were found to be superior in their ability to recall and recognise slides presented quickly, which depicted normal match situations. Their superiority was consistent with a deeper level of encoding for meaningful material. The authors also reported that experts use a greater depth of forward planning, through the use of thinking-aloud and evaluation paradigms. This helped experts in choosing appropriate shot options and to evaluate existing situations with enhanced accuracy, discriminability, and prospective planning.

Singer et al. (1996) also examined visual search strategy amongst highly skilled and novice performers, however they chose to perform their study using tennis players. Using a laboratory setting, visual search patterns were recorded as they viewed filmed opponent’s serve and hit ground strokes. Also recorded was players’ anticipation accuracy and speed of the intended type and location of serves and the intended placement of ground strokes. Discrimination analysis revealed that highly skilled players and beginners differentiated most due to fixations on certain cues and predicting ball direction. Furthermore, beginners fixated for longer durations towards the opponents’ head than the highly skilled performers in relation to serves. However analysis of visual patterns performed during ground strokes suggested that experts and novices were similar.

The aforementioned studies reported that amongst certain individual sports, differences are apparent between experts and novice performers within components of perceptual-cognitive skills. However, Abernethy (1990) discovered that when squash players were tested within a field setting no significant differences were evident. Whilst these studies reported some confounding results, further dated research (Abernethy, Thomas & Thomas,1993; Starkey & Allard, 1993) support the notion that perceptual-cognitive skills are an important determinant of sport expertise. Moreover, the previous studies have focused predominately on individual sports. It is stated that the difference between experts and novice performers in relation to perceptual-cognitive skills is more pertinent within team sports such as soccer. This is due to the rapidly changing environment and the awareness needed to process information from several different sources such as the ball, opponents and teammates, before deciding on an appropriate response (Williams, 2000).

The first study examining soccer players of different skill levels was conducted by Helsen and Pauwels (1993). They aimed to examine search patterns used by expert and novice soccer players when presented with video simulations, which required tactical decision-making. Participants were asked to respond to near 'life-sized' filmed attacking situations involving a restricted amount of players (3 vs 3, 4 vs 4), and also 'set play' instances, such as corners and free kicks. At a specific moment, from the simulation, the ball appeared to be played in the direction of the participant by an attacking teammate. The participant had a ball placed at his feet and was challenged to respond quickly and accurately by attempting to either dribble around a goalkeeper or opponent, shoot at goal or pass to a teammate depicted on the screen. Helsen and Pauwels (1993) reported that expert players possessed significantly faster initiation and ball-contact times, as well as total response times. Expert players were also more accurate in their decision-making. Expert players better all round performance was attributed to their ability to recognise structure and redundancy within the display, resulting in more efficient use of available search time. To support this assumption, eye movement data was collated which showed that expert players visual search patterns are economical. That is to say they make fewer fixations but of longer duration on selected areas of the display. For instance, experts were more concerned with the position of the ‘sweeper’ and any areas of ‘free’ space that they could potentially exploit. In contrast, novice players searched for information from less sophisticated areas such as teammates, the goal or the ball. These differences may be related to the experts awareness and understanding of the role that the ‘sweeper’ plays in providing defensive cover (Helsen and Pauwels, 1993).

Williams, Davids, Burwitz and Williams (1994) had several objectives during their study on experienced and inexperienced soccer players. The first involved examining anticipation, the authors hypothesized that the experienced players would demonstrate superior anticipatory performance due to their greater soccer-specific knowledge base. Their second objective was to identify proficiency-related differences within visual search strategies. The study attempted to improve on similar previous research by experimenting using realistic, large-screen film presentations, implemented to provide a more representative view of the game for participants. The study selected 30 participants in total (15 experienced and 15 inexperienced), all of which played in defensive positions on the pitch. The filmed situations adopted for the study were taken from a sample of varsity and professional level matches, not specifically involving the individuals participating in the study. Therefore it may be questionable as to whether the matches chosen are meaningful to each of the participants (Jordet et al., 2013). Furthermore, to measure eye movement data participants had to wear a helmet during the trial and although “subjects commented that the helmet was comfortable and did not interfere with performance” (Williams, et al., 1994, p. 129) it surely provides a difference to actual ‘real life’ match performance that participants would be accustomed to.

Each film clip involved an attacking pattern of play, which ended with a pass being played into the attacking third of the field. On viewing each pattern participants had to indicate verbally, accurately and quickly the intended direction of the pass. Results indicate that experienced players were much quicker in anticipating the direction of a pass than less skilled players. The typical response of the skilled players was to react either before or immediately after the pass was played. In contrast, less skilled players tended to react only after viewing the initial portion of ball flight, furthermore they fixated more frequently on the ball and the player passing the ball. It was reported that skilled defenders used a more extensive search strategy, evident through more fixations of shorter duration on more areas of the pitch. As may be expected, less skilled players were often caught ‘ball watching’, whereas skilled players would fixate on positions and movements of players ‘off the ball’. Skilled players demonstrated higher search rates (i.e. more fixations of shorter duration) during defensive 11 vs 11 situations when compared to offensive situations applied in previous research (Helsen & Pauwels, 1993), which adopted a smaller number of players. Theoretically, experts are expected to make lower search rates due to their reduced information-processing load or because their better ‘chunking’ require less sensory input to create a coherent perceptual representation of the display (Abertnethy, 1990; Williams, 2000). However, in relation to the results of Williams et al. (1994), defensive plays may not incur the same amount of temporal pressure from opponents as attacking situations, that is to say there may be time to undertake a more comprehensive analysis of the display. Results appear to show that soccer players are characterised by higher search rates when attempting to recognise general offensive or defensive structure. However they may employ fewer search rates in more compact, specific contexts involving fewer players (Williams et al., 1994).

To assess this assumption Williams & Davids (1998) compared search strategies used during typical sub group (3 vs 3) and individual (1 vs 1) defensive plays with those observed in the 11 vs 11 format previously tested. During the 3 vs 3 sub group situations, participants were asked to imagine themselves as a sweeper or covering defender. Each filmed sequence involved two defenders, who were marking two offensive players and a defensive midfielder who was marking an attacking midfielder. Participants were asked to anticipate the attacking midfield player's pass, responding by either moving right, left, forwards or backwards. For 1 vs 1 situations, participants were asked to perform as though they were a challenging defender. Specifically, each sequence involved an attacking player dribbling the ball directly towards the participant, who was asked to anticipate whether the attacker would attempt to dribble past him on his right or left hand side. Visual search data was also recorded to gather information relating to search order, fixation locations, fixation durations and the total number of fixations performed.

Williams and Davids (1998) reported that experienced players were better than their counterparts at anticipating the pass in 3 vs 3 situations. No differences were evident within response accuracy, however experienced players were quicker in their response. Furthermore, no differences were evident amongst the series of visual search variables recorded during the trials. Experienced players were also quicker and more accurate in 1 vs 1 simulations. Differences were also reported within the visual search data, within which experienced players focused more on the hip region of the opponent as well as using more fixations of shorter durations. Moreover, experienced players alternated their fixations between the ball and hip more frequently, indicating that these two specific areas were important in anticipating opponents' movements (Williams & Davids, 1998; Williams, 2000). The focus of attention upon the opponents hip region may be due to the proximity of it to the centre of gravity. Therefore when a player dribbles left or right, there is a displacement in the position of their centre of gravity in the corresponding direction. This transformation may provide the participants with important information regarding the direction of an opponents' dribble (Williams & Davids, 1998).

Analysis of visual search rates during the study suggest that defenders alter their search rate depending on the constraints imposed on the visual system. For instance, within an 11 vs 11 simulation experienced players use a search strategy that includes more fixations but of shorter duration. This type of strategy is advantageous for defenders as they have to be aware of many sources of perceptual information, which are located disparately across a large area of the pitch (Williams, 2000). Therefore within the sub group 3 vs 3 simulation, players perform fewer fixations, as there are less sources of perceptual information. That is to say within these contexts defenders will often place a greater emphasis on the use of peripheral vision. Finally, the 1 vs 1 simulation trials produced results which show that defenders need very precise information provided by changes to key joint angles to specify information on velocity, direction and force of locomotion in dribbling. Due to the apparent significant information gathered from the hip, lower leg, and ball region players need to fixate on these areas (Williams & Davids, 1998).

