Situation awareness in soccer.

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SITUATION AWARENESS IN SOCCER

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Abstract

Individual player awareness of the situation has been studied in the general psychology field under the term Situation Awareness (SA). In brief SA refers to how aware you are of everything in the environment around you (Endsley, 2000a). There has been little acknowledgement of this term in the sports literature (James & Patrick, 2004) but is popular within the aircraft domain (Rodgers, Mogford & Strauch, 2000). However, as James and Patrick (2004) suggest parallels can be drawn between these two awareness tasks. The first study attempted to see whether poor SA was a cause of errors made by soccer players. Twelve English Premier League games were analysed with the aim of identifying aspects of play where a player's poor SA resulted in an error. All video clips containing errors attributed to SA were then placed into nine categories based on the task requirements to achieve SA. Some further video clips containing errors attributed to poor performance and not SA were selected as 'control clips'. A compilation video containing three clips for each SA category and five for the control category was shown to a panel of expert raters to decide whether the mistake was due to lack of awareness or bad performance. An inter-rater reliability test indicated that the expert soccer coaches agreed that 19 of the 32 clips contained an error in performance as a result of poor SA, none of which was a control clip. The raters thought the player on these clips to be close to completely unaware (mean rating = 6.17 on a 7pt Likert scale, SD = 0.75) of the important feature causing the performance error i.e. they were rated as having very poor SA. By adopting a task led perspective this study has suggested that in at least seven different situations, two were excluded due to weak rater agreement, poor SA is a possibility which in turn can cause performance error.

Having identified seven categories of game situation within soccer that make SA deficiencies a possibility it was necessary to measure a soccer player's SA during these events. Ericsson (2003) has suggested that artificial conditions may fail to capture the nature of an experts' performance and thus an ecologically valid setting was required. The seven categories were merged into four to facilitate the data collection phase as this meant that it was more likely that a particular category would occur during a match because the category descriptors were not so precise. A novel

technique was used to measure participants SA; PLATO liquid crystal occlusion spectacles (Milgram, 1987) were worn and turned opaque simultaneous to the game being suspended. A pitch schematic was then presented to the participant to record awareness measures (accuracy, frequency and confidence of the location of team mates and opponents). Participant responses were compared to a video recording to assess accuracy and results showed the participants were able to relatively accurately (to within a few metres) locate 60.78% of the other nine players (goalkeepers were excluded) on the pitch. It is however unknown how this relates to full size matches. Some form of discrimination in their attention allocation was also evident as more of the important players (about 74%) were located than the unimportant ones (about 49%). Some bias was also found toward attending to opponents above team mates based on the fact that the error associated with opponent location estimations were lower than for team mates although only significantly for important players (team mates M = 2.13m, SD = 2.62; opponents M = 0.94m, SD = 1.47). This was thought to be due to players knowing their team mates' locations as a result of familiarity of team positions. This hypothesis needs to be tested by having players play in unfamiliar teams and in different positions. The findings are limited by the use of six-a-side matches on a reduced size pitch as it is impossible to say how many players participants would be aware of during the full soccer match. The situations used in this study were also hand picked as being likely for SA to be poor and so these results may be indicative of relatively low awareness. However since play was suspended before a mistake could be made it is not possible to ascertain this. Certainly this study did not capture the diversity of the soccer environment as suggested by James and Patrick (2004) as necessary for predictive validity and therefore future studies need to broaden the situations tested. Finally the extent to which these findings translate to other players of different abilities and experience needs to be assessed via the classical expert novice paradigm, preferably using full match simulations.

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Chapter 1: Introduction

This thesis presents two studies, both based within association football or soccer, which is not only an invasive field game (Ali & Farrally, 1990) but also the most popular worldwide sport (Reilly, 1996); with a total of over 200 million people being actively involved (Sugden & Tomlinson, 1998). Both studies developed methodologies to investigate awareness in soccer, the first of these has been submitted for publication but no decision regarding publication has been received at the time of writing. This study suggested that awareness is a cause for performance errors and presented some situations which were suggested as potentially problematical for players. The final, and main study, assessed these situations in simulated matches using special spectacles worn by one player so that the play could be suspended and the player interrogated. The findings and conclusions for this study form the main basis of this thesis. 'Awareness of the situation' has been studied in general psychology research under the term Situation Awareness (SA). In brief SA refers to how aware you are of everything in the environment around you (Endsley, 2000a) and since there has been little acknowledgement of this term in the sports literature (James and Patrick, 2004) the studies presented in this thesis set out to investigate this.

The term Situation Awareness (SA) is a term of loose usage which has been defined many times. This has led to recent criticism that SA has become the 'buzzword of the 90's' (Wiener, 1993) and highlights the need for researchers to stick to a clear meaning for the term to prevent a significant handicap to progress in this field. According to Endsley (1987, 1988) 'Situation awareness is the perception of the elements in the environment within a volume of time and space, the comprehension of their meaning, and the projection of their status in the near future.' SA is a concept which has become renowned for its importance in aiding aviation performance for many years and research has been focussed in this field (Salas, Prince, Baker & Shrestha, 1995). However, whilst the majority of research has looked at the significance of SA within the aircraft and air traffic control domains some further research has been conducted on SA in nuclear power plant operators, automobile drivers and chess experts (e.g., Gugerty, 1997; Hogg, Folleso, Strand-

Volden & Torralba, 1995; Woodhouse & Woodhouse, 1995). As James and Patrick (2004) have indicated there is very minimal research regarding the importance of SA in the sporting sector, particularly soccer, although there appears to be a need for this. For example, Wayne Harrison (2002), an ex professional soccer player and UEFA 'A' licensed coach, highlights the importance of awareness within soccer by suggesting that coaches must encourage players to establish in their minds what to do with the ball before they receive it, thus allowing them to be aware of their options in advance. He also emphasises how players must have the ability to look beyond the ball, in doing so they can maintain an awareness of the relative positioning of team mates and opposition players, and the direction in which each player is moving. Further support for the importance of soccer players being aware is given by Tony Adams, in his autobiography 'Addicted' (1998, p 258). The former Arsenal and England captain discusses how he considers awareness of what is happening on the pitch to be a trait which separates the best players from the average players. In particular he praises Bryan Robson (ex England and Manchester United captain) for having many brilliant aspects of his game but highlights the best as being his 'fantastic awareness'.

James and Patrick (2004) have drawn parallels between the awareness tasks facing a soccer player and those facing a fighter pilot, a common research area for SA in psychology. A fighter pilot needs spatial knowledge (awareness) of the dynamic, three dimensional surrounding environment and it is suggested that this is exactly what faces players of invasion games such as soccer. Considering soccer in this way suggests that errors in performance may be attributed to SA problems. For example, possible problems with SA in soccer include scenarios such as when a player receives the ball and changes direction immediately without being aware of an opponent closing in, leading to the opponent making a tackle and gaining possession of the ball.

Therefore, there is a need to utilise research based methodologies to ascertain whether a) there is a potential problem with SA in soccer, and if so b) to establish the types of event that leads to a player having poor SA. The first study of this thesis set out to ascertain the answer to the first question, whether SA is problematical in soccer. A video was developed that encapsulated nine categories/scenarios of play in soccer which four co-experimenters had identified as containing instances of play where they thought poor SA had resulted in a player making a performance error. Results of this study led to the undertaking of the second study which aimed to measure awareness in situ in order to begin to understand a player's SA at any given time. According to James and Patrick (2004) the complications with SA measurement in sport are primarily concerned with deriving measures that retain ecological validity as well as capturing the diversity of the sporting situations. In their view SA is situation specific and therefore reasons for poor SA cannot necessarily be transferred between situations. Ericsson (2003) has also suggested that studies which take place within controlled laboratory settings may constrain an expert's performance level and as such real world studies are essential to begin to capture the nature of expertise. With these views in mind a methodology was devised and tested to measure the SA of individual soccer players.

Chapter 2: Literature Review

This chapter introduces the term Situation Awareness (SA) as it has been used in the psychology literature. The initial goal is to provide a conceptual understanding of the term so that the role of SA in sport, more relevantly soccer, can be investigated. Thus some discussion of suitable definitions for SA is given before providing research findings in other psychology domains and relating these to soccer. Critical to this discourse is how researchers have argued over whether SA is a psychological construct or not and in particular where SA fits in to a psychological model with other cognitive constructs such as decision making and attention. This is particularly relevant as previous research in sport has not specifically identified SA as a research area but has considered factors such as perception and anticipation which are in scope with SA. The two different sources of literature lead to speculations as to how problems associated with SA can lead to performance errors in some soccer situations. The last section is devoted to measurement of SA with regard to how the different methods employed may be suitable for use within a soccer field study.

2.1 Introducing SA

Prior to analysis and discussion of the term SA it is initially necessary to clearly define the term. This involves sticking to a clear, consistent meaning but this has become a problem in recent times, instigating criticism that SA has become the buzzword of the 90's (Wiener, 1993). In its simplest terms SA refers to how aware you are of everything in the environment around you (Endsley, 2000a). This definition is somewhat brief and attempts have been made to define SA more accurately than this (Endsley, 1988; Sarter & Woods, 1991). Other definitions have also been developed which are closely linked to specific domain e.g. aircraft piloting (Fracker, 1988), while other researchers have developed more general definitions (e.g. Endsley, 1988). Throughout the definitions though, it is apparent that there are consistencies and similarities such as persistent reference to the comprehension of situations.

Situation Awareness (SA) can be defined as:

> '*the perception of the elements in the environment within a volume of time and space, the comprehension of their meaning, and the projection of their status in the near future*' (Endsley, 1988, p. 97).

This general definition provides a description of the key factors that are to be involved when discussing and studying SA. These include perceiving, comprehending, updating, comparing, evaluating as well as predicting elements within the surrounding environment and are fundamental to the definition of SA. Endsley (1995a) supports the definition (1988) by suggesting that SA is a construct broader than just including perception of information in the environment, and it can be applied to various fields with many underlying cognitive processes in common. Sarter and Woods (1991) defined SA as:

> '*the accessibility of a comprehensive and coherent situation representation which is continuously being updated in accordance with the results of recurrent situation assessments*' (p. 52).

Endsley's (1988) definition of SA can be directly related to a game situation in soccer. 'The perception of the elements in the environment' can refer to factors such as other players (team mates and opponents) the ball and the goals on the soccer pitch. 'The comprehension of their meaning' refers to the player perceiving these objects as more than just elements, but as dynamic factors which determine game-play and future decisions i.e. 'the projection of their status in the near future'. For example, a player may have control of the ball but due to an opponent closing down a decision is made to pass to a team mate. The player is therefore able to understand that the oncoming opponent is a likely threat and decides that rather than risk being tackled, passing to a team mate in order to retain possession of the ball is a better option. Thus the player predicts the future status and possible outcomes of the situation. Consequently, due to the specific relevance and compatibility it has with the sports environment Endsley's (1988) definition of SA will be referred to throughout.

In addition to the definition, Endsley has produced a model of SA (1995a), which can be seen in Figure 3.1. The model illustrates SA as a platform which collates information regarding the current state of the environment. Decision making and performance are seen as separate processes to SA but they are dependent upon information provided by it. SA is not only influenced by the environment but also some individual traits and abilities. For instance, the model depicts SA to be a function of individuals information-processing mechanisms which can be affected by previous experiences and training of specific tasks. Both Figure 3.1 and Endsley's (1988) definition, point to SA having three levels; these levels help to establish what SA actually entails and how a person comes to achieve it. Successful completion of all three levels will provide the necessary information from within the environment to base a decision regarding action selection.