The several experiments performed during the Williams and Davids (1998) study provided further understanding of the different visual techniques applied by defenders in different situations as well as examining differences amongst experienced and novice soccer players. With previous research focusing on perceptual-cognitive skills and how they are applied during offensive and defensive situations in soccer, Savelsbergh, Williams, Van Der Kamp and Ward (2002) used a novel approach to examine skill-based differences in anticipation and visual search behaviour during penalty kicks in soccer. The study was undertaken from a perception-action perspective, which presumes that information evolves over time. Using their innovative paradigm, visual information was picked up continuously rather than discretely and their method of measurement used a joystick linked to a potentiometer to ensure continuous data sampling, rather than the participants having to press a button. Using this method allowed corrections to be made to the response in a continuous manner as the flow of information changes across early and late stages of a penalty kick (Savelsbergh et al., 2002). The authors hypothesised, similarly to previous research, that expert goalkeepers would demonstrate superior anticipation and more effective and efficient visual search strategies than their novice counterparts.

Savelsbergh et al. (2002) used 14 goalkeepers in total, seven semi-professional and seven novice performers. Filmed sequences of penalty kicks were produced in conjunction with PSV Eindhoven Football Club, and were performed by a selection of their youth team players who were told to aim at a certain area of the goal. With the goal divided into 6 areas, players were told to try and disguise the intended destination of the penalty kick, as they would in a competitive match. The test procedure involved participants standing behind the joystick, which was positioned at waist height. They had to anticipate the direction of each penalty kick quickly and accurately by moving the joystick as if to block the oncoming kick. A successful save was awarded if the joystick was positioned in the correct location the moment the ball crossed the goal line. Participants were able to amend their initial decision as the penalty kick evolved. Before the penalties were presented, participants had to undertake a non-task-specific test to determine whether there were any 'baseline' differences in reaction time between the two groups of goalkeepers. This test did not involve clips of penalties, instead an asterisk was presented at one of the six possible locations and the participants had to move the joystick to the correct position as quickly as possible. After familiarisation and habituation, 30 film clips were presented, five penalties in each section. These film clips were chosen by experienced soccer coaches who decided that out of the 120 original penalties, the 30 chosen were representative of a typical penalty kick. Importantly, the location of the penalties was randomised, but kept in the same order for each participant. Anticipation was recorded using various measurements including penalties saved, correct side, and time of initiation of joystick. Similarly, various measurements were obtained to measure visual search data including search rates and percentage viewing times.

Results of the anticipation test show no significant differences between the two groups of goalkeepers in the percentage of penalties saved (P=0.06). However, the difference between the two groups in terms of percentage score was relatively large (experts = 37.5, novice = 25.9%), almost reaching the significance level. This trend is highlighted by the fact that expert goalkeepers were significantly more accurate at predicting both the height and side of the penalty kick. The expert goalkeepers made fewer corrective movements with the joystick and started these movements later than their novice counterparts. No differences were evident between simple reaction times within the two groups. Regarding the visual search data, expert goalkeepers performed fewer fixations of longer duration. They also fixated on significantly fewer areas per trial than novice performers (2.6 vs 3.1), however there were no differences on any of the search rate variables between successful and unsuccessful trials (Savelsbergh et al., 2002). This could imply that perceptual skill is only partially dependent on the visual search strategies employed by an individual. This led to the authors to believe that experts' superior performance may reflect more effective extraction of information per foveal fixation or greater use of their peripheral vision (Abernethy, 1990, Savelsbergh et al., 2002). Savelsbergh et al. 2002, suggested that future research should employ other methods of cue usage, such as event occlusion techniques and verbal reports, in alignment with eye movement registration methods. Furthermore they propose that considerations should be made to examine if goalkeepers anticipatory performance can be improved in saving penalty kicks through the use of perceptual training.

More contemporary research conducted by Canal-Bruland et al. (2011) employed methods previously applied by Reingold, Charness, Pomplun and Stample (2001) who assessed whether expert chess players use fewer visual fixations whilst at the same time processing more information from a greater portion of the chess board. Canal-Bruland et al. (2011) wanted to assess this notion in a more complex environment, namely soccer. Adopting similar methods to those applied by Reingold et al. (2001), Canal-Bruland et al. (2011) examined visual span using the gaze-contingent window technique combined with a change detection task based on photographs taken from professional soccer matches. As with previous soccer related eye movement research, Canal-Bruland et al. (2011) compared expert soccer players to their less skilled counterparts. It was predicted that expert players would use a larger visual span with less fixations than the less skilled players, when asked to detect a change in two repeatedly changing stimuli, showing the same situation that differs in one position.

A total of 56 male participants took part in the study which applied stimulus displaying offensive, defensive and unstructured soccer situations which each presented 10 to 17 soccer players (i.e. 5 to 9 players from each teams). Once sat in front of the screen (with the middle of the screen at eye level) participants were given instructions before pressing the space bar to initiate the experiment. Once they had detected the manipulated position they pressed the space bar as soon as possible, and indicated the target area using the cursor. The software used automatically recorded participant's detection times and response accuracies. Furthermore, the gaze-contingent window was always centred on participants' gaze positions and consequently moved when gaze position changed. In regard to the gaze-contingent window ANOVA tests revealed no significant main effect for either visual span (=0.458, $p > 0.10$) or situation category (=0.629, $p > 0.10$). Canal-Bruland et al. (2011) summarise that analysis of their performance variables indicate no differences between the different levels of expertise regarding either size of visual span or reaction times. ANOVA showed that the number of fixations differed significantly between the groups. Post hoc comparisons revealed that expert and less skilled players used fewer fixations than inexperienced control participants. Moreover, fixation duration was significantly longer in skilled soccer players compared to novices, but the fixation duration of less skilled players did not differ significantly from either of the two other groups. The studies findings differ to those using previous methodology in a more structured environment (Reingold et al., 2001), as although skilled performers use fewer fixations of longer duration, in soccer this strategy does not seem to be accompanied by larger visual spans. The authors conclude that future research should attempt to enhance methodological developments by using dynamic video clips whilst retaining the use of the gaze-contingent window and the change detection paradigms.

Roca, Ford, McRobert and Williams (2011) examined the underlying processes mediating expert anticipation and decision-making in soccer. The simulation employed included video footage filmed from a first person perspective, as oppose to previously used less realistic third person perspectives. The footage depicted an 11 versus 11 soccer match and required participants to perform a movement-based response similar to that of a real-world setting. A multi-dimensional approach was adopted involving two experiments, firstly an eye movement-recording task and secondly a verbal report of thinking task (Roca et al., 2011). Regarding visual search data analysis, three measures were selected to calculate behaviour, including search rate, percentage viewing time and fixation order. Their findings present a number of systematic differences in visual search behaviour between the two groups.

Such differences were similar to those reported in previous research (Williams et al., 1994), however Roca et al. (2011) reported significantly more fixations than that of previous research (2.6 fixations per second compared to 1.4). The authors cited the more realistic environmental stimuli involving functional responses to 11 versus 11 soccer action sequences presented on a ‘life size’ screen and filmed from a first person perspective. Roca et al. (2011) suggest that future research examining anticipation and decision-making in realistic performance environments with the aim to providing a more complete understanding of the processes than underpin expertise. By doing so, this would allow individuals involved in talent development to design training correctly. With the vast majority of the aforementioned research employing similar methodology to examine perceptual-cognitive skills, certain contemporary research has attempted to use performance analysis methods to assess decision-making and the processes that enhance decision-making.

Lorains, Ball and MacMahon (2013) used a custom designed notational analysis system to evaluate decision making in Australian football. The authors also assessed how the notational analysis method would transfer from being used in a training setting to a match environment. With the reliance on staged scenarios or video based decision-making tasks to assess decision-making accuracy, Lorains et al. (2013) alluded to the fact that notational analysis methods allow competitive match performance to be examined either during or post match. It is argued that by using ‘real’ matches, true insights into performance can be gained (Araujo, Davids & Hristovski, 2006). The study set out to assess components of performance including game context, decision-making and the effectiveness of those decisions. To do this, Lorains et al. (2013) recruited 13 elite Australian footballers competing in the same team. The coding method was designed in consultation with three AFL level coaches, within which decision-making quality would be measured on a 0-3 point scale. Analysis was carried out on four matches from one season, using footage filmed from both the side of the pitch and behind the goal. During the study, participants were asked to complete a five-week decision-making video based training intervention. This included a series of attacking AFL clips which participants were asked to watch and subsequently identify the location of a pass using a computer mouse.

Results of a one-way ANOVA revealed a significant interaction between total accuracy and season time (= 8.76, p = 0.01). Further analysis into the quality of decisions revealed that later in the season players were choosing the best option more often than other options. Results of inter-rater reliability testing show very high reliability ratings for each performance indicator (k=0.79 - 0.98). Particularly for indicators such as 'number of options' which may be difficult to code, a near perfect intra-rater reliability (k=0.93) was achieved. Importantly the analysis system allowed the cognitive and physical execution components of decision-making to be analysed separately, something lacking in previous research. Furthermore, from a practical perspective coaches and athletes found this to be the most beneficial element of the analysis program (Lorains et al., 2013).

The research of Lorains et al. (2013) implemented a novel notational analysis system designed to evaluate decision-making in Australian football, to date no such research exists within soccer. However, Jordet et al. (2013) conducted a study to examine the relationship between visual search strategies (cognitive behaviour) and performance (physical execution) amongst elite soccer players. Using close up video images of individual players from Sky Sports split screen 'PlayerCam' broadcasts, 1279 situations were obtained involving English Premier League players. Jordet et al. (2013) cited the urgent need to produce more ecologically valid laboratory paradigms as well as the need to assess athletes' perception and action in 'real-world' competitive matches. Performance was assessed in two ways, firstly players who had received prestigious awards (such as FIFA world player of the year) would indicate that a player was at a higher performance level than that of players who had not receive such awards. Secondly, for each of the included situations, pass completion rate, direction and location was assessed.

Inter-observer reliability was conducted and found absolute agreement on the number of explorations in 72% of situations. Jordet et al. (2013) state that due to the complex behaviour that is being analysed, in a fast paced team sport setting, the reliability results are more than acceptable. However, with more than 1 out of every 4 instances providing different reliability scores, it could be argued that reliability scores in future research should look to achieve greater agreement scores to be able to provide more valid results. Results of the analysis reveal that a clear positive relationship exists between visual exploratory behaviours initiated prior to receiving the ball and performance with the ball. The best players were found to explore more frequently (M= .33 searches/second) than others (M= .27 searches/second) and there was a positive relationship between exploratory frequency and pass completion. When focusing on forward passes only, the same relationship is found. Players who explore little complete just 39.8% of passes, whereas players who explore often complete 57.7% of their forward passes. Although visual exploratory behaviours are not completely unknown the behaviours’ exact role for field vision is rarely addressed in research, practice or the media. The studies findings suggest that visual exploration frequency (VEF) can help distinguish the better soccer players from the less proficient performers. Therefore practically it is something that scouts and coaches may use to identify talent and aid the development of talented performers (Jordet et al., 2013).

It may be argued that the laboratory-based approach used in more dated research provided a solid grounding to perceptual-cognitive performance in sport, which included a vast amount of theoretical underpinning. Furthermore, it is debatable as to how scientific and theoretically based the more contemporary, field based studies are without the inclusion of equipment such as eye movement registration and tracking systems. Conversely, the recent field based research could arguably provide more pertinent practical implications to be applied within a sporting setting. Lorains et al. (2013) and Jordet et al. (2013) have eradicated limitations of previous research relating to ecological validity by examining perceptual-cognitive performance within ‘real-world’ competitive matches. Additionally, their research has attempted to study the relationship between perceptual-cognitive skills and performance outcome in competitive matches. The findings of Jordet et al. (2013) suggest that perceptual-cognitive performance, specifically visual exploratory behaviour, has a positive relationship with performance outcome for elite level soccer players, such findings could potentially influence future training and development programmes within soccer.

As previously mentioned, the focus of talent development within soccer academies has increased over the last ten years and whilst the Jordet et al. (2013) study provides a novel approach to reduce limitations of previous research, their study uses elite soccer players participating in the English Premier League. That is to say, the methodology has yet to be applied within youth soccer where it could be argued that the practical implications of such findings could be more beneficial to academy coaches in relation to talent identification and player development.

Method

Ethical Clearance

Ethical approval was granted by the University of Chester Ethics Committee, supplemented further by approval gained from the soccer academy to use competitive match footage of their Under 15 age group. The soccer academy received a written statement ensuring their anonymity and confidentiality.

Design and Participants

13 matches from an English Premier League soccer academy under 15 team were analysed during the study. The academy is currently rated as ‘category one’ by the Premier League based on their elite player performance plan (EPPP). All of the matches took place at the home venue of the soccer academy team. Out of a possible 19 individuals who participated in any of the 13 matches, 8 players were selected for analysis (exclusion of goalkeepers and substitutes playing too few minutes during the 13 matches). Players were identified through a team sheet provided by the coach, detailing each member of the squad. As players often change shirt numbers from match to match, a small description of each individual was also provided to enable the analyst to identify each individual. Individual players were also given alternative names (ranging from player A – player H) to make sure they remained anonymous throughout the process. Player B and Player F were identified as having higher ability as they had been selected to attend a national training camp.

Analysis system and Identification of Performance Indicators

Only certain game situations were selected for analysis, this included any situation where a player had relevant information behind his back that would be beneficial for him to detect (Jordet et al., 2013). Therefore the criterion created for a situation to be included for analysis was defined as;

"An instance were a player has to receive a pass from a team mate located closer to his team's own goal than the participant, which would make it relevant to engage in some type of exploratory behaviour to see what is behind his back" (Jordet et al., 2013, p.2).

In total, 524 situations were identified as meeting the criteria and were included within the analysis procedure. Analysis of visual exploratory behaviour was based on the operational definition of a visual exploration;

"A body and/or head movement in which the player's face is actively and temporarily directed away from the ball, seemingly with the intention of looking for team mates, opponents or other environmental objects or events, relevant to perform a subsequent action with the ball" (Jordet et al., 2013, p.2).

Applying the Jordet et al. (2013) methodology, visual explorations that occurred within 10 seconds prior to the player receiving the ball were counted. For every situation included within the analysis, further assessment was carried out to examine what a player did when he was in possession of the ball. Performance analysis research within soccer has often failed to publish operational definitions, negating the opportunity to compare and replicate studies (James, 2006; MacKenzie & Cushion, 2013). Therefore the following performance indicators, which were applied to collate this information, are stated below. To maintain consistency throughout the data collection a definition dictionary was created (James, 2006).

Performance Indicators:

Pass – “The attempt by a player to relinquish possession of the ball by giving possession to another player on the analysed team. Typically, this is achieved by intentionally kicking or heading the ball to a teammate. Occasionally this might involve another body part but the intent to give possession to a specific team-mate must be demonstrated” (James, Mellalieu, Hollely, 2002, p.90).

Pass successful forwards - Any intended pass made by an individual in a forward direction that is received by a team mate. The team mate who receives that must then be in possession of the ball. A player was considered to be in possession of the ball if he had sufficient control on the ball to influence its final direction.

Pass unsuccessful forwards – Any intended pass made by an individual in a forward direction that is not received by a team mate.

Pass successful sideward’s – Any intended pass made by an individual in a sideward’s direction that is received by a team mate.

Pass unsuccessful sideward’s – Any intended pass made by an individual in a sideward’s direction that is not received by a team mate.

Pass successful backwards – Any intended pass made by an individual in a backwards direction that is received by a team mate.

Pass unsuccessful backwards – Any intended pass made by an individual in a backwards direction that is not received by a team mate.

Short pass – Any pass that began within one zone and was played into an adjacent zone (see figure 1).

Long pass – Any pass that began within one zone and was played into a zone that was not adjacent to where the pass originated.

Successful shot – Any attempt at goal by an individual that was directed on target.