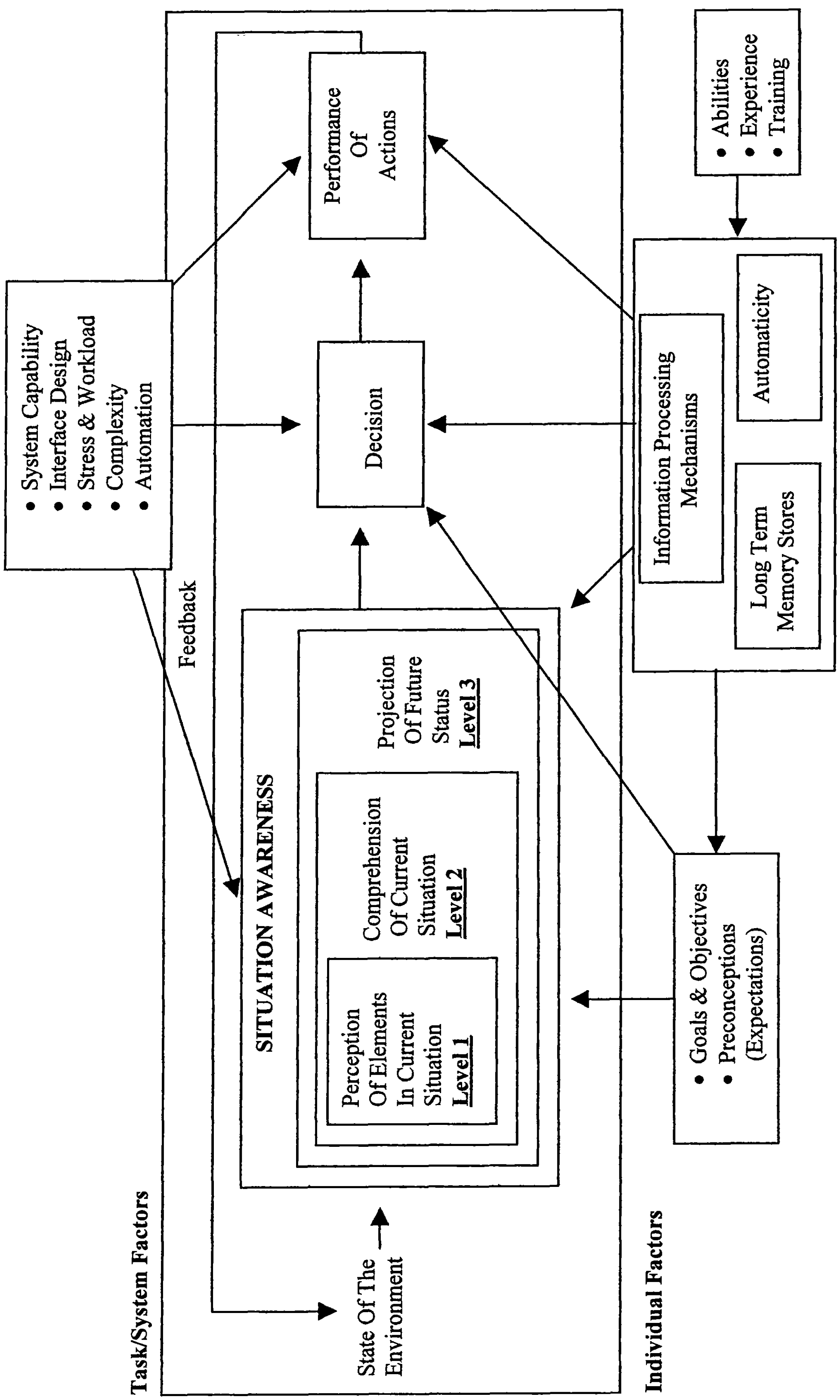


Figure 2.1: Model of situation awareness in dynamic decision making (Endsley, 1995a)

2.2 Levels of SA

Three hierarchical phases or levels of achieving SA are referred to in Endsley's definition and model (1988, 1995a). There is a logical sequence in which the levels are to be accomplished in order for SA to be fully achieved. Each level has an individual criterion which must be met before progression to the next level is made.

Level 1 SA: Perception of the Elements in the Environment.

The initial stage in achieving SA involves perceiving the status, attributes and dynamics of relevant elements, in the environment. For example, a pilot needs to perceive elements such as mountains, other aircraft and warning lights, dynamics of all enemy and ally forces in a given area, and their relationship to other points of reference. In their study investigating aircraft piloting errors, Jones and Endsley (1996) found that 76% of SA errors in pilots were due to problems in the perception of needed information. Endsley (2000a) also points out that without a basic perception of important information, the odds of forming an incorrect picture of the situation increase dramatically. In soccer a related example would be that of a player who is defending an opposition corner kick. In this situation the player requires awareness regarding the location of the opponent who is being marked, team mates and the ball. Lack of awareness of these factors could lead to the opposition creating a goal scoring opportunity.

Level 2 SA: Comprehension of the Current Situation.

Level 2 SA goes further than merely being aware of the elements perceived in Level 1 to include an understanding of the implication of those elements in reference to related goals. Based on knowledge of Level 1 elements, the decision maker forms a mental image of the environment, comprehending the importance of every object. For example, in aviation a fighter pilot may need to comprehend that the presence of several enemy aircraft in a particular arrangement indicates certain things about their objectives. In such environments, a novice operator may be capable of achieving the same Level 1 SA as an expert decision maker, but may fall far short of achieving a high Level 2 SA, and thus fully comprehending the situation, i.e. the novice can visualise all the enemy aircraft, however will not be able to process the importance of their relative positions and probable threats. In their study, Jones and Endsley

(1996) found that 20% of SA errors were found to involve level 2 SA problems. Within soccer, Level 2 SA can refer to the player not only recognizing that there are opponents and team mates on the pitch, but determining the role that each plays, and their relative importance in the game at a particular time. For example, when defending a corner the opponent the player has been designated to mark is of much greater importance to them than any other opponent.

Level 3 SA: Projection of the Future Status.

The highest level of SA involves the ability to forecast future events and dynamics within the environment and is only reached by those operators who have the highest level of understanding of the situation. For example, knowing that an enemy aircraft is in a certain location and is currently offensive allows a military pilot to anticipate that the aircraft is likely to attack in a given manner. Endsley (2000a) suggested that in almost every field studied (aircraft, ATC, power plant operations, maintenance, and medicine), experienced operators rely heavily on future projections, and that this skill is the mark of a true expert. This also applies to soccer at its highest level, as players must be able to predict and anticipate certain actions of opponents and team mates. For example, if a defender is marking an opposing attacker who is predominantly left-footed it may be likely that the attacker is more inclined to attempt to get past the defender using his left rather than right foot. Therefore, the defender may realise this and begin to be able to predict the movement of the attacker successfully, thus improving performance. Even at elite level soccer it is often the case that defenders do not prevent an attacker moving to his preferred foot suggesting that SA could be a problem.

Due to its multi-level components, SA is far more than just perceiving information from the surrounding environment. Its other aspects include understanding the meaning of the perceived information, comparing it with performer goals, and providing projected future states which are vital for the decision making process. It is important to understand these different aspects of SA (as seen in Endsley's model, 1995a), and recognise that factors such as decision making are separate from SA. Time plays an important part in the formulation of SA (especially at levels 2 and 3), it is crucial to be able to predict how much time is available during the performance of a task. The 'situation' part of SA describes the environment within which awareness must be attained, and time is inevitable in the environment. The *'within a volume of time and space'* part of the definition of SA (Endsley, 1988), demonstrates the fact that the parts of the situation important to individuals are not only related to space (i.e. where something is) but also time (i.e. when something is going to happen). The situation is also dynamic, so is constantly changing. A person's SA must therefore constantly change with the environment otherwise it will be inaccurate and out of date (Endsley, 2000a).

2.3 SA and Decision Making/Performance

According to Endsley (1995a) SA is recognised as a construct separate from decision making and performance. This is because even elite decision makers will make the wrong decisions if their SA is inaccurate. Equally if someone has perfect SA they may still make the wrong decision leading to bad performance of a task. Endsley (2000a) produces reasons for this including: selection of an inadequate strategy/tactic, decisions may be limited due to organisational or technical constraints, lack of experience in the given situation as well as individual personality traits. For example an individual may be too indecisive and not risky enough, leading to them making what they deem to be a safe decision which in retrospect may turn out to be a poor decision. Endsley continues by describing how SA, decision making and performance are at different stages of the dynamic decision making process. Initially an individual must be aware of what is going on in their surrounding situation, the accuracy of this awareness leads to a decision being made regarding what action to take. If both constructs are adequate the performance of the action must be correct to complete the process. These three constructs also have differing factors which influence them and have different ways of dealing with these factors, thus they should all be treated separately. However, SA is seen as the main precursor to decision making, as an individual is able to decide what to do about a situation, and then carry out the appropriate actions (Endsley, 2000a). In a study investigating human errors in aircraft accidents, it was found that 26.6% involved situations where there was poor decision making even though the crew had an adequate level of SA required to make a correct decision (Endsley, 1995a). This is true for soccer as well, as it possible for a player to be completely aware of the opponents in the surrounding area, but may make a wrong decision regarding which one to mark allowing another to become free to receive the ball in a goal scoring position, possibly costing the team dearly. It is also possible to make good decisions with poor SA, even if it is purely by luck. After researching into the integral relationship between SA and decision making it has been suggested that decisions are formed by SA and SA is formed by decisions (Smith & Hancock, 1994). However, although they are obviously linked Endsley (2000a) emphasises the importance of not coupling SA and decision making together as one process

As mentioned previously SA is also separate to performance. It is possible to have total SA but a lack of ability or skill may still lead to errors being made. For example, a soccer player may be aware of a space ahead of them in which to dribble the ball into but due to lack of technical skill, control of the ball is lost, which may result in the opposition gaining possession of it. According to Endsley (2000a) in addition to distinctions being made between SA and decision making, and SA and performance, it is necessary to recognise that human decision making and performance are separate constructs in many environments. A required movement may be incorrectly executed as a result of factors which include physical errors, poor system capabilities and insufficient training. For example, the presence of external cues (such as unpredictable weather conditions) may create poor performance outcomes even though good decisions had been made, and vice versa. Strong winds may spoil a pass made by a soccer player even though the decision to make that pass was correct. Therefore, it can be seen that SA, decision making and performance are all separate constructs that can affect each other equally but can be detached through various other factors.

2.4 The Nature of SA

Patrick and James (2004) point out that although SA has been the subject of much research there is still uncertainty regarding its status as a construct. It has been debated that SA can be seen as the product of completing a specific task. This viewpoint stems from the processes versus the products argument surrounding SA at present. Within the field of SA 'product' refers to a person's awareness of a situation whereas 'processes' refers to the cognitive processes used to develop this product. Such processes may include attention, perception, automaticity, memory etc.

Separating the two clearly seems a difficult task but both Pew (1994) and Endsley (1995a) attempt this by identifying the 'product' as situation awareness and the 'processes' as situation(al) assessment. According to Patrick and James (2004) the distinction made between 'product' and 'processes' within this perspective is theoretically clear. However, practically, within psychology it is extremely difficult to create a separation between any cognitive processes and the products they develop. Although these processes and products cannot be separated, a combination of them will establish a person's SA. For example, in soccer as in many dynamic environments things are constantly changing so knowledge to aid achievement of SA must be task-relevant. This suggests that separating processes from products will not be beneficial as no insight is given as to how a person achieved the knowledge to develop the product. Therefore for SA to be fully understood and accepted it must be made clear that it consists of both a person's knowledge of a situation and the processes that develop this knowledge.

In order to optimally comprehend SA and the processes which make it up both Patrick and James (2004) and Endsley (1995a) utilise a task-oriented approach. This approach implies that SA is the outcome of performing the task of 'achieving and maintaining SA' correctly; this task can be sub-divided to incorporate Endsley's three levels of SA. Endsley (1995a) highlights the fact that this task must be separated from the tasks of decision making and performance. These three tasks occur in a coherent sequence with the task of 'achieving and maintaining SA' being a prerequisite for decision making, which in turn influences performance. The vital point which is being conveyed is that the task 'achieving and maintaining SA' is seen as a trigger for successful performance. As already mentioned this task can be sub-divided into three sub-tasks (Endsley's levels of SA) which are individually defined by what they achieve (i.e. their goals) instead of by which processes aid them to achieve their goals. This is because these processes can differ within every situation so consequently cannot be generally specified within a definition of the sub-tasks. Therefore, it is pointless trying to identify a set cognitive processes which will complete the task of achieving SA as in dynamic environments, such as soccer, the situation is constantly changing leading to the use of varying processes. It is also necessary to specify details of the task situation in order to aid investigation into the performance of the task and thus improve on this performance. Subsequently, it is clear that for analysis of the task of 'achieving and maintaining SA' to be beneficial, details of the situation and its context are essential.

A further implication of investigating SA through the task-orientated perspective is that branding a person as having good or bad SA from situation to situation can be extremely deceptive and unfair. Again, this is due to the fact that every situation may require the use of differing cognitive process for completion of the task of 'achieving and maintaining SA'. Therefore, when a person has been labelled as having bad SA it should be made clear that this person has not adequately performed the task of achieving SA within a defined situation and vice versa. It is important to define the situation because as differing situations will require differing cognitive processes a person who has good SA in one situation will not necessarily have good SA in another. Consequently, it may not be practical to view SA as being a personal trait or skill which may affect performance.

In agreement with Patrick and James (2004), it seems best to construe SA from within the task-orientated approach as already discussed. Within this theory the association between the constantly changing situation and a person's awareness must be analysed. The two are undividable as if the situation changes the task requirements of achieving SA will also be altered. For example, within soccer a player may be in a defensive situation where they have to be aware of an opponent making an offensive run past them. However, in as little time as a split second the opponents attack may be broken down and the players' team will gain possession of the ball thus altering the situation dramatically. This will require a total change in the focus of the players awareness, for instance, finding space to receive a pass may become the new goal. This may involve the utilisation of varying cognitive processes at a higher or lower skill level depending on the change in environment of the situation. As the situation and a person's awareness within that situation are undividable it will be difficult to develop generalisations concerning SA until an association has been made between the characteristics of a particular situation and the requirements to become aware within it. In conclusion, it seems defensible to state that SA is not a stand alone psychological construct but is achieved through the combination of varying cognitive processes.