Unsuccessful shot – Any attempt at goal by an individual that was directed off target.

Successful cross – Any pass played into the box from a wide zone in which the next touch of the ball is made by a teammate.

Unsuccessful cross – Any pass played into the box from a wide zone in which the next touch of the ball was made by an opponent.

Touch – Any instance in which an individual made contact with the ball. There had to be clear displacement of the ball for a touch to be recorded, the total number of touches for each individual instance was recorded.

Dispossessed – Any instance in which an individual has received the ball from a team mate and subsequently lost possession, either through their own poor ball control of through being tackled.

The performance indicators selected were adapted from both previous research (Scoulding, James & Taylor, 2002; James et al., 2002, Pulling, 2012) and Opta (2012).

The pitch areas demarcated within Figure 1 enabled identification of pass distance and also location of action. The defensive third (players own third) included zone 1, 2 and 3. The middle third included zone 4, 5 and 6. The final section of the pitch, the attacking third included zone 7,8 and 9. Regarding pass distance, short passes involved any pass that was attempted which started in one zone and reached its target within an adjacent zone. For instance, a pass that originated in zone 1 and was completed when reaching a player in zone 2, 5 or 6. Alternatively, examples of long passes include passes that originated in zone 1 and was completed when reaching a player in zone 3, 4, 7, 8 or 9.

Direction of play →

ZONE 1	ZONE 6	ZONE 7
ZONE 2	ZONE 5	ZONE 8
ZONE 3	ZONE 4	ZONE 9

Figure 1: A diagram of the pitch schematic used to denote the different areas of the pitch.

Recording and analysis procedure

Match footage was recorded prior to the inception of the study. All matches were recorded from a vantage point, which was positioned at the half way line. Matches were saved on an external hard drive and uploaded onto an Apple Macbook to be analysed. Sportscode Gamebreaker was used to view the matches, this enabled the footage to be rewound easily and re-viewed, as it was not possible to collate all the necessary information during live play back. Using Microsoft Excel (2007) a spreadsheet was devised for each match to allow notation of the necessary performance measures. For each match the information collated included player name, shirt number, position, amount of explorations, action, outcome of action, pitch area, direction and number of touches.

Statistical Analysis

Collected data were analysed for normal distribution using the Shapiro-Wilk test. Data from visual exploration frequency per second scores was not of normal distribution therefore a Mann-Whitney U test was conducted to assess whether there was a significant difference between players of differing ability (comparison between higher ability group and lower ability group). Furthermore Kruskal-Wallis tests were carried out upon individual players visual exploration frequency per second scores, with further Mann-Whitney U tests on any significant data.

Similarly, data from the visual exploration (successful action), visual exploration (unsuccessful action), no visual exploration (successful action) and no visual exploration (unsuccessful action) categories was not of normal distribution, therefore a Mann-Whitney U test was conducted to assess differences between the two groups. To assess differences amongst specific visual exploration categories (between zero – six) Kruskal-Wallis tests were conducted with further Mann-Whitney U tests on any significant data.

To test the impact of exploratory behaviours on performance visual explorations were split into three groups. Any search rates between 0-0.10 searches per second were labelled as ‘low’, search rates between 0.11-0.30 searches per second were labelled as ‘moderate’ and search rates between 0.31-0.6 searches per second were labelled as ‘high’. Categorical logistic regression analysis was then conducted, firstly with pass completion as the binary dependent variable. Further categorical logistic regression analysis was conducted to assess different match situations including direction of pass, location of pass, pass length and number of touches. The binary dependent variable for those four categories were forward pass completion, attacking third pass completion, long pass completion and few touch (0-2) pass completion. A significance level of $p<0.05$ was set for all calculations which were carried out using IBM SPSS statistics 20.

Using percentage error calculations, intra-observer reliability was conducted to assess visual exploration frequency, pitch area and direction of action (Hughes, Cooper & Nevill, 2004). Three of the thirteen matches were selected at random to be re-analysed. Three players participating in each of those games were selected to be the focus of the reliability testing. Matches were re-analysed two weeks after initial analysis to account for memory effects (Waldron & Worsfold, 2010).

Table 1, 2 and 3 present the reliability scores for visual explorations frequency, pitch area and direction of action performance indicators. The following tables show that most of the calculations were within the 10% tolerance level set by Hughes et al. (2004). However, within several categories (highlighted in bold) there are scores greater than the 10% tolerance level. The scores greater than 10% may occur due to the low frequency of actions within that indicator. Cooper et al. (2007) suggest that infrequent indicators may require more tolerable limits of error, as one small absolute error may result in a greater percentage error score. The results that are greater than 10% in all three tables are within the visual exploration performance indicators. In all three tables there are no scores over 10% in any of the pitch area or direction of action performance indicators.

Table 1 Intra-reliability test scores for visual exploration frequency, pitch area and direction of action for player B.

Performance Indicator	Match 1 player B (% difference)	Match 2 player B (% difference)	Match 3 player B (% difference)
0 VE	0	0	0
1 VE	0	0	0
2 VE	**18.2**	0	0
3 VE	**28.6**	0	0
4 VE	0	0	0
5 VE	0	0	0
6 VE	0	0	0
Forward action	0	0	0
Backwards action	0	0	0
Sideways action	0	0	0
Defensive third	0	0	0
Middle third	0	0	0
Attacking third	0	0	0

Note: All results over 10% are highlighted in bold font.

Table 2 presents the intra-reliability test scores for visual exploration frequency, pitch area and direction of action for player D.

Performance Indicator	Match 1 player D	Match 2 player D	Match 3 player D
0 VE	0	0	0
1 VE	0	0	0
2 VE	0	**66.7**	0
3 VE	0	**66.7**	0
4 VE	0	0	0
5 VE	0	0	0
6 VE	0	0	0
Forward action	0	0	0
Backwards action	0	0	0
Sideways action	0	0	0
Defensive third	0	0	0
Middle third	0	0	0
Attacking third	0	0	0

Note: All results over 10% are highlighted in bold font.

Table 3 presents the intra-reliability test scores for visual exploration frequency, pitch area and direction of action for player F.

Performance Indicator	Match 1 player F	Match 2 player F	Match 3 player F
0 VE	0	0	0
1 VE	0	0	0
2 VE	**66.7**	0	**66.7**
3 VE	**40**	0	**40**
4 VE	0	0	0
5 VE	0	**40**	0
6 VE	0	**18.2**	0
Forward action	0	0	0
Backwards action	0	0	0
Sideways action	0	0	0
Defensive third	0	0	0
Middle third	0	0	0
Attacking third	0	0	0

Note: All results over 10% are highlighted in bold font.

Results

A total of 524 match situations were analysed during the study. Of those 524 situations, the final outcome resulted in a pass (successful or unsuccessful) on 474 occasions. The remaining 50 situations included 34 dispossessions, 9 shots and 7 crosses. Due to the infrequent nature of such actions, it was decided that individual analysis of dispossessions, shots and crosses would not be conducted as the small sample size may produce misleading results. Over the 13-match period a total of 74 situations were discounted from the analysis procedure, as the video footage did not display the individual player completing the action for the whole ten seconds prior to the action being performed.

Table 4 displays the mean and standard deviation visual exploration frequency scores for all individual players. Also reported are mean and standard deviation visual exploration frequency scores for higher ability players combined and lower ability players combined.

Player	Searches/second
Player A	0.14±0.12
Player B	0.28±0.11
Player C	0.14±0.06
Player D	0.25±0.14
Player E	0.17±0.14
Player F	0.37±0.13
Player G	0.18±0.13
Player H	0.12±0.10
Higher ability (Player B and F combined)	0.33±0.13
Lower ability (Player A,C,D,E,G,H combined)	0.18±0.13

VEF scores between individual players range from between 0.12 searches per second (player H) to 0.37 searches per second (player F). The two players of higher ability (player B and player F) produced the two highest individual scores amongst the eight players, 0.28 and 0.37 respectively. Furthermore when combining the higher ability players and lower ability players, higher ability players make a greater amount of searches per second (0.33) than their teammates (0.18 searches per second).

Table 5 displays asymptotic significance (2-tailed) of searches/second between individual players of higher and lower ability. Asymptotic significance (2-tailed) between higher and lower ability players when grouped together is also reported.

	Player B	Player F	Player B and F combined (Higher Ability)
Player A	.000*	.000*	N/A
Player C	.000*	.000*	N/A
Player D	.119	.000*	N/A
Player E	.000*	.000*	N/A
Player G	.000*	.000*	N/A
Player H	.000*	.000*	N/A
Players A,C,D,E,G,H, Combined (Lower Ability)	N/A	N/A	0.000*

*Note: *=Significant difference (2-tailed).*

Table 2 shows that significant differences occur when comparing players of higher ability against players of lower ability. Player B (higher ability) made significantly more visual searches per second than all players of lower ability (p=0.000), apart from player D (p=0.119). Player F (higher ability) made significantly more visual search per second than all players of lower ability (p=0.000). When players are combined into groups of higher and lower ability, players of higher ability were found to conduct significantly more visual searches per second than players of lower ability (p=0.000).

Table 6 compares individual players successful and unsuccessful actions when they performed a visual exploration.

Player	Visual explorations that led to a successful action	Visual exploration that led to a unsuccessful action	P Value
Player A	2.64±1.91*	0.64±0.92	0.006
Player B	7.9±4.53*	1.27±1.1	0.004
Player C	2.5±1.38*	0.17±0.41	0.023
Player D	4.54±3.26*	0.77±0.69	0.001
Player E	3.25±2*	0.38±0.52	0.007
Player F	7.9±3.75*	0.9±0.83	0.001
Player G	5.17±2.59*	1.08±1	0.000
Player H	2±1.54	1.3±0.87	0.438

*Note: Results presented as means and standard deviations. * = Significant difference (2-tailed).*

Table 6 shows that significant differences are present between visual explorations that led to a successful action and visual explorations that led to an unsuccessful action for all players except player H. That is to say that when players performed visual explorations they were more likely to perform a successful action as opposed to an unsuccessful action.

Table 7 compares individual players successful and unsuccessful actions when they did not perform a visual exploration.

Player	No visual explorations that led to a successful action	No visual exploration that led to an unsuccessful action	P Value
Player A	0.55±0.52	0.64±0.92	0.836
Player B	0.18±0.4	0±0	0.149
Player C	0±0	0.17±0.41	0.317
Player D	0.31±0.63	0.08±0.28	0.143
Player E	0.38±0.52	0.25±0.46	0.935
Player F	0±0	0±0	1.000
Player G	1± 0.74*	0.33±0.85	0.014
Player H	0.4±0.50	0.7±1.06	0.598

*Note: Results presented as means and standard deviations. *=Significant difference (2-tailed).*

Table 7 shows that, unlike table 6, only one significant difference is apparent when comparing situations were no visual explorations led to a successful action and situations were no visual explorations led to an unsuccessful action. Player G recorded significantly more successful actions than unsuccessful actions when performing no visual explorations (0.014).

Table 8 compares successful and unsuccessful actions for all players, relating to each specific category of visual exploration (zero-six).

VE	Player A	Player B	Player C	Player D	Player E	Player F	Player G	Player H
No VE successful/**unsuccessful**	0.55±0.52 **0.64±0.92**	0.18±0.40 **0±0**	0±0 **0.17±0.40**	0.31±0.48 **0.08±0.28**	0.38±0.74 **0.25±0.47**	N/A **N/A**	1±0.74* **0.33±0.89**	0.4±0.7 **0.7±1.05**
One VE successful/**unsuccessful**	0.9±0.70 **0.36±0.67**	0.27±0.47 **0.27±0.45**	1.5±0.84* **0.17±0.40**	0.46±0.66 **0.31±0.63**	1.5±1.86* **0±0**	0.27±0.47 **0.27±0.47**	1.25±0.75* **0.58±0.67**	0.7±0.95 **0.3±0.49**
Two VE successful/**unsuccessful**	1.09±0.94* **0.27±0.47**	2.63±2.34* **0.55±0.69**	1±0.89* **0±0**	1.38±1.50* **0.31±0.48**	0.8±0.89 **0.13±0.36**	1±0.94* **0.18±0.40**	2.27±1.68* **0.42±0.51**	1±0.94* **0.2±0.42**
Three VE successful**/unsuccessful**	0.36±0.67 **0±0**	2.72±2* **0.27±0.47**	0.17±0.40 **0±0**	1.38±1.12* **0±0**	0.63±0.74 **0.13±0.36**	1.45±1.20* **0.18±0.40**	1.17±0.83* **0±0**	0.3±0.48 **0.1±0.32**
Four VE successful/**unsuccessful**	0.27±0.65 **0±0**	1.73±1.68* **0.1±0.40**	N/A **N/A**	0.54±0.78 **0.15±0.38**	0.25±0.46 **0±0**	2.63±2.25* **0.09±0.30**	0.58±0.90 **0.08±0.29**	N/A **N/A**
Five VE successful/**unsuccessful**	N/A **N/A**	0.54±0.82* **0±0**	N/A **N/A**	0.38±0.65* **0±0**	N/A **N/A**	2.18±1.68* **0.09±0.30**	0.08±0.29 **0±0**	N/A **N/A**

Six VE	N/A	N/A	N/A	0.08±0.28	0.13±0.36	0.45±0.69	0.08±0.29	N/A
successful/**unsuccessful**	**N/A**	**N/A**	**N/A**	**0.08±0.28**	**0.13±0.36**	**0.09±0.30**	**0±0**	**N/A**

*Note: Results presented as means and standard deviations. Unsuccessful actions are reported in bold. *=Significant difference (2-tailed). N/A= Players did not perform that amount of searches in any situations.*

From table 8 it can be reported that collectively, ‘two VE’ was the most commonly performed amount of searches throughout the analysis. It can also be reported that the highest overall mean score for successful actions occurs within the ‘two VE’ category. However for certain individual players (player, B, D, F), their highest mean score occurred within the ‘three VE’, ‘one VE’ and ‘four VE’ respectively. Within the ‘no VE’ category, players A, C and H had higher mean scores for unsuccessful actions as opposed to successful actions. This was not apparent for any of the other visual exploration categories (1 VE to 6 VE).

Table 8 also shows that within certain categories of visual exploration some players made significantly more successful actions than unsuccessful actions. Player A made significantly more successful actions than unsuccessful actions when scanning his surroundings twice prior to receiving the ball (p=0.032). Player B similarly made more successful actions than unsuccessful actions when making two searches (p=0.031). Player B also made significantly more successful actions during instances where he searched three (p=0.001), four (p= 0.004) and five times (p=0.034). Player C made significantly more successful than unsuccessful actions in the ‘one VE’ category (p=0.027) as well as the ‘two VE’ category (p=0.034). Player D had significantly more successful than unsuccessful actions in three of the categories, including ‘two VE’ (p=0.023), ‘three VE’ (p=0.000) and ‘five VE’ (p=0.033). Player E made more successful actions than unsuccessful actions in the ‘one VE’ category (p=0.034). Player F recorded significant more successful actions in four of the six VE categories, including ‘two VE’ (p=0.035), ‘three VE’ (p=0.010), ‘four VE’ (p=0.001) and also ‘five VE’ (p=0.000). Player G made more successful actions than unsuccessful actions when making no searches (0.014), one search (p=0.048) and two searches (0.016). Player H recorded a significant difference between successful and unsuccessful actions within just the ‘two VE’ category (0.035). Finally no players made significantly more successful actions than unsuccessful actions when they performed six visual explorations within one situation.

When the relationship between visual exploration and performance is analysed across all 474 passing situations (successful=407, unsuccessful=67) a positive relationship is evident. That is to say, players who explore more frequently reach their teammates with more successful passes (figure 2). Players who made between 0-0.10 visual explorations per second completed 73% of their passes. When players made between 0.11-0.30 searches per second they completed 89% of their passes. Furthermore, 92% of passes were completed when players made between 0.31-0.60 searches per second. Significance level and odds ratio (OR) scores are reported in table 9.