2.5 History of SA

To date, research examining SA has focused on its implications in the successful operations of complex machinery, in which the operator's SA is presented as a crucial construct on which decision making and performance hinge. This mainly includes research within the safe operation of aircrafts (e.g. Endsley, 1993), efficient air traffic control (e.g. Durso, Truitt, Hackworth, Crutchfield, & Manning, 1998), nuclear power plant operators (e.g. Hogg, Folleso, Strand-Volden & Torralba, 1995), automobile drivers (e.g. Gugerty, 1997) and chess experts (e.g. Durso, Truitt, Hackworth, Crutchfield, Nikolic, Moertl, Ohrt, & Manning, 1995). Collectively these studies have been successful as they offer support for SA having an important role within the completion of the tasks. According to Durso and Gronlund (1999) this prominent role seen to be had by SA is at least in part due to the increasingly cognitive nature of the tasks operators are asked to perform. For example, in a study looking at air traffic controllers, 62% of the en route operational errors made were attributed to the controllers being unaware of an error developing (Durso et al., 1998). Furthermore, Woodhouse and Woodhouse (1995) investigated the occurrence of controlled-flight into terrain (CFIT) accidents, in which nearly 5000 people were killed from 1978 to 1992. Their findings suggested that 74% of these accidents were due to the flight crew's lack of awareness, rather than a lack of skill or proficiency.

Despite such extensive research into SA over a number of varying fields, very little interest has been linked explicitly within sport which is surprising when considering the task requirements of various sports (James & Patrick, 2004). This may be due the fact that no known attempt has yet been made to develop a valid measurement technique. Consequently, parallels have to be made between existing research and how it can be related to sport. Although it may seem inconceivable the results of SA research within the aircraft domain, such as Woodhouse and Woodhouse (1995) can be related to the environment of a soccer player. An obvious difference between a fighter pilots perception and that of a soccer player is that one is based on instrument readings whereas the other is based on the surrounding environment. Nevertheless, according to Endsley (1993) a fighter pilot is required to have substantial awareness of their dynamic three dimensional environments, which is exactly the type of expectation a soccer players' coach may have. Also, through practice a soccer player has gained the ability to carefully manipulate the movement of the ball when in possession of it. Similarly, a fighter pilot has learnt to control and manoeuvre a plane and its weaponry within differing environments. Both parties will also use alike cognitive processes within their separate fields. For instance a fighter pilot will need to control the plane whilst attending to the external terrain as well as anticipating what a nearing enemy may be about to do. In comparison, a soccer player in possession of the ball will need to stay in control whilst attending to an oncoming opponent as well as anticipating the movement of a team mate into a position to be passed to. However, Endsley (2000a) briefly documented how important SA can be in sport by describing how in sports, such as soccer or hockey the importance of SA in set play situations is readily apparent.

2.6 SA in Sport

2.6.1 Early studies

As mentioned previously, within the Sports Psychology literature SA has received very little attention (James & Patrick, 2004). However, a significant amount of research has been carried out within the field of perception in sport and it is possible that the results of this work can be used to help identify the nature of expert sport performers various SA requirements. One of the first pieces of such work was conducted by Fullerton (1925) who investigated the visual performance of the famous Babe Ruth. It was discovered that Ruth's eyesight was 12% faster than that of an average person. He was therefore labelled as having a superior visual hardware system compared to other batters and this was given as the reason for his outstanding batting performances in baseball. If, for example, a 'curve ball' was pitched towards him, Babe Ruth would have theoretically been able to identify it earlier in its flight than most other batters. Thus, he would have more time to decide where to attempt to hit the ball and adjust into the correct position as he was able to gain SA quicker than others. However, recent research has suggested (e.g., Garland & Barry, 1991) that in terms of perceptual advantage, expertise in sport may be based more on the successful completion of more cognitive tasks or software factors as opposed to hardware advantages of the sensory system (Abernethy, 1987).

Further pioneering research within the perception field was that of de Groot (1965) who showed chess masters classic mid-game configurations for intervals of five to ten seconds. The masters were able to recall from memory, the positions of the chess pieces almost perfectly (93%) in contrast to club players who had a recall accuracy of only 51%. Chase and Simon (1973) developed this experiment further by including random configurations of the chess pieces which resulted in no difference in performance by players of differing abilities (masters vs. club players). These results suggest that the experts' recall superiority was due to them having a larger specific task knowledge base and a better efficiency in retrieving this information. This superior knowledge base is thought to be organised more efficiently by recoding visual information into fewer more meaningful chunks (Ericsson & Chase, 1982). This chunking hypothesis proposes that experts can store information e.g. the rook, knight, bishop and three pawn configuration as one piece of information as opposed to six pieces of information for a chess novice. Consequently it is easier to store large amounts of information and subsequently retrieve it. It would also seem that the more familiar the visual information, a by-product of experience, the easier it is to select the most important information for attention, sometimes referred to as pattern matching or pattern recognition. According to Williams and Davids (1995) the development of a pattern recognition capability enables performers to chunk information into more meaningful wholes. Researchers have also suggested (e.g. Kaempf, Wolf & Miller, 1993) that expert performers use pattern recognition to identify and comprehend perceived information significantly faster than less skilled individuals which also enables them to predict a particular outcome or order of play in a given situation. For example, in soccer an expert defender may come up against attackers who play in a similar way week in week out. This enables them to recognise say a certain body movement which they know initiates a particular move, in accordance with their past experiences. As a result of this good SA may be achieved earlier in a given situation allowing the defender more time to plan and execute a response.

In a similar experiment to that of de Groot (1965) and Chase and Simon (1973) Williams, Davids, Burwitz and Williams (1993) tested the hypothesis that experts have superior soccer-specific knowledge bases compared to novices. Participants viewed 10-second video clips of structured and unstructured passages of play on a life-size screen. Between clips the participants were required to recall specific player positions using a player-analysis software programme. Experts were found to have superior recall performance on the structured trials but no significant differences were discovered between the groups for the unstructured trials. Thus the authors came to the same conclusion as Chase and Simon (1973) that expert soccer players performance is based on a well organised soccer-specific knowledge base stored in long term memory. Many studies have been conducted in other sports which have utilised similar methodologies to that of Williams et al. (1993), some are slightly different in that half the slides/video clips presented have already been viewed by the participants. Their performance of the task is then dependent on the accuracy with which they can recognise previously viewed information. Allard, Graham and Paarsalu (1980) initiated work such as this within sport by presenting expert and novice basketball players with 80 slides made up of structured and unstructured game situations. The participants attempted to recognise which slides they had previously seen in the recall task. Results and conclusions were similar to those of Williams et al. (1993) in that expert players were significantly more accurate than novices in recognition of structured game situations only and this was attributed to them encoding task-specific information to a more meaningful level than novices. Further research has led to Williams, Davids and Williams (1999) suggesting that having the ability to recall structured patterns of play can be a vital factor in faster anticipation and thus faster achievement of SA in a variety of team sports after similar findings to those of Allard et al. (1980) have been discovered in American football (Garland & Barry, 1991) and snooker (Abernethy, Neal & Koning, 1994).

2.6.2 Alternative research methodologies

More recently eye tracking techniques have been used to investigate participants' anticipation skills through knowledge of where the eyes fixate. This typically involves participants wearing a head mounted camera which records the areas of the display their vision is anchored on (via displacement between position of eye in the head, position of head in space and pupil and corneal reflection). Assessment is based on duration of fixations on differing areas of the display and the search patterns involved. Conclusions are based on the assumption that performers selectively attend to the areas of the display that they fixate on although this is by no means certain as information in the periphery may well be attended to. Tyldesley, Bootsma and Bomhoff (1982) investigated the eye movements of experienced and inexperienced soccer goalkeepers when viewing static slides which depicted a player taking a penalty kick. Participants were asked to anticipate as accurately as possible, the direction in which the penalty would be struck. Results found that the experienced goalkeepers fixated on the display for shorter periods than novices before making a faster response. This suggests that experts could utilise their extensive soccer-specific knowledge base to pattern match more efficiently enabling the quicker response. The experienced goalkeepers' initial fixation was usually directed towards the hips and kicking leg followed by the upper body rotation. This suggests that good SA may be achieved by attending to vital cues within the rotation of the penalty takers hips and kicking leg. However, as pointed out by Williams and Davids (1998), there are limitations in using static slides, in particular the participant's response fails to accommodate the vital information associated with what has previously occurred, is currently occurring and will occur. In addition static slides frequently fail to provide participants with a realistic game specific viewpoint (i.e. from players' usual perspective), which may bring into question the validity of the results. The commonly used penalty kick scenario has been useful as a starting point for perceptual skill analysis due to the closed nature of the skill and the relative simplicity of the setting, however more dynamic game scenarios and ecologically valid experiments are required to make serious in roads in this area.

More recently dynamic film presentations have been used for research in soccer in an attempt to eradicate some of the limitations that static slides presented. For example, when investigating advance cue utilisation in soccer Williams and Burwitz (1993) utilised a temporal occlusion approach of video clips of soccer players taking penalty kicks shown from a normal goalkeeping perspective on a life size screen to expert and novice goalkeepers. The clips were stopped randomly at four different occlusion points: 120ms prior to final ball contact, 40ms prior to final ball contact, at final ball contact, and 40ms after final ball contact and participants were asked to anticipate the direction of each penalty kick. Experts were found to demonstrate superior performance only for the penalty kicks edited at the earliest occlusion points, i.e. 120ms and 40ms prior to ball contact suggesting that expert goalkeepers can achieve SA earlier than novices by recognising pre-impact cues in the visual display. It is likely that this ability is as a result of utilising soccer specific knowledge through pattern matching. In support of Tyldesley et al. (1982) post-test questionnaire results suggested that expert goalkeepers extracted valuable information from selectively attending to a penalty taker's hips and kicking leg prior to ball contact. However some scepticism must be apparent for this conclusion as the extent to which this type of information is verbalisable is debatable. A more recent study by Savelsbergh, Williams, Van Der Kamp and Ward (2002) had expert and novice soccer goalkeepers watch a video of penalty kicks, again occluded at contact, but this time they were instructed to move a joystick in accordance to the direction they anticipated the penalty to be struck. It was discovered that experts were more accurate than novices, made fewer corrective movements with the joystick whilst they fixated their gaze more on the kicking leg, non-kicking leg and ball areas. Experts were also found to make fewer fixations of longer duration than novices but seemingly did not respond earlier as had been found in Tyldesley et al.'s study (1982). The difference between viewing static slides and video clips may be responsible for this finding although contemporary thinking suggests that experts do not necessarily respond earlier but prefer to more accurately understand the visual cues before initiating a response. Clearly the task demands determine the extent to which anticipation is necessary and an expert is likely to wait until the optimum moment before initiating a response.

Jones, James and Mellalieu (2002) investigated the affects of temporal occlusion on expert and novice soccer players when analysing the skill of dribbling the ball. Soccer players were filmed from a head on viewpoint whilst dribbling the ball and were asked to treat the camera as an opponent. This led to the dribble culminating with the player using one of two tricks (foot over the ball or body swerve, with the foot over the ball trick thought to be the more complex) to initiate a final movement to the left or right of the camera. The clips were occluded at 0ms, 200ms, 400ms, 600ms and 800ms before the final ball contact that initiated the change of direction. Participants were shown clips in random order of both occlusion point and asked whether they thought the player on film was about to dribble the ball to their left or right. The results showed that the highly skilled players were significantly better in anticipating the direction than novices at occlusion points 600ms, 400ms, 200ms and 0ms. Analysis into the effect of the complexity of the trick used during the dribble suggested that the experts were able to detect cues from both tricks equally well whereas novices had significantly lower ability for the more complicated trick. In agreement with de Groot (1965), Chase and Simon (1973) and Williams and Burwitz (1993) these findings continue to suggest that through experience experts have built up a superior soccer-specific knowledge base compared to novices. This knowledge base is seemingly used to interpret events which have similarities to those previously experienced. Consequently this enables experts to exploit earlier sources of information from the visual display in order to gain SA more efficiently than novices.

Recently Ward and Williams (2003) analysed the perceptual skills of expert and novice junior soccer players (U9-U17) using similar methods to those of Jones, James and Mellalieu (2002). Video clips of 11v11 game situations were edited to be occluded 120ms before final ball contact. At the point of occlusion participants were instructed to anticipate the direction in which the player on screen was about to dribble or pass the ball as well as highlight who they thought were the key players in the situation, who had been rated in order of importance by expert coaches. The results showed that U17 soccer players were able to identify about 60% of key players in positions to receive a pass in conjunction with the expert coaches' opinions. This study is different from previous temporal occlusion research as in terms of achieving SA in soccer it discovered that soccer players are able to use an accurate probability hierarchy to the key players in the display by using their level of threat as an index of selective attention allocation.