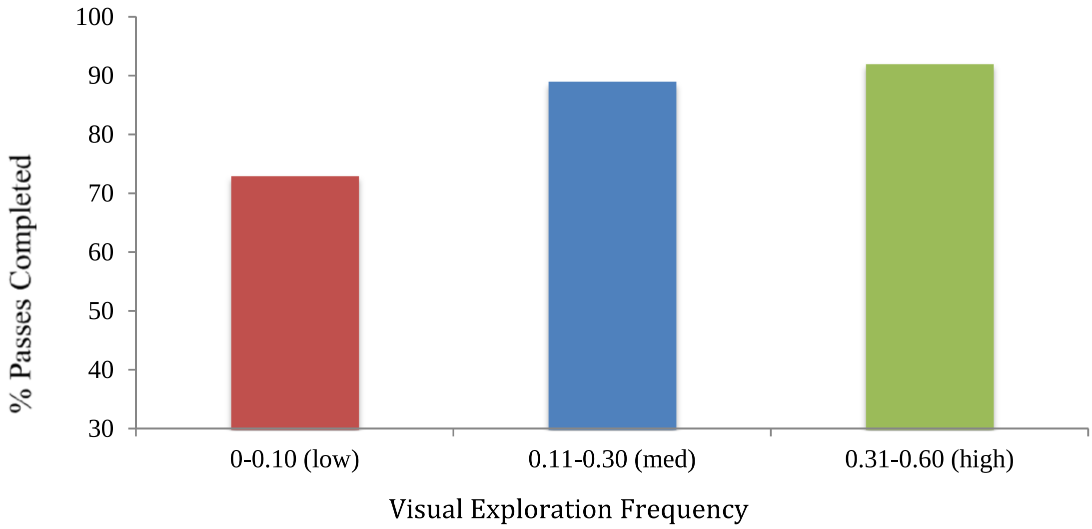

Figure 2: Visual exploration frequency (visual explorations/second) and pass completion percentage (n = 8 players/474 game situations).

This relationship is consistent amongst several different match conditions. The first of those match conditions involves the area of the pitch in which the pass was completed, focus was placed upon the attacking third of the pitch. Figure 3 displays VEF and pass completion percentage within the attacking third of the pitch (n=110 situations). Players who possessed low search rates in the attacking third of the pitch completed 66% of their passes. Players who have a moderate search rate completed 81% of passes successfully. Furthermore, players conducting high search rates, between 0.31-0.60 searches per second, recorded the highest percentage of successful passes (92%). The second match condition assessed was forward passes (n=203 situations). Figure 3 reports that the players who conducted between 0-0.10 searches per second completed 43% of passes. 82% of passes were successfully completed when players conducted between 0.11-0.30 searches per second. The highest pass completion rate (87%) occurred amongst the highest search rates (0.31-0.60). Figure 3 shows that within the third match condition assessed, long passes (n=23), players who conducted between 0-

0.10 and 0.11-0.30 searches per second completed 50% and 70% of passes respectively. The highest pass completion rate was evident amongst the highest search rate category were 81% of passes were successfully completed.

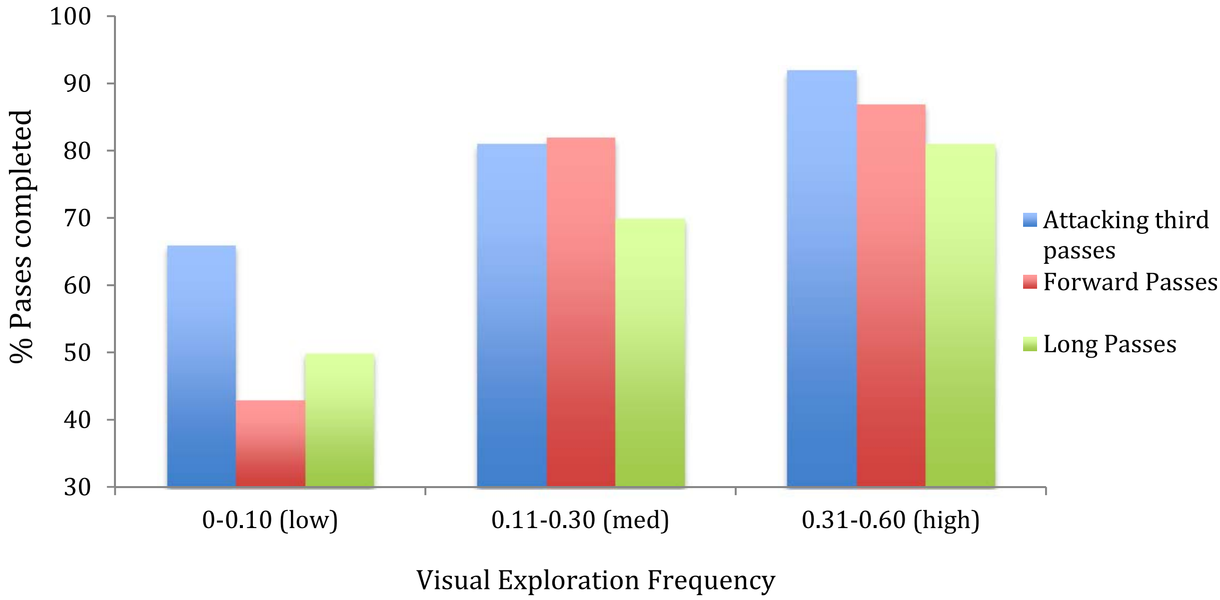

Figure 3: Visual exploration frequency (visual exploration/second) and pass completion percentage for attacking third passes, forward passes and long passes.

The final match condition, assessed whether players who take few touches (between 0-2 touches) prior to performing a pass are more successful (n=272). Players who conducted between 0-0.10 searches per second and had between 0-2 touches on the ball completed 79% of passes. Secondly, players who conducted between 0.11-0.30 searches per second and had between 0-2 touches on the ball completed 94% of passes. Finally players who explored between 0.31-0.60 searches per second completed 91% of passes. Whilst both medium and high rates of searches produced a greater percentage of successful passes than lower searches, medium search rates (unlike the previous match conditions) produced the highest percentage of successful passes (94%). The following table reports odds ratio scores, p value scores and confidence limits for the visual exploration frequencies in relation to pass completion and the different match situations reported in figure 3.

Table 9 presents odds ratios, p value scores and 95% confidence limits when comparing players' visual exploration frequencies across several different match situations.

	P value	Odds ratio	95% confidence limits
% Pass completion (moderate search rate)	0.000	4.61	2.41 to 8.83
% Pass completion (high search rate)	0.000	7.80	3.26 to 18.6
% Pass completion attacking third passes (moderate search rate)	0.06	2.57	0.98 to 6.79
% Pass completion attacking third passes (high search rate)	0.109	5.78	0.68 to 49.34
% Pass completion forward passes (moderate search rate)	0.000	6.37	2.81 to 14.41
% Pass completion forward passes (high search rate)	0.000	8.57	3.34 to 22
% Pass completion long passes (moderate search rate)	0.532	2.67	0.12 to 57.62
% Pass completion long passes (high search rate)	0.392	4	0.17 to 95.76
% Pass completion 0-2 touches	0.003	4	1.62 to 10.1

(moderate search rate)			
% Pass completion 0-2 touches (high search rate)	0.05	2.76	1 to 7.6

Note: Low search rates were set as the reference value for all categories.

Table 9 shows that of the ten categories, five of them were significant differently to low search rates. The highest OR score was obtained within the '% pass completion forward passes (high search rate)' category (8.57). With the exception of the '% pass completion 0-2 touches' categories, the four other match conditions all recorded higher OR scores within the high search rate categories when compared with the moderate search rate categories. Within several of the 95% confidence limits categories the range between the lower and upper values is large. The '% pass completion attacking third passes (high search rate)' category has 95% confidence limits ranging from 0.68 - 49.34. The '% pass completion long passes (moderate search rate)' 95% confidence limits also have a large difference, ranging from 0.12 – 57.62. Finally the widest difference in 95% confidence limit score occurs within the '% pass completion long passes (high search rate)' category, with a score ranging from 0.17 – 95.76. The small sample sizes applied may explain why there are such wide-ranging scores within these categories.

Discussion

The results of the study indicate that several significant differences are apparent when examining visual search behaviour in youth soccer players within one English academy soccer team. Four of the stated hypotheses can be accepted as increased visual exploration frequency was found to have a positive relationship with performance outcome. Moreover, players of higher ability were found to explore their surroundings more often than players of lower ability.

Visual exploration frequency between higher and lower ability players

In agreement with the findings of Jordet et al. (2013) and Roca et al. (2011), players of higher ability were found to make more visual searches than their teammates of lower ability. However, such findings contradict conclusions made in several other studies, which found contrasting results to those of the current study. Canal-Bruland et al. (2011) and Helsen and Pauwels (1993) both found that higher skilled performers conduct fewer searches than less skilled players but had searches of longer duration, allowing them to extrapolate more information. Having said that, with the aforementioned methodological limitations of such studies, the most comparable study is that of Jordet et al. (2013). When comparing the elite level youth soccer players visual exploration frequencies reported in the current study, with that of the elite level adult soccer players there are both similarities and differences. When combining search frequencies of higher ability players both studies have the same average search per second frequency score (0.33).

However when such scores are viewed as individual scores there is a large difference between the two studies. Jordet et al. (2013) reported frequency scores of 0.62

searches per second in comparison to the score of 0.38 searches per second within the current study. Similarly the combined search frequencies of lower ability players produce large differences. Jordet et al (2013) reported a combined score of 0.27 searches per second in comparison to the score of 0.18 searches per second in the current study. The disparities between youth level and adult level elite soccer are to be expected, especially considering the age of players who participated in the current study. These differences highlight the importance for such skills to be constantly reinforced and improved upon within youth soccer players.

It could be argued that the findings of the current study may have occurred due to a greater understanding of the game that higher skilled players possess. That is to say, higher skilled players may realise that due to the rapidly changing nature of soccer it may not be most beneficial to conduct a low amount of explorations involving longer durations. Therefore by partaking in a greater amount of fixations any changes in the surrounding environment that may be occurring rapidly can be viewed, processed and acted upon. Furthermore, the greater search rate frequencies of higher ability players may also relate to their ability to understand and apply what they are being coached and taught within competitive match situations. Reilly and Williams (2003) state that skilled soccer players enhanced perceptual performance may be reflective of their superior knowledge, which has been developed through specific practice and coach instruction.

Although it cannot be unequivocally guaranteed that individuals within the current study have been exposed to perceptual skill training (specifically relating to visual searches), the concept of scanning your surroundings or ‘checking your shoulder’ is commonly adopted practice within soccer. Having said that, it is important to make the distinction between coaches telling players to ‘check their shoulder’ and coaches teaching players to ‘check their shoulder’. This is particularly pertinent within youth soccer, where it is imperative that players are taught why, how and when to perform such skills, rather than just being told to do so (Montz, 2013). Whilst coaches must teach such information appropriately, the degree to which information is distributed amongst a team or group of players may also differ depending on the ability of the player. Within soccer, coaches have been found to interact more, correct more and provide significantly more information to effective players when compared to non-effective players (Worsfold, 2012). Whilst it has been acknowledged that perceptual skill can be improved through specific practice and instruction (Reilly & Williams, 2003), it should be stated that talented players might be predisposed to acquiring the knowledge structure underlying perceptual and decision making skill in soccer (Williams, 2000). Currently it is not clear what proportion of perceptual skill is innate compared with that developed through purposeful practice (Reilly & Williams, 2003).

Comparing search strategy rate with performance outcome

Analysis of performance outcome in relation to search strategies adopted by individual soccer players has often been lacking within previous research, particularly within competitive matches. The results of the current study highlight that when players do conduct visual explorations they are significantly more likely to perform a successful action than an unsuccessful action. Moreover, when players do not conduct visual explorations results of performance outcome was varied. That is to say for several players no visual explorations led too more successful than unsuccessful actions and for some players the opposite was apparent, however none of these results produced significant differences. By searching their surroundings, players can extract sources of information that would not be available to them if they did not perform visual searches. This information often relates to the positioning of both teammates and opposition players and allows individuals to make an appropriate decision when they receive the ball, ultimately resulting in a successful action (Williams, 2000). Conversely, without performing visual explorations, players are often unaware of the positioning of their teammates and wait until they receive the ball before searching their surroundings. With the fast pace nature of soccer, waiting until they receive the ball is often too long, allowing opponents to put the player on the ball under pressure which could lead to either an incorrect decision or an unsuccessful execution.

When analysis of specific visual exploration frequencies is broken down, several significant differences are also apparent. When seven of the eight players make two visual searches prior to receiving the ball they were found to perform significantly more successful actions than unsuccessful actions. It was also found that in total, players performed two visual searches per situation more than any other amount of explorations. When four of the eight players made three visual searches prior to receiving the ball they were also found to perform significantly more successful actions than unsuccessful actions. Fewer significant differences were found amongst other visual exploration frequencies, however certain players did perform significantly more successful actions within the one, four and five exploration frequency categories. The biggest difference between successful and unsuccessful actions occurred within the 'four visual exploration' category, where player F performed 2.63 successful actions per match compared to 0.09 unsuccessful actions per match. There were no instances within the 1-6 visual exploration categories were players made significantly more unsuccessful than successful actions. Again reiterating the importance of conducting searches prior to receiving the ball.

Analysis of search rates in relation to different match conditions

In agreement with the findings of Jordet et al. (2013) a positive relationship was found between visual search frequency and several match conditions. The first variable examined was overall pass completion. When youth soccer players performed between 0-0.10 searches per second they successfully completed passes 73% of the time. This figure increased to 89% for search rates between 0.11-0.30 searches per second, and rose further to 92% when players conducted searches above 0.31 per second. By conducting more searches prior to receiving the ball, players have a greater awareness of what is around them, thus allowing them to decide upon an appropriate pass selection.

In comparison to the pass completion scores of Jordet et al. (2013) the findings of the current study reveal that within all search rate categories youth players performed more successful passes than adult players. This may be influenced by the sample of players used within the studies. That is to say, within the current study all players competed for the same team who were successful in the majority of the matches analysed. Conversely, Jordet et al. (2013) analysed players from various teams across the English premier league, some of who would have been competing for teams who were not winning matches on a regular basis. Often within such teams the participant’s teammates may not be of sufficient quality, ultimately making it more difficult to perform successful passes. Furthermore, based on anecdotal evidence the team analysed within the current study adopted a passing style involving, short simple passes whereas within the Jordet et al. (2013) study players may have been employing different tactics such as more direct passes of longer distance (which have a higher risk attached).

Analysis of different pitch areas was also reported within the current study. Rather than focus simply on the two different halves of the pitch (Jordet et al., 2013) the current study examined passes conducted within the defensive, middle and attacking thirds of the pitch. Focusing on each third of the pitch rather than just splitting the pitch into two halves allows more specific analysis. Furthermore focusing on the opponents half of the pitch may not provide a true perspective of performance. That is to say, completing a pass in the opponent's penalty area and completing a pass a yard into the opponents half would be registered as the same thing. Therefore by breaking the pitch down into thirds more specific conclusions can be ascertained.

As may be expected, in comparison to overall pass completion, fewer passes are completed in the final third of the pitch. Within the attacking third of the pitch, more opposition players are likely to be situated than in the middle and defensive third of the pitch. Therefore making a successful pass within such areas is more challenging than in other areas where players have more time, space and teammates. When the relationship between attacking third pass completion percentage and search rate was analysed the same relationship was found as overall pass completion. That is to say when players made a greater amount of searches they performed more successful passes. Players within the current study were found to complete more passes in the attacking third in each search rate category when compared with attacking half passes analysed in the Jordet et al. (2013) research. These differences may occur for similar reasons to those previously mentioned for overall pass completion, however they may also occur due to the disparity in the number of situations analysed in both studies. The current study analysed 110 attacking third passes whereas Jordet et al. (2013) analysed 1029 passes that were completed in the opponent's half. This suggests, as previously alluded to, that over a larger sample of passing situations the percentage of passes successfully completed would decrease due to the increased difficulty.