In a further study Ward, Williams and Ward (2003) analysed the effect of positional differences on a soccer player's anticipation as opposed to the usual expert-novice paradigm. Expert attackers and defenders watched a sequence of 11v11 video clips and were asked to anticipate the intention of the player in possession of the ball. The viewing perspective of the clips altered randomly from that of a defender to that of an attacker. Each clip was occluded 120ms before final ball contact and the participants indicated whether they thought the player was about to shoot, pass or dribble. The results indicated superior performance by the defenders suggesting they achieved good SA quicker than the attackers. Also the clips presented from the defenders viewpoint were easier to anticipate than those from an attackers perspective. The authors suggested that these findings were as a consequence of the defender's role in a team which leads to important differences in their soccer-specific knowledge bases. This view supports the contention that SA is situation specific and that a player may have good SA in one situation, likely to be one that is familiar, but poor SA in another possibly unfamiliar or difficult situation. Whilst research in soccer has indicated expertise effects for perceptual skills there is still comparatively little information regarding what cues are meaningful and how attention is allocated during open play.

In one attempt to improve the realism and validity of perceptual skill research in soccer, Helsen and Pauwels (1993) used an eye tracking system via a head mounted camera to analyse expert and novice soccer players' responses to various offensive game situations. The participants were presented with a dynamic life-size display which showed the offensive game situation develop on screen until the ball appeared to be played back to them. Participants then physically responded as if a member of the attacking team in the game situation either by dribbling the ball, passing to a team mate or having a shot at goal. The results found the experts to have faster initiation, ball contact and response times as well as being more accurate in their decisions than novices therefore supporting previous research findings. Experts tended to focus more on the opposition sweeper and areas of free space whereas the novices focussed on the more immediate problems of fellow attackers, the goal and the ball itself. Thus it seems that expert soccer players have learnt that information is derived from locations other than those used by novices meaning that their level of SA is greater. Similarly, Williams, Davids, Burwitz and Williams (1994) showed expert and novice soccer players clips of a 11v11 soccer match before asking them to anticipate ball direction. Again the results indicated superior anticipatory performance by the experts. Novice players fixated more on the ball and the player with the ball compared to the experts who fixated more on the locations of the player's not in possession of the ball and were therefore less inclined to ball watch.

Janelle, Champenoy, Coombes and Mousseau (2003) have recently tried to provide an insight into how experts develop superior knowledge bases compared to novices by comparing the effectiveness of different cueing conditions during observational learning of a pass in soccer. Participants were assigned to one of six groups to practice making a pass under various instructional strategies: verbal instruction, discovery learning, video model, video model with visual cues, video model with verbal cues, and video model with visual and verbal cues. Throughout practice and in a retention test the group who received video modelling as well as visual and verbal cues displayed less error in the accuracy of their passes and better technique than any other group. These findings identify observational learning as an effective instructional strategy, increasingly so when combined with visual and verbal cues. Hence it is logical to suggest that experience of watching and being involved in soccer situations under the guidance of a reasonable coach will increase a soccer player's specific knowledge base.

Williams and Davids (1998) used a combination of eye tracking and spatial occlusion methods to assess experts and novices in one-on-one and three-on-three soccer simulations. As with previous research, experts displayed superior anticipation to novices in both situations. No differences were found in eye fixations on the three-on-three situation but during the one-on-one situations experts made more fixations of shorter durations. This is opposite to the finding of Savelsbergh et al. (2002) who found expert goalkeepers to have fewer and longer fixations than novices when viewing video clips of penalty kicks. However, the task demands of facing an opponent dribbling the ball are more complex than for the penalty kick. Williams and Davids (1998) suggested that defenders require precise information from the opponents changing body shape and angle of movement with the ball to detect the direction of their dribble. This information may not be provided fully by peripheral vision and so defenders may be forced to regularly use foveal vision in the form of more rapid and shorter duration fixations to recognise familiar cues. As with previous research in the one-on-one situation experts appeared to fixate more on the hips and kicking leg region (Tyldesley et al. 1982; Williams and Burwitz, 1993) whilst trying to achieve good SA. Interestingly this finding was not supported by results from the spatial occlusion study. Different body parts were randomly occluded during the footage and occluding the hip region failed to affect the performance of the experts any more than that of the novices. The authors suggested that this can be explained by the experts' ability to acquire similar information from related body parts such as the lower leg, something which the novices were unable to do. Another explanation was that experts may use the hip region to anchor foveal vision whilst extracting information from the periphery. Of course this is the major limitation of eye tracking research, it is impossible to know where information is extracted from, only estimation is possible.

2.6.3 Ecological approaches

The above summary of the sports psychology literature suggests that experts achieve better SA than novices in many situations. Suggestions have also been made regarding which information sources are used by experts e.g. the rotation of the hips and lower legs seem to be a vital area for soccer goalkeepers to attend to when facing penalty kicks. Nevertheless there is a clear need for more ecologically valid techniques for exploring SA in different situations related to soccer as the majority of previous research has been carried out within laboratory settings. But why do researchers believe it beneficial for an athlete's performance to be analysed within their normal environment? The reason is the development of the theory behind ecological psychology. According to Williams et al. (1999) the information processing approach, which is the traditional model for understanding perception and action has recently come under criticism from researchers preferring the ecological approach. Handford, Davids, Bennett and Button (1997) elaborate by stating that the person-machine metaphor behind cognitive science and the information processing approach is rejected in favour of the ecological approach, which highlights the role the environment can have in shaping actions. These actions may therefore be better understood as a specialised relationship between a biological organism and its own specific everyday environment. Williams et al. (1999) agree with this by describing how the ecological approach integrates tools from psychology, biology and physics to gain an understanding of how an organism functions successfully in its own normal environment. Beek and Meijer's (1988) view of the ecological approach is that the relationship between perception and action is aimed at '...phenomena within the organism-environment synergy rather than within the organism per se'. Kugler and Turvey (1987, p. xii) define ecological psychology as

> *'...the study of information transactions between living systems and their environments, especially as they pertain to perceiving situations of significance to planning and executing of purposes activated in the environment.'*

Handford et al. (1997) suggest that theorists such as these who believe in the ecological approach are suggesting that perceptual information, in the form of energy flows, constrain the co-ordinated movements which emerge during goal-directed activity.

According to Davids, Handford and Williams (1994) the founding father of ecological psychology is Gibson (1979). He believed that a lawful relationship is existent between the properties of the environment and the structure of surrounding energy distributions, thus suggesting that perception is specific to sensory information. This theory questions the assumptions of the behaviourist and cognitive schools who believe that the relationship between an animal and its environment is contingent. An ecological approach describes a living system and its environment as constantly engaged in energy transactions (Davids et al., 1994). Furthermore, according to Gibson (1979), in relation to sport an equally constraining relationship exists between an athlete and the performance environment. The athlete relies on environmental information to aid the co-ordination of actions in relation to significant events, objects and surfaces. Therefore, it may be more beneficial to scientists to ensure that experiments are conducted within the subjects' natural performance environment. Maguire (1991) refines this theory more to the sporting arena by describing how at present there is a tendency to treat athletes as machines who have to deal with highly rationalised and technologised physical and mental training methods. Hoberman (1988) noticed that an athlete's body is often now treated as a laboratory specimen whose structure and potential can often be measured in quantitative terms. Maguire (1991) sees these taken-for-granted assumptions along with the outdated philosophy of science which is influencing sports science as problematic. The solution suggested is described as an alternative vision of the potential of sports science - if athletes are analysed 'in the round' a more scientific picture of their performance may be produced as it is more likely to capture them as whole selves rather than isolated physiological or psychological units. This emphasises the point made by the ecological approach which is sympathetic to the teaching, coaching and study of skill acquisition in the extremely dynamic environment of modern sport (Davids et al., 1994). However, increased research effort is required to evaluate the practical impact of the maintenance of the ecological perspective in the sport and exercise context (Handford et al., 1997).

Ericsson (2003) has also criticised experiments within the sports field based in laboratories suggesting that their artificiality means that capturing an experts' superior performance and the underlying mechanisms controlling this performance is impossible. He went on to say that gaining an understanding of expertise may only be possible by analysis of experts within their normal competitive environment. James and Patrick (2004) lend support to this notion by advocating how important it is to analyse the nature of SA within sports by using ecologically valid approaches. Until now the major obstacle against research within real world settings has been the problem of suspending or disturbing the flow of play. However recent advances in technology have allowed this obstacle to be challenged. Fery and Crognier (2001) asked expert tennis players to wear PLATO liquid crystal occlusion spectacles (Milgram, 1987) whilst playing in a game situation against players of the same ability. Some rallies within the game situation were realistic whereas others were artificially engineered. The idea being that during realistic rallies the participant would better accumulate probabilistic information regarding the opponents shot. The spectacles were turned from transparent to opaque via remote control 100ms after the opponent made a passing shot. At this point the participants were instructed to imitate their chosen shot before using a hand held device to indicate where the ball may have landed. The expert tennis players were shown to have the ability to identify where the opponents shot would have landed by gaining good SA through processes such as stroke observation, ball trajectory and situation specific probability assessments. Interestingly, the realism of the game situation seemingly had no affect on anticipatory performance which was due to the availability of useful ball flight information according to the researchers. Crognier, Veret and Fery (2003) carried out a follow up study which involved raising a protective blanket immediately after the opponent had made a passing shot so the ball never reached the net. The occlusion spectacles were turned opaque as the opponent reached the top of their strokes backswing, thus removing the useful ball flight information seen in the previous study. Consequently, unlike the previous study, results showed the experts anticipation was better within the realistic rallies than the unrealistic ones. It was argued that in this situation, where no ball flight information was available, participants had to use anticipatory information extracted from the opponents' stroke and situation specific probability assessments.

The use of occlusion spectacles seems a valid technique for reproducing realistic game situations and their use for dynamic sports such as soccer seems feasible. It is through the development of real game scenarios that many of the previously cited problems may be overcome and a better understanding of how SA is acquired achieved. James and Patrick (2004) conclude that the difficulties related to analysis of SA in sport are based around the problem of developing measurement techniques that not only retain ecological validity but also capture the diversity of the sporting environment. The next section will review the efforts made in other disciplines to measure SA with a view to providing guidelines for sports research.

2.7 SA measurement

There have been many different measurement methods of SA developed to date, none of which have been directly related to soccer. The majority of these methods have been conducted within aircraft and nuclear power plant domains; some have been shown to be more valid and reliable than others (e.g., Endsley, 1995b; Taylor, 1990). This is because there is clearly a problem in identifying SA, which leads to problems when trying to measure it. For example, in a game of soccer, there may be an instance where it appears that the player in possession is completely unaware of an opponent coming from behind to make a challenge. However, we cannot be certain that the player is totally unaware, as we cannot tell what they are thinking or know what they are seeing. Therefore, a measurement technique needs to be developed which can answer these questions, and thus aid our understanding of SA. The term SA has continued to remain controversial because the operational definition and measurement of it are still very vague. According to Pew (2000) it is the responsibility of human factors specialists to define SA in a way that will lead to useful, valid, and reliable measurement methods as well as meeting the requirements of the analyst population.

Pritchett and Hansman (2000) distinguish performance based measures of SA as being different from others, as performance based testing focuses solely on the participant's output. This is unlike many measurement techniques, which attempt to establish the participant's knowledge periodically throughout an experiment. The authors also discuss how knowledge-based and verbalisation methods of measuring

SA can be useful in that they examine the information and processes internal to the participant's awareness. But these measures do have limitations, as they may disrupt or alter the participant's task i.e. the intrusive nature potentially introduces error. However, Durso and Gronlund (1999) suggest that merely measuring performance is not useful to researchers in helping to understand SA. Pritchett and Hansman (2000) agree with this by stating that performance based measures only directly examine elements external to the operator, and the user's awareness of the situation can only be inferred. Direct performance measures of SA are advantageous to the researcher in that they are objective and usually non-intrusive. However, there are a limited number of occasions when direct performance measures will be appropriate for the assessment of SA and according to Pew (2000) these occasions occur when there is full agreement that the performance being measured is solely determined by SA. If this is not the case, Endsley (1995b) suggests that poor performance by the participant may occur from a lack of information, poor sampling strategies, heavy workload, poor decision making, or action errors, among other elements, the majority of which do not relate to SA. Therefore, in order to ensure that SA is the focus of the performance it is common for researchers to design specific scenarios in order to create opportunities for performance measures to be used to assess SA issues. Use of this method within soccer seems feasible but care must be taken when administering the process, as it is essential to recreate the scenarios as accurately as possible so the demands on the participants' SA don't alter. However, the use of specific scenarios does allow SA achievement to be compared and contrasted across differing game situations via performance based measures, it may also help to identify the varying cognitive processes that can help a soccer player gain SA in these situations.

A method of scenario manipulation used by Busquets et al. (1994) in the flight deck involved introducing disruptions to the crew in order to disorientate them from their routine jobs. The disruption itself involved blanking cockpit displays for a period of time during which a systematic offset was introduced in the aircrafts position. SA was measured as the success of recovery or the time needed to recover from the disorientation. Significant differences were found in performance as a function of the display conditions under study. Sarter and Woods (1991) suggested a slightly different method, which introduced anomalous data readings to the participants, without their knowledge. The measure of SA was then calculated as the time it took the participants to detect the anomalous data. Endsley (1995a) discusses that this type of manipulation is intrusive and may produce misleading results, as the participant is required to discover what happened to the altered data while still trying to ensure quality performance of other tasks. Pew (2000) agrees with this but also mentions how the method is applicable to research in SA, if in order to detect the anomaly the participant is required to have an understanding that is vital to successful task performance. However, this method does not seem feasible for soccer as it is difficult to envisage how a disruption could be introduced. A possible solution may be to introduce random events into a game situation in an attempt to disorientate the participant; these events may include team mates or opponents moving completely out of position. Nevertheless, in agreement with Endsley (1995a) and Pew (2000) disruptions such as this may produce misleading results as they aren't game specific and therefore the interpretation of them isn't vital to performance. Also, a soccer players' detection of the player's that are randomly out of position will be affected by the focus of their attention at the time and consequently may not give a true reflection of their SA.

Subjective measures

As it is difficult to gather quantitative objective measures of SA a lot of investigators tend to rely on subjective measures, these involve assigning a numerical value to the participant's SA (Jones, 2000). The techniques used include self-ratings, observer ratings, SART, SWORD and SARS. These methods are advantageous as they are very cost effective, easy to administer, non-intrusive and allows subjective estimations of SA to be measured in controlled real world settings (Endsley, 1996). They do have limitations which have been highlighted by Endsley (1995b); for example, if the SA ratings are collected during a simulation trial they may be limited as the participants will not totally understand what is happening in their environment.

Self-rating techniques involve asking the participant to subjectively evaluate their own SA on a scale. A major criticism of this technique is that participants cannot be aware of their own lack of SA (Jones, 2000). Using these techniques to measure SA may result in benefits for the researcher as well, according to Taylor and Selcon

(1991) self-rating measures provide a basis for insight into the underlying cognitive process involved in the achievement of SA. However, the extent to which cognitive process are available to introspection is complicated by the likelihood that experts process some information subconsciously, a well known by-product of expertise. A further limitation of self-rating techniques that can be applied to the soccer domain is that if the participants are required to subjectively evaluate their own SA post trial it is likely that the ratings will be affected by the outcome of their performance. i.e., if a participant performs well, whether it is due to good SA or good fortune, he/she will more than likely evaluate good performance as being down to good SA, and vice versa (Endsley, 1995b). Subsequently, it doesn't seem that the use of self-ratings of SA will be of any practical use within soccer.

Observer ratings involve an independent, trained observer judging the quality of a participant's SA. According to Endsley (1995b) this type of SA measurement is attractive to the observer because they will normally have more information than the participant regarding what is actually going on in a given scenario. However, Jones (2000) discusses how the observers will only have limited knowledge as regards to the participant's understanding of the situation and must rely on obvious indications to determine SA. These indications include any actions and imbedded or elicited verbalisations made by the participant. For example, in soccer this may include a player verbalising instructions to a team mate regarding the position of an opponent or the trained observer may spot the player in possession of the ball making a good pass selection due to deriving information from the visual field regarding team mate and opponent locations. Endsley (1995b) suggests that although this information can be useful diagnostically in detecting errors in SA (misperceptions or lack of knowledge), it will not provide a reliable representation of the participant's SA as further information may be stored internally which isn't verbalised (Endsley, 1994) or acted upon. Therefore the rating of SA by external observers is limited (Endsley 1995a) and if applied to soccer may not give a true reflection of a players' SA. Furthermore, within soccer it will be difficult to categorise certain verbal phrases and body movements in terms of SA achievement as situations often change extremely randomly and quickly, which causes complexity in ascertaining what a player may be referring to at any given time.

In an effort to make subjective measures of SA more rigorous, Taylor (1990) developed the Situation Awareness Rating Technique (SART), based in the aircraft domain. According to Pew (2000) SART can be seen as the most thoughtful and systematically developed self-assessing test of SA to date. Selcon and Taylor (1990) interviewed experienced aircrew in order to determine which elements they considered essential for good SA, and ten generic SA constructs were recognised. They included instability of situation, variability of situation, complexity of situation, arousal, spare mental capacity, concentration, division of attention, information quantity, information quality and familiarity. According to Taylor (1990) these ten generic constructs cluster into three broader domains. The three domains consist of Attentional demand (instability of situation, variability of situation, and complexity of situation), Attentional supply (constructs of arousal, spare mental capacity, concentration, and division of attention), and Understanding (information quantity, information quality, and familiarity). Therefore, SA can be estimated subjectively using either the 3-dimensional or 10-dimensional SART. If the 3-D SART is being used, ratings are usually made on a 10 centimetre line with the endpoints low (0cm) and high (10cm). If the 10-D SART is being used, a 7-point rating scale is utilised for each of the ten generic SA constructs upon which the participants have to mark their qualitative observations (Taylor & Selcon, 1991). Vidulich, Crabtree and McCoy (1993) investigated the validity and sensitivity of the SART measurement technique using the 10-D SART. They found that the overall SART rating produced a measure that is sensitive to changes in SA, but the lack of test-retest reliability raises cause for concern as regards to the validity of this finding. SART has many advantages, according to Selcon and Taylor (1990) the ecological validity of SART is high as its dimensions were gathered directly from operational aircrew and the generic constructs have potential to be relevant to non-aircrew domains, this may include soccer. However, the technique does have its disadvantages, Selcon and Taylor (1990) showed that SART is correlated with performance measures but Endsley (1995a) suggests that it is still unclear whether or not this is due to the workload of the task or the understanding (i.e., SA) components required. This would pose a similar problem within soccer as most self-rating techniques in that if ratings can be influenced by the outcome of a player's performance they may not give a true reflection of a players' SA. Also, to apply SART to soccer an overview of the applicability of the generic constructs would have to be carried out by expert coaches and players in conjunction with psychologists. However, according to Taylor and Selcon (1991) the sufficiency of the 10 constructs within the domains has not yet been clearly enough established and the developers of the scale realise that there is still considerable scope for scale development, which must be completed before SART can be used within the soccer field.

Hughes, Hassoun and Ward (1990) used the Subjective Workload Dominance (SWORD) metric as a subjective rating tool for SA. According to Endsley (1995b) SWORD allows participants to make pairwise comparison ratings of competing design concepts regarding the degree to which concept entails less workload than the other. The analytic hierarchy process technique is then used to combine the results by providing a linear ordering of the preferred design concepts. As SWORD was successful as a workload metric, Vidulich and Hughes (1991) adapted it so it could be used as an SA metric. No changes were required in the data collection or analysis procedures, the only change required was in the instructions to the participants. When SWORD is used in the field of SA, the scale is simply called SA-SWORD in order to distinguish it from the workload measure (Jones, 2000). Hughes et al. (1990) tested SA-SWORD in a study instructing pilots to rate the level that differing displays provided information regarding SA as opposed to workload. As hypothesised the pilots preferred the display that was subjectively rated using SWORD, as providing the more relevant SA information. To test the reliability of the SA-SWORD ratings Vidulich and Hughes (1991) used an inter-rater (participant) correlation, nine of the ten participants positively correlated which suggested that the SA-SWORD were reliably related to the task conditions. Therefore, the technique may hold promise as an easy to implement subjective measure of SA but as it is based within the aircraft domain it may be difficult to apply to soccer. For instance, it will be difficult to present soccer players with displays which differ in the amount of SA information presented, especially within real game scenarios. If this can be achieved it is also essential that the players are familiar with a detailed definition of SA in order to prevent confusion. However, as this study by Hughes et al. (1990) was among the first using SA-SWORD no real final conclusions can be drawn as regards to its effectiveness. The effectiveness of this method is brought into further doubt by Jones (2000) who acknowledges that SA-SWORD may not be the answer to problems within SA metrics as any single metric of SA is unlikely to increase information regarding the role of SA in complex tasks. As there is much doubt concerning the role SA-SWORD can have in measuring SA it seems that further research is needed utilising this technique before it can even be considered as being applicable to soccer.

The SARS scale also attempts to measures SA subjectively, as Jones (2000) explains it is based in the tactical air environment and was created after consulting experienced F-15 pilots, leading to the development of 31 behaviour elements of SA considered to be important to mission success. Each behavioural element fits into eight categories of mission performance – General traits, Tactical game plan, System operation, Communication, Information interpretation, Tactical employment-bvr, Tactical employment-visual, tactical employment-general. The SARS scale involves the participants rating themselves and their peers on each of the 31 behaviours on a 6-point scale ranging from Acceptable to Outstanding. Bell and Waag (1995) found the scale to have high internal consistency and inter-rater reliability when used in the aircraft domain. They concluded that the results proved SA to be a meaningful construct that can be used by both peers and supervisors to classify mission ready pilots. However, according to Endsley (1996) the SARS scale doesn't provide a subjective measure of SA in the same sense as the other scales that have been discussed. Also, Jones (2000) suggests that within SARS, SA is regarded as an innate ability as opposed to a changeable state of knowledge and as SARS is closely related to the aircraft domain its applicability within other domains is unrealistic. Therefore, the use of this scale within soccer seems unlikely but it may be possible to amend the eight categories so that they are specific to the task in hand. Similarly to previous methods discussed, ratings made by the participants and their peers may be influenced by performance, thus creating a misleading reflection of a players' SA. Finally, as Jones (2000) concludes SARS is a relatively new measure that has received limited testing, consequently further research is needed to validate the scale before it can be fairly judged and utilised within a new domain, such as soccer.

In summary it seems that subjective SA measurement techniques may be a popular choice among investigators within the aircraft domain as they are of low cost, easy to implement, non-intrusive and they can be utilised in controlled real-world settings.

However, none of these techniques have been tested within the soccer field so their applicability has been discussed and findings suggest that as many of them are based on SA rating scales within the aircraft domain a problem arises. An investigation of common scenarios in soccer would have to be carried out by expert coaches and players in conjunction with psychologists leading to the development of a group of scenarios which are separated by the demands they have on a player's SA. Nevertheless there is still the problem that self ratings and observer ratings of SA will be influenced by the outcome of a player's performance and therefore won't provide a true reflection of a players' SA. Endsley (1995b) contributes to this issue by suggesting that self ratings of SA may convey a measure of a participants confidence levels rather than concerning how much knowledge and understanding they have of the situation. Therefore, as a participants' self ratings may not reflect the true situation it will possibly be more effective to use subjective SA data in accordance with objective data e.g. performance measures. In addition to this Jones (2000) points out that few subjective measures have been tested extensively and their validity and reliability may need to be investigated further before they can be justified.

Objective measures

The Situation Awareness Global Technique (SAGAT) is a global tool which assesses SA across all of its elements based on a comprehensive assessment of participant SA requirements (Endsley, 1987). SAGAT is based upon a simulation system which is frozen randomly throughout the experiment and the participants are questioned regarding their perceptions of the situation based on Level 1, 2, and 3 SA components (Endsley, 2000b). These queries allow for detailed information regarding the SA of the participant to be collected on an element by element basis which can be evaluated against reality, therefore providing an objective assessment of participant SA. Endsley (1995b) states that SAGAT provides a direct measure of SA as it analyses the participant's perceptions rather than inferring them from behaviours that may be influenced by factors other than SA (i.e. can be objectively collected and evaluated). A further advantage of the simulation is that it does not require participants or observers to make judgements regarding situation knowledge on the basis of incomplete information as subjective measurement techniques do. In addition, the use of random sampling of stop times and query presentation provides unbiased estimates of SA, which allows SA scores to be easily compared between participants (Endsley, 2000b). As pointed out by Endsley (1995b) the initial disadvantage of this technique involves the momentary pause within the simulation as it will disrupt the participant's performance and may affect their concentration in-between pauses. A further important issue highlighted by Endsley (2000b) which must be addressed when using SAGAT is that of deciding what queries should be used during the freeze for a particular setting. These queries must be relevant to the operator's SA and are decided upon through the use of a cognitive task analysis system called a goal-directed task analysis (Table 3.1).