Pass distance was also accounted for during the analysis procedure and as with overall pass completion a positive relationship was reported. When players conduct the fewest amount of searches they complete passes of longer distance just half the time (50%). However when players conduct the highest amount of searches they have a pass completion rate of 81%. This result suggests that by conducting more searches prior to receiving the ball players are seemingly in a better position to assess whether a pass of longer distance is appropriate during that specific instance. It could be argued, that players who search less frequently are unaware of the same amount of information and therefore misinterpret the opportunity to perform a pass of greater distance. Having said that, with passes of greater distance, the degree to which technical performance impacts the outcome of a pass may be greater than passes of shorter distance.

A further match condition analysed that has not previously been examined within perceptual-cognitive skill research was the amount of touches taken by players prior to completing a pass. The amounts of touches players take within one situation where split into three categories, 0-2 touches, 3-4 touches and 4-8 touches. It was hypothesised that players taking the fewest amounts of touches will perform more successful passes when they adopt a greater visual search rate as opposed to when they adopted a lower search rate. Findings suggest that when players conduct medium (0.11-0.30) and high (0.31-0.60) search rates they complete a greater percentage of passes than when making between 0-0.10 searches per second. However, unlike the previously discussed variables, the highest pass percentage occurred when players conducted between 0.11-0.30 searches per second, rather than between 0.31-0.60. However with a percentage difference of just 3% further analysis would need to be conducted to replicate such findings.

A limitation of using pass completion as a performance measure is that it can be relatively simple to find a teammate if you never make any risky decisions. Whilst attacking third passes control for this to some extent, a more viable option was deemed to be forward passes. Forward passes are directed to where opponents set up their defence; this requires passes to be accurate and creative in order to be successful (Jordet et al., 2013). When forward pass results are analysed, as with overall pass completion, a positive relationship is evident. Players conducting the highest search rates completed 87% of forward passes, more than double the amount of successful passes when players just the lowest amount of searches per second (43%). This statistically significant result (p=0.000) shows the importance of visual explorations towards completing successful passes, which are penetrative and often profitable for the attacking team. In comparison to forward pass completion scores reported by Jordet et al. (2013), both low (39.8%) and high (57.7%) search rates are lower than the subsequent categories.

Practical Implications

Many of the studies conducted upon perceptual-cognitive skill in soccer have failed to discuss the practical implications of their findings in detail. Failing to discuss practical implications can only be detrimental to the relationship between research and practice, which needs to be developed (Mackenzie & Cushion, 2013).

As visual search behaviours have been found to discriminate the better performers from less proficient performers, soccer academies could benefit from such information in various ways. Although it is unknown to what extent visual search behaviours are trained within soccer academies, (including the soccer academy used within the current study) employing certain drills or practices, which specifically focus on increasing visual search rate, could lead to improved performance (Williams, 2000). Visual search behaviour training could also become more ingrained within a coaching process. For instance, coaches employ 'buzz' words and phrases during matches, often as a reminder to their players to perform certain physical actions (for example getting 'touch tight' when marking an opposing player). Therefore coaches could create a 'buzz' phrase for players to remind them to conduct searches on their surroundings. Such behaviours have previously been found to be highly trainable in professional soccer players, where only a few weeks of practice was found to increase visual search frequency and for some players led to improved performance (Jordet, 2005).

However, it is important that visual search behaviours are taught, so that individual players learn the ideal time to implement exploratory behaviour. Performance analysis tools would allow players to review their exploratory behaviours, particularly the use of close up camera footage. Whilst this may impractical during matches, it could potentially be used within training sessions to monitor certain players over a prolonged period of time. Alternatively, with recent advances in technology, the idea of filming from the perspective of the individual is now arguably less awkward. Specifically with companies such as GoPro, who have developed a small mounted camera that is fitted onto a headband, which can be worn by individual players. This enables footage to be recorded from the perspective of the individual, providing a close up view of the ‘action’ that allows the person watching the footage to see what the player can see. As a coach, being able to sit down with the individual player and analyse such footage could be a useful way of discussing their visual exploratory behaviours.

Whilst several sporting tests have been invented to examine and monitor physical performance (vo2 max test, T-test) no such test exists to examine visual search behaviour within a soccer specific setting. Although teams such as Borussia Dortmund have begun to develop simulations to replicate match performance with the creation of ‘the footbonaut’, the emphasis of these systems is similarly focusing on the physical aspect of performance (by asking players to pass the ball into a highlighted target). Using such technology, tests could be constructed to assess physical performance in relation to visual search behaviours. Simulations such as ‘the footbonaut’ are expensive however it may not necessarily be overly expensive to create such tests, which could monitor players over monthly and yearly periods.

In addition to employing analysis of visual search behaviours within a team’s training schedule, scouts could also use such analysis to assess prospective signings. It may be in the remit of a scout to focus on the individual performer during a match, even when they do not have the ball or are directly involved in the action. However, by conducting a more systematic analysis of visual search behaviour, scouts may develop a greater understanding of how well prepared prospective players are to make good decisions when they ultimately receive the ball. The most appropriate method of analysing performance in this manner would be to direct a video camera on the player in question allowing scouts and coaches to get a ‘close up’ of the behaviours employed (Jordet et al., 2013).

Limitations/Future Directions

A limitation of the current research is that the filmed match footage used for the analysis had already been recorded prior to the study’s inception. That is to say, the footage followed the ball and was not specifically focusing on any of the players. This differs from the match footage used within the Jordet et al. (2013) study, which included Sky Sport’s split screen ‘PlayerCam’ broadcasting footage. This enabled simultaneous viewing of both a close up image of each player and a smaller overview of the general game events and the ball. However such broadcasting technology is not available within soccer academies and the camera footage used caused a considerable amount of situations that would have been included in the study to be missed. Furthermore, without having the close up option of ‘PlayerCam’ footage, calculating the amount of visual explorations within a situation often proved difficult for the analyst and this is borne out within the reliability scores. Future studies that aim to analyse visual search strategies within competitive sporting action should aim to collate and link together both close up and wider angled footage to reduce reliability errors and prevent situations from being discounted.

Although the study provides an insight into the visual search behaviours of youth team soccer players within competitive matches, which is lacking from previous research, the study only focuses upon players from one specific team. Therefore, by only analysing one specific team the results cannot satisfactorily be stated as representative of elite level youth team soccer players. Certain teams may place more focus than others on visual explorations within the coaching process, certain teams may adopt different styles of play, which could impact overall pass success thus influencing the relationship that has with visual exploratory behaviour. Within future studies, researchers should aim to analyse a wider range of clubs, including teams of differing status (in relation to EPPP) and age group. Within those teams, positional groups should also be accounted for to assess similarities and differences between defenders, midfielders and strikers.

Not only should future research analyse performance from a wider range of teams, but they should also look to expand the amount of situations included within their analysis. The current study applied the criterion definition created by Jordet et al. (2013), which limited instances to those in which a player conformed to a specific set of match conditions. Future research should aim to expand the amount of situations that can be included within the analysis. For instance, situations where a player receives a ball in a deeper, more defensive position from a player in a more advanced position would not have been included within the analysis of the current study, but could still provide information relating to visual search behaviour.

In conclusion, the positive relationship found between visual search behaviours and successful performance in youth soccer has added to the findings of previous research, particularly the study of Jordet et al. (2013) who identified the same relationship in elite level adult soccer players. Players of higher ability were also found to conduct more visual searches than players of lower ability. Although the same relationship is evident, differences are apparent between adult and youth performers in the amount of searches they conduct. Future research should aim to replicate and develop such studies to provide a greater overall understanding of the importance of visual search strategies within soccer. The findings of the study could have several practical implications relating to coaches, scouts and players. It could be argued that coaches have often overlooked visual search behaviour as such strategies take place prior to a player receiving the ball (Jordet et al., 2013). Whilst the current study focuses on youth team performance in soccer, conducting systematic analyses of visual search behaviours in relation to performance outcome amongst other sports is recommended.

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Appendix

All files are saved onto disc attached.

1.1 Overall player results spreadsheet taken from Microsoft Excel

1.2 Reliability spreadsheet taken from Microsoft Excel

1.3 SPSS Data files

1.4 SPSS Output files