Table 2.1: Format of Goal-Directed Task Analysis (adapted from Endsley, 2000b)

Format of Goal-Directed Task Analysis
Goal
Subgoal
Decision
Projection (Level 3 SA)
Comprehension (Level 2 SA)
Data (Level 1 SA)

According to Endsley (2000b) within goal-directed task analysis, the major goals of the task are identified along with the major sub-goals required to meet each of these goals. Next, the decisions that must be made to perform each sub-goal are identified as well as the SA requirements for making these decisions and carrying out each sub-goal. The basis of the analysis is usually formed using expert elicitation, verbal protocols, observation of operator performance of tasks, analysis of written materials and documentation. The SAGAT technique gives the experimenter control over the freezing of the simulation and the data collection, without any effect on the participant or any of the processes within the experimental domain. The author also suggests how most known uses of SAGAT have been based within aircraft simulations, but in general it can be applied to any domain in which a realistic simulation of task performance exists and an analysis of SA requirements has been made in order to develop the queries. Therefore, applying SAGAT to soccer would prove difficult as there is currently no information regarding SA requirements to complete goal-directed analysis. Also, SAGAT involves freezing the simulation at random points, which won't be practical in actual soccer matches although simulated matches would be feasible. However individual SA measurements would then be dependent on the varying situations, which in turn lead to potentially invalid results. To overcome this problem, scenarios that occur frequently and often cause soccer players to make SA related errors have to be identified so that game simulations can then be suspended at these points for a players' SA to be measured.

The use of questionnaires combined with the method of freezing a simulation at known points of SA requirement may provide an objective measure of SA, because according to Endsley (1995b) detailed information can be gathered on an element-by-element basis which can be evaluated against reality. The major difference between this method and SAGAT is that within SAGAT the simulation is frozen randomly but freezing the simulation at pre-determined points makes the suggested method more applicable to soccer. For this to be achieved common game scenarios have to be recognised which are grouped by the demands they have on a soccer player's SA. Game simulations could then be frozen/suspended as these scenarios occur to allow the participant to be questioned regarding their perceptions of current events. This would enable a direct measure of a player's SA (as far as this is feasible) as the technique directly analyses perceptions as opposed to inferring them from behaviours which may be influenced by factors other than SA. According to Endsley (1995b) post-test questionnaires allow ample time for participants to respond to a detailed list of questions regarding there SA throughout the trial, but the author also mentions how recall can be negatively affected by the amount of time and events that occur between the activities of interest and the answering of the questionnaire. Consequently, post-test questionnaires may only reliably calculate the participant's SA at the very end of the trial. Endsley (1995b) also suggested that this problem may be overcome by asking the participants about their SA while the experiment is ongoing, but this could in turn be highly intrusive on the task. Therefore, as suggested earlier it may be best to suspend the simulation as a known SA related scenario is developing and then immediately question the participant regarding their perceptions of the current situation. To prevent the participant gaining any additional SA information from the environment during the slight delay between play being suspended and questions being directed to them, a similar technique to that used by Fery and Crognier (2001) is suggested. They asked expert tennis players to wear PLATO liquid crystal occlusion spectacles (Milgram, 1987) whilst playing in a game situation before the spectacles were turned from transparent to opaque via remote control 100ms after the opponent made a passing shot. The participants were then required to imitate their chosen shot before using a hand held device to indicate where the ball may have landed. In a similar way, a soccer player could wear the spectacles during a game simulation and as a specific scenario arises the spectacles are turned opaque before an experimenter asks questions regarding the player's perceptions of the environment. These spectacles may have a slight hindrance on vision towards the ball when at the feet of the person wearing them. However, it is hypothesised that this shouldn't have an adverse affect on the performance of a soccer player as from an early age they are encouraged to 'keep their head up' and let sense of the balls position become as automatic as possible. This method could provide a direct and objective measure of SA in soccer.

2.8 Rationale for Study 2

The following study is aimed at establishing areas of play where SA may be a potential problem for soccer players. Previous research (Jones, James & Mellalieu, 2002) has concluded that some professional soccer players may have a better ability to avoid being tackled, can visualise more difficult passes and have better anticipation of both team mates and opponents movements than others. One way of describing these perceptual advantages is to suggest that the differing abilities between players of different skill levels can be in part attributed to the capability of soccer players to achieve SA. As pointed out by James and Patrick (2004) there has been little recognition of the term SA within the sporting literature let alone any specific mention of it as an important contributor to soccer players' performance. This contrasts with more anecdotal evidence of say soccer pundits working for television broadcasters who frequently refer to a player's 'awareness' when analysing particular aspects of a match. For example, professional pundit Alan Hansen (ex Liverpool and Scotland team captain) described former Portugal national team captain Luis Figo's performances throughout Euro 2004 as outstanding and attributed much of it to him being consistently aware of the movements of both his team mates and opponents. It would seem therefore that there is a need to scientifically investigate whether or not SA plays a significant role within soccer. Initially a sensible starting point would seem to be the identification of particular game situations which potentially have SA manifestations. For example, if a player is not aware of an opponent who goes on to dispossess the player and score a goal then one would rightly conclude that not being aware of the opponent was critical in this performance error. It would also seem likely that if the opponent was coming up to the player from behind then the chance of lack of awareness of the opponent would be greater than when the opponent is in other more prominent positions. Clearly this is a simple and fairly obvious observation but what other situations occur that have potentially drastic consequences for poor SA?

In order to identify potential game situations, matches need to be viewed for performance errors thought to be a consequence of poor SA. It has been argued that details of the situation and its context are essential for understanding SA and thus video recordings taken from live matches allow knowledgeable researchers the possibility of identifying these situations. However since an understanding of both a person's knowledge of a situation (impossible using this methodology) and the processes that develop this knowledge (again unrealistic within this technique) are necessary for understanding the task of 'achieving and maintaining SA' it would seem that this method is limited in its potential. It has also been pointed out that the situation and a person's awareness within that situation are undividable. Thus whilst this study may be able to identify situations where SA could be problematical it will be difficult to develop generalisations concerning SA until an association has been made between the characteristics of a particular situation and the requirements to become aware within it. These are goals for the second study but first the situations need to be identified.

Chapter 3: Study 1 - The role of SA in soccer

Jones, P.D., James, N., Patrick, J. and Mawson, H. (under review). The role of SA in soccer. *Journal of Sports Sciences.*

3.1 Introduction

Situation Awareness (SA) has received a great deal of interest in experimental psychology in the past fifteen years within industrial contexts (e.g., Endsley & Garland, 2000); military command and control (Artman, 2000) and driving (Gugerty, 1997) although studies within aviation predominate. Both pilots and air traffic controllers have been studied mainly due to the high consequences resulting from a lack of SA (e.g. Rodgers, Mogford & Strauch, 2000; Sarter & Woods, 1994; Taylor, 1990; Waag & Houck, 1995). It is surprising however that SA has received scant explicit recognition within the Sports Science literature even though Endsley (2000a) stated that "in sports, such as soccer or hockey, for instance, the importance of SA in selecting and running plays is readily apparent" (p.10). This paper will attempt to reconcile the experimental psychology research in SA with sports science research in the primary perceptual processes and anticipation, all of which are in scope to SA, to provide guidelines for future sports related research.

The best known and often cited definition of SA refers to three hierarchical phases 'the perception of the elements in the environment within a volume of time and space, the comprehension of their meaning and the projection of their status in the near future' (Endsley, 1988, p. 97). However the popularity of this citation does not reflect the confusion within the literature over whether SA is seen as a person's knowledge or awareness of a situation (product) or the information processes including perception, comprehension etc., which are responsible for generating that knowledge. Pew (1994) and Endsley (1995a) preserve this distinction by labelling the former, situation awareness, and the latter, situation(al) assessment. Theoretically, this distinction is clear, although operationally it is difficult, if not impossible to separate the many cognitive processes from their associated products, particularly in complex, dynamic performance situations. Patrick and James (2004) have thus suggested that research in SA should embrace not only a person's knowledge of a situation but also the processes responsible for producing such knowledge, which will depend on the situation and its context. They thus suggest a task-oriented perspective to consider SA as the product of performing satisfactorily the task of 'achieving and maintaining SA'. This approach concurs with Endsley's (1995a) view that the achievement of SA should be separated from the subsequent tasks of decision making and performance.

Task analysis techniques such as Hierarchical Task Analysis (HTA) (e.g. Shepherd, 2001) advocate tasks are defined in terms of their goals. By adopting the rules and vocabulary advocated by HTA we can represent the three tasks advocated by Endsley (1995a) in the hierarchical diagram of Figure 4.1 (1.1 – 1.3) together with their associated plan (sports performance). In task analytic-terms, the former task is a logical prerequisite for the latter tasks such that the achievement of SA is a prerequisite for successful action. This cycle of task behaviours will be repeated for each of the many actions that are required for a sports performance. Taking this task-analytic approach a stage further Endsley's three hierarchical phase definition of SA (1988) quoted above can be viewed as three sub-tasks (1.1.1 – 1.1.3 of Figure 4.1) that comprise the task of 'achieving and maintaining SA'.

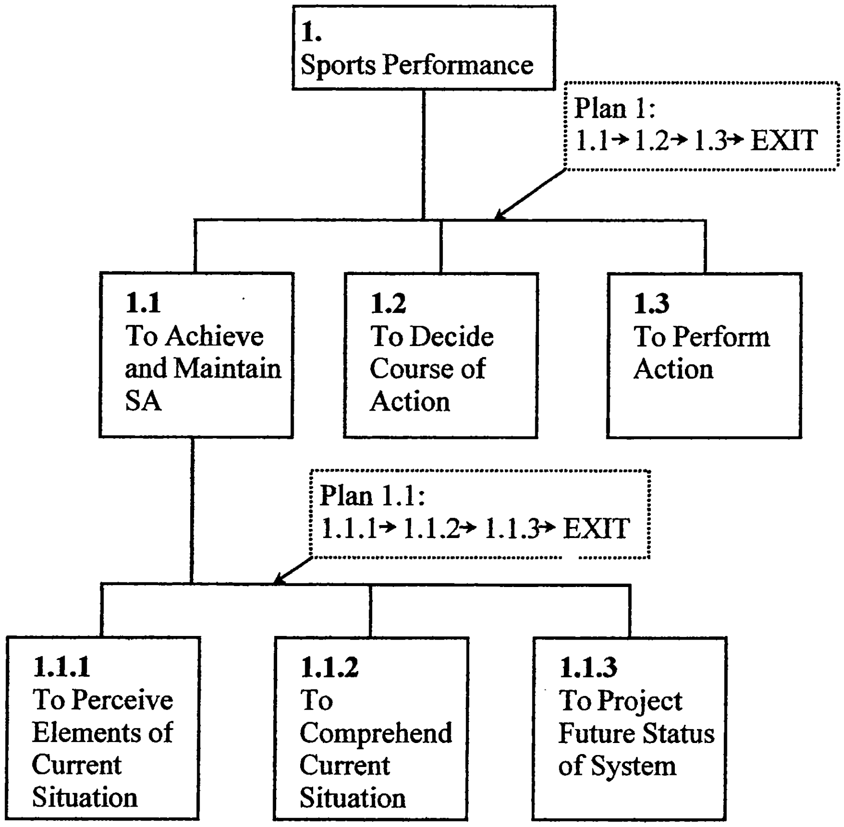


Figure 3.1: The task hierarchy of sports performance, including the achievement of SA (adapted from Patrick & James, 2004).

This task-oriented perspective emphasizes that SA is the outcome of performing a task and this task (i.e. achieving and maintaining SA) can be broken down into three constituent sub-tasks together with their plan. All of these tasks and subtasks are defined by their goals (i.e. what has to be achieved), corresponding to Endsley's hierarchical phases of SA, rather than by the processes involved in achieving these goals (i.e. how). These processes, both cognitive and actions, may be heterogeneous with respect to the same task goal, depending upon the task situation and context. Consider for example a soccer situation whereby a player has control of the ball and looks to make a pass. To perceive the elements of the situation (task 1.1.1) the player will need to *decide* which players to monitor e.g. team-mates to pass to and opponents who may interfere. Despite the goal being to *perceive* elements of the situation, any or all psychological processes may be involved in achieving this goal besides perceptual ones, including, attention, memory, decision making and action. Whilst the SA labels can be confused with the information processing stages in cognitive models it should be recognised that none of the tasks represented in Figure 4.1 are bounded by specific psychological processes as the interaction between each task and the player/context varies according to the situation. Thus in order to analyze any sports task and improve performance of it, all of the detail of the task situation and context needs to be specified.

How does this approach fit in with current sports related literature? There is a wealth of research into perception, comprehension and prediction of sports performance, all within the scope of SA but little explicit acknowledgement of SA (see also James & Patrick, 2004). The important concept that SA research can bring to sports research is the recognition of the importance of the situation and consequently the generality of specific findings. Indeed Pew (1994) questioned whether any generality could exist in solutions relating to SA given that every task/situation could possibly require a unique solution. Clearly if this is the case it is not necessary to even invoke the concept of SA at a phenomenological level. However the issue of generality versus specificity is a problem in all areas of both pure and applied science which has not been fully answered. Empirical work is thus required to examine this issue.

The aims of this study are to determine whether SA is of relevance to sporting contexts, in this instance soccer and to investigate whether any generality between situations exists.

3.2 Methodology

3.2.1 Apparatus

A Panasonic NV-HS820 video recorder/player and a Panasonic TV were used to watch 12 English Premier League games involving 18 different teams recorded live off Sky television from the 2000/01 and 2001/02 seasons. A Canopus Storm PC video card was used to transfer data between VHS and digital formats (native digital video). Adobe Premier v6.0 and Commotion Pro v4.0 software were used for non-linear editing before transferring the data back to video. The completed videos were displayed to the raters on a 32in Panasonic TV placed directly in front of the raters at a distance of 2.4m.

3.2.2 Development of video clips

The initial goal was to identify potential performance problems in soccer that were potentially a result of a player not achieving a satisfactory level of SA to enable a successful performance outcome. Two of the experimenters independently selected performance errors which they thought may have been as a result of poor SA from 12 English Premier League matches from the 00/01 and 01/02 seasons recorded from Sky television. All common video clips were then subjected to consideration by the four co-experimenters. Clips that were considered suitable were then categorised according to the pertinent action. This iterative process resulted in nine categories of soccer action, where during each sequence of play it was thought that poor SA had contributed to the performance error (Table 4.1).

Three video clips were selected for each of the nine categories plus a further five control clips where a player's error was attributed to bad performance (i.e. bad control, mis-kick etc.) rather than poor SA. These control clips were to be included to test whether the expert raters (used in the study) were able to distinguish between poor SA and bad performance. The final video compilation was thus to comprise of 32 assessed clips (including the control clips) plus one clip at the beginning of the video for familiarisation purposes.

Table 3.1: Categories of soccer action during which SA was thought to have contributed to poor performance

Category	Common action that defines the category
1 'Dribbling the ball and misplacing pass'	This involved a player being under little pressure from opponents whilst moving forward with control of the ball before misplacing an attempted pass to a team mate.
2 'Receiving pass and misplacing subsequent pass'	A player in space and receiving possession of the ball from a team mate then misplaced an attempted pass to a different team mate.
3 'Receiving pass, turning and being dispossessed by opponent behind'	When a player received a pass from a team mate and then immediately turned into an oncoming opponent resulting in losing possession of the ball.
4 'Receiving ball and being dispossessed by opponent chasing back'	This involved a player receiving a pass from a team mate, before getting dispossessed by an opponent approaching from behind.
5 'Receiving pass, controlling ball, avoiding one opponent and being dispossessed by a second opponent'	Here a player was the recipient of a pass from a team mate and whilst avoiding an attempted tackle from one opponent was dispossessed by another opponent
6 'Waiting to receive pass which is intercepted'	This involved a player in a stationary position waiting for a pass from a team mate rather than moving towards the ball which resulted in an interception by an opponent.
7 'Dribbling at speed and being dispossessed from behind by opponent chasing back'	A player moving forward at speed whilst in possession of the ball was dispossessed from behind by an opponent chasing back.
8 'Crossing into penalty area and not finding team-mates'	A player with possession of the ball in a wide area of the pitch crosses the ball into the penalty area when there is no team mate in the vicinity to receive the pass.
9 'Failing to mark attackers in and around the penalty area'	Here a player was in a defensive position but was not marking an opponent which leads to the opposition creating a goal scoring opportunity.

Each clip was initially cut to six seconds duration in Adobe Premier and duplicated four times. Preliminary trials had suggested that raters needed to see the clip this number of times to allow sufficient understanding of the situation and hence allow them to make a reasonable assessment of the clip. To help this familiarisation process it was decided that the first time the clip was to be shown to the rater a marker (a red dot) was to be placed just above the head of the player whose performance was to be assessed (as in Figure 4.2). This was achieved in software using the motion tracking function called 'AutoPaint' in Commotion Pro v4.0. When the final video was constructed an inter-trial interval of four seconds of black video was placed between each clip to give the raters time to record their answers. The final 22 minute video therefore contained a total of 33 clips, each to be shown four times. Eight versions of the video were created presenting the same clips in different random sequences to eliminate any order effects.

Figure 3.2: Video still showing marker above the head of the player whose performance was being assessed

3.2.3 Participants

Eight expert raters with an average age of 42.1 yrs (SD = 11.5) and 25 yrs (SD = 6.54) soccer experience (professional players and coaches) viewed the video clips. 5 were employed by the Football Association of Wales (FAW) and three by a professional team within the English Professional Leagues. All coaches had their 'UEFA A Licence' professional coaching certificate.

3.2.4 Procedure

Each rater watched the video independently following brief instructions on what to expect during the study. Raters were informed of the familiarisation clip and the four second blank between each of the four showings of the same clip. They were instructed about the task and how to respond to the clips and were also given the opportunity to practice recording answers using the rating scales and were able to ask any questions. When the study began the raters watched each clip and then recorded their rating of the level of SA for the highlighted player in each clip (Figure 4.3), their confidence in that SA rating (Figure 4.4) and the relative importance of the player's mistake to the game as a whole (Figure 4.5).

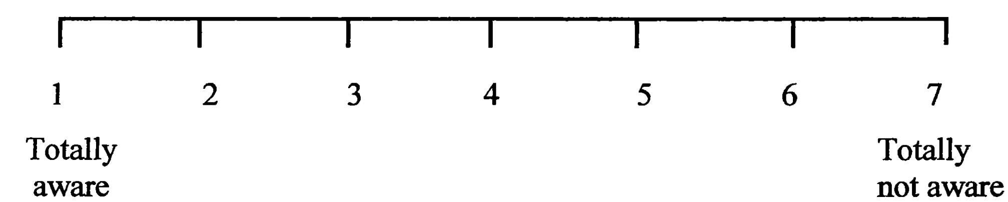


Figure 3.3: Rating scale for raters to record their opinion of the highlighted player's level of SA

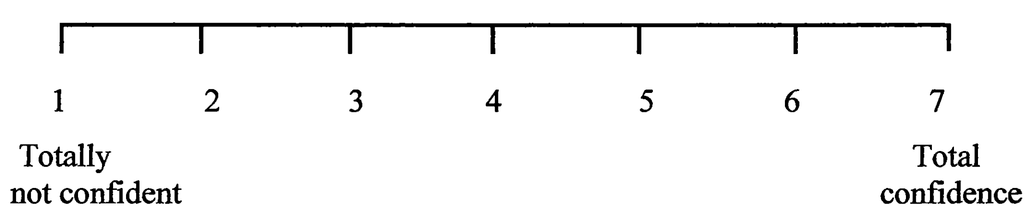


Figure 3.4: Rating scale for raters to record their confidence for their opinion of the highlighted player's level of SA

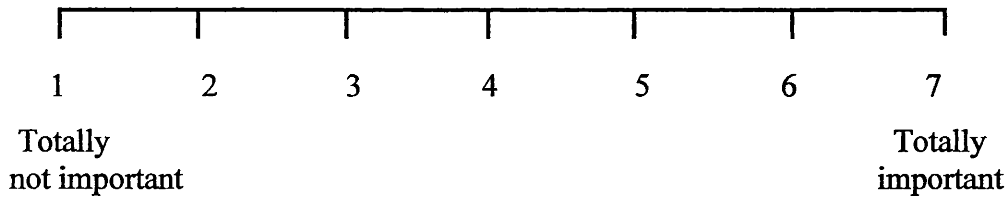


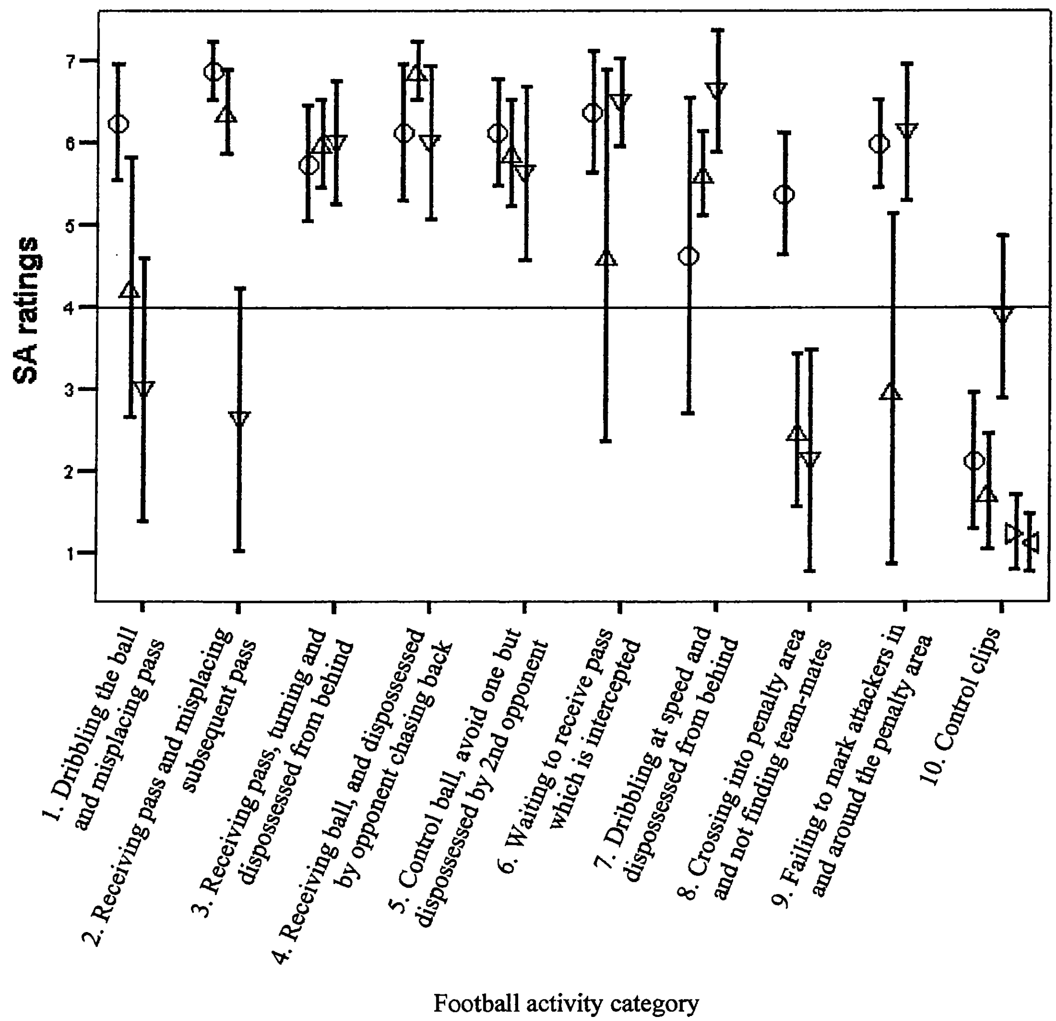
Figure 3.5: Rating scale for raters to record their opinion of the relative importance of the highlighted player's mistake to the game as a whole

3.2.5 Data Extraction and Analysis

This study was concerned with raters' opinions of soccer players' SA. Consequently the degree to which the raters agreed (inter-rater reliability) with each other was critical. A number of measures of inter-rater reliability have been proposed e.g. the intraclass correlation coefficient, average deviation and r_{WG} inter rater agreement indexes. Ebel (1951) and Haggard (1958) argue that the best of these measures is the intraclass correlation coefficient (ICC) because some formulations of this correlation can assess any discrepancies in the level of ratings between raters. However there has been much debate regarding how ICC's are calculated and the validity of subsequent inferences (i.e., Lahey, Downey, & Saal, 1983; McGraw & Wong, 1996; Shrout & Fleiss, 1979), therefore it wasn't considered to be suitable for this study. Consequently, the average deviation method will be utilised here as recent research by Burke, Finkelstein and Dusig (1999) proposes this method as the best for calculating inter-rater agreement, it is computed by finding the absolute deviation of each rating from the mean or median of the group rating and then averaging the deviations. This method receives further support from Dunlap, Burke and Smith-Crowe (2003) who recommend its use in studies such as this one as the average deviation indexes can be interpreted in terms of the actual categories of the rating scale used.

3.3 Results

Of the 32 video clips shown to the eight raters five were control clips in which SA was not thought to be responsible for poor performance. All five control clips had mean ratings of less than four which confirmed the expectation that poor SA was not involved in the poor performance (Figure 4.6).



Key: In categories 1 - 9 there were 3 clips within each category designated by ○, △, ▽.
In the control clip (category 10) there were 5 clips represented by ○, △, ▽, ▷, ◁.

Figure 3.6: Mean and standard deviations of SA ratings for the 32 clips

Ratings of clips with a mean of less than four (i.e., the middle of the SA scale) were considered problematic as the coaches did not consider SA to be the cause of the poor performance. In addition to the five control clips five other clips received mean ratings of less than four and consequently these clips were discarded from the subsequent analyses resulting in 22 clips remaining across nine categories.

There was a significant difference between coaches' ratings of the level of SA manifested in the clips ($F (21, 140) = 4.33$, $p < 0.001$). The average deviation method of calculating the inter rater agreement found a significant agreement between the coaches' ratings of 19 clips (18 at $p < 0.01$ and 1 at $p < 0.05$). The three remaining clips that did not have significant agreement came from categories 1, 6 and 7.

Reliability can also be indirectly assessed by raters' confidence in their assessment of SA levels. Mean confidence ratings for the 22 clips were high (mean ± s: 5.52 ± 1.45) with no significant difference between coaches' ratings ($F (20, 140) = 1.41$, $p = 0.13$). A similar level of confidence was demonstrated for the five control clips (mean ± s: 5.95 ± 1.18).

3.3.1 Differences in awareness between situations

In order to assess the relative contribution of SA to the poor performance between the different SA categories it was necessary to analyse the magnitude of the SA ratings provided by the coaches. Despite the reasonable inter rater agreement demonstrated above in order to be cautious the three video clips that were not associated with a significant average deviation agreement were discarded from the following analyses. This meant that two of the nine categories (categories 1 and 8) also had to be discarded as they were only represented by one remaining video clip rendering inferential statistics unjustified.

The satisfactory inter rater agreement meant that it was feasible to use the mean of the coaches' ratings as an aggregate measure for each category. A one way ANOVA suggested there was a significant difference in the mean level of SA between the remaining eight categories (including the control category) ($F (7, 14) = 21.86$, $p < 0.001$). A post-hoc Scheffé revealed that only the control clips differed significantly from the other categories (Table 4.2).

Table 3.2: Mean SA and importance ratings

SA category		SA rating	Importance
2 'Receiving pass and misplacing subsequent pass'	Mean	6.63	5.50
	SD	*0.50*	*1.10*
3 'Receiving pass, turning and dispossessed from behind'	Mean	5.92	3.75
	SD	*0.65*	*1.33*
4 'Receiving ball and dispossessed by opponent chasing back'	Mean	6.33	5.17
	SD	*0.82*	*1.95*
5 'Control ball, avoid one but dispossessed by 2nd opponent'	Mean	5.88	4.29
	SD	*0.80*	*1.30*
6 'Waiting to receive pass which is intercepted'	Mean	6.44	4.63
	SD	*0.63*	*1.54*
7 'Dribbling at speed & dispossessed from behind'	Mean	6.13	4.13
	SD	*0.81*	*1.26*
9 'Failing to mark attackers in and around the penalty area'	Mean	6.06	6.69
	SD	*0.68*	*0.79*
10 'Control clips'	Mean	2.03	3.90
	SD	*1.21*	*1.32*

It was also useful to assess the relative importance of the player's mistake to the game as a whole. There was a significant difference between coaches' ratings of the importance ($F(20, 140) = 7.70$, $p < 0.001$). The average deviation method of calculating the inter rater agreement found a significant agreement between coaches' ratings of importance for 9 of the 19 SA category clips (3 at $p < 0.001$, 3 at $p < 0.01$ and 3 at $p < 0.05$).

3.4 Discussion

The expert soccer coaches rated (on average) that 22 of the 27 clips presented to them exhibited poor performance by one player, which was a result of him having poor SA. However the inter-rater reliability measure suggested that the raters were in satisfactory agreement on only 19 of the clips. Analysis of the magnitude of the perceived SA levels on these clips suggested the raters thought the player to be close to completely unaware (mean rating = 6.17 out of 7, SD = 0.75) of the important feature e.g. the opponent who tackled him. Some caution is warranted regarding this finding however since this methodology provides mean ratings which can mask the fact the one or two raters may have had different views to the majority. When expert ratings are not direct assessments, of SA in this instance, some rater error can be present due to task difficulty and unfamiliarity. Not withstanding these potential sources of error the finding that soccer players have been judged to be unaware of important aspects of the game in some very important situations e.g. the errors in category 9 were rated as very important to the potential outcome of the game, has important ramifications for soccer coaching. This finding was based on an opportunistic sample however, clips were pre-selected as involving errors due to lack of awareness, so the categories selected are not necessarily representative of game events i.e. the sampled events may occur infrequently. The true scale of the problem of poor SA in soccer has therefore not been identified, a necessary future study, although the case has been made that soccer players potentially have problems with awareness.

The importance of the situation has been stressed throughout this study suggesting that awareness is dependant upon the situation and that levels of SA are therefore related to how familiar the situation is. The results showed players sometimes differentiated between important and unimportant players (see also Ward & Williams, 2003) and also between team mates and opponents. This seems sensible particularly the important unimportant distinction although theoretical perspectives discussing the mechanisms enabling this process are not well documented in the literature. One potential explanation for the apparent closer monitoring of the opponents found in this study is that if the team mates of a player are located in a familiar formation then perhaps less attention is afforded them as the player's soccer knowledge base can predict reasonably accurately movements in the near future. Consequently more attention can be allocated to opponents who in some instances are the major threat to keeping possession.

The reasons for lack of SA are still unclear at this point however, although by adopting a task led perspective this study has made some insights into causality. By categorising soccer sequences according to the actions of the player who made the performance error each clip within a category had similar task demands for the player who made this performance error. Consequently when raters were in agreement that clips within a category contained performance errors due to poor SA it seems reasonable to suggest that some generality exists between the clips, namely the task demands for the player. This approach goes some way towards answering Pew's (1994) comment that each situation is unique and therefore requires a unique solution. However even within a similar situation e.g. when in possession of the ball and an opponent approaches from behind, the situation is different to the extent that all players are in different positions, running at different angles etc. However the critical error in the above example is not being aware of the opponent behind who then dispossesses the player. The salient features which seemed to predict poor SA in this study involved the player waiting to receive a pass, dribbling with the ball and failing to mark opponents. It is easy to suggest that each of these scenarios involves a narrow focus of attention i.e. on the player in possession of the ball or the ball itself. However this may be far too simplistic as at novice levels one might expect this sort of error but at elite levels and probably sub-elite levels this would not be expected. Consequently, to improve a player's SA, coaching scenarios could be set up to enable practice at looking around more, particularly in the areas identified as problematic, prior to receiving or dribbling with the ball.

Having identified some situations where it seems players may be prone to having poor SA it should be pointed out that it is still not possible to ascertain whether the reason for the poor SA is because of a narrow focus of attention e.g. ball watching, or due to attending to inappropriate sources e.g. an opponent running off the ball. Previous studies have shown that expert soccer players focus on different aspects of the play compared to novices e.g. Helsen and Pauwels (1993) but the findings of this type of study have been in artificial settings and questions are therefore raised regarding their validity. Secondly, little is known regarding the quantity of information that can be attended to. It seems that experts are likely to be able to attend to more information (the chunking hypothesis, Ericsson & Chase, 1982) and specifically Ward and Williams (2003) showed that U17 soccer players were able to identify about 60% of key players in positions to receive a pass. Clearly as expertise develops and some aspects of soccer skills become automatic then more attention can be allocated to salient features of the visual field, which clearly relates to good SA. Future studies need to investigate this relationship between skill level and awareness through ecologically valid assessments of what soccer players attend to in different situations so that reasons for poor SA can be identified.

Chapter 4: Study 2 – Measuring SA in soccer

4.1 Introduction

The results of study 1 of this thesis confirm that on some occasions soccer players have poor SA, specifically during play that was characterised by seven different categories determined through commonality of the task requirements needed to achieve good SA. However knowing that SA is an issue and actually measuring a soccer player's SA are two different things. Thus the aim of the following study is to measure SA in a realistic soccer setting.

Patrick and James (2004) have argued that details of the situation and its context are essential for understanding SA. Thus having identified situations where SA is problematical these situations need to be interrogated to determine a player's knowledge of the situation (product) and thus derive clues as to what processes enable this knowledge. This thinking fits into the model of understanding the task of 'achieving and maintaining SA' proposed by Patrick and James (2004). The nature of the interrogation should adhere to Ericsson's (2003) view that artificial conditions may fail to capture the nature of an experts' performance. Thus realistic match conditions are required not only retain ecological validity but also capture the diversity of the sporting environment. A method of suspending a soccer game simulation at the point where it is known the participant may require adequate SA to complete a task satisfactorily is therefore the desired goal. Once the simulation is suspended, the means by which the participant is subjected to interrogation becomes critical. Some form of post-event questionnaire utilising a similar method to the Situation Awareness Global Technique (SAGAT) fits the desired criteria although the crucial difference being that within SAGAT the simulation is frozen randomly but in this study known aspects of play, based on the previous study's findings, are required to precede the suspension of play. However careful appraisal by the team of four co-experimenters suggested that amalgamating the seven categories into four (Table 5.1) would enable clearly recognisable situations during a match which would occur with enough frequency to enable a reasonable sample of game situations to be captured. Once these game simulations are suspended at a pre-determined point participant's SA of surrounding players' locations can be measured.

Hypotheses

Given the soccer ability level of the participants it was expected that that they would have good awareness of other players as they would not fixate on the ball as would lower ability players (Harrison, 2002). The extent to which they would apportion attention to other players was difficult to predict however given the limited previous research. Ward and Williams (2003) have suggested that U17 soccer players were able to identify about 60% of key players in positions to receive a pass. Consequently it was expected that participants would be able to match this performance although simple comparisons are not possible as the determination of key players is likely to be different between studies and, for this study, different between situations as each will be unique. The major difference between Ward and Williams' (2003) study and this one is that here players that need to be identified are not necessarily going to be in positions to receive a pass. Indeed they could be the ball carrier and either team mates or opponents. The extent to which these factors impinge on the importance attached to them and the likelihood of them being attended to are unknown at this time. Clearly, however, players in each experimental trial need to be assessed for importance independently using strict criteria related to the context (which also reflects the SA category). In this way important and unimportant players will be discriminated for each trial although given the novelty of this study prediction related to awareness of these players is difficult. Indeed since soccer is such a fast moving sport it can be hypothesised that players could be important in one instance and not the next and vice versa. Thus it seems unlikely that players would only be aware of important players since an unimportant player is bound to become important at some point and one could thus reason that waiting for that player to become important before being aware of him/her would be implausible. This point seems to raise questions over the whole process of determining importance, something that this study will aim to investigate. The fast evolving situation that characterises soccer however does suggest that a primary goal for some players will be to predict future events e.g. a goalkeeper may need to predict whether the attacker will shoot or dribble? Ward, Williams and Ward (2003) found that defenders could determine the intention of the player in possession of the ball better than attackers, which seems plausible given that the defenders typical role is to mark pass recipients or tackle the ball carrier. Clearly the determination of the ball carrier's (when this is an opponent) next move is a vital task for a defender but an unfamiliar one for an attacker. Since this study involves both attackers and defenders involved in both attacking and defending roles it seems unlikely that these constructs can be rigorously investigated as the data set will be broken down into too many parts. Instead it is hypothesised that awareness of unimportant team mates is easier than unimportant opponents because of the familiarity of playing positions. In other words when directly questioned as to the whereabouts of a team mate the participant could easily consider where the player should be, according to their playing position within the team, and make an educated guess based on this knowledge and previous knowledge ascertained during the game. Important players, on the other hand, are hypothesised to be attended to more than unimportant ones, irrespective of whether they are team mates or opponents. Finally, given that the situations have been selected as potential problem areas for the participant it is thought likely that in some instance at least some important players will not be attended to, and in the most extreme cases this would be the most important player and this lack of SA would have lead to performance error.

4.2 Methodology

This section will be divided into three sub-sections, the first describes the experimental process, the second explains the reliability measures made for all the possible measurement errors within the data collection and the third provides a detailed description of how data was extracted from the study.

4.2.1 Experimental Process

4.2.1.1 Participants

12 University 1st XI and 12 National domestic league Academy players took part in the two six-a-side matches. From within each group four players acted as participants. The University players (mean age = 21.17 years ± 1.92) had on average been participating in competitive soccer for seven years and at the time of testing their training involved a mean of 2.5, two hour sessions as well as 1.75 competitive matches a week. The Academy players who undertook the study (mean age = 18.17 years ± 2.25) had on average been participating in competitive soccer for six years and at the time of testing their training involved a mean of 3.5, two hour training sessions as well as 1.5 competitive matches a week.

4.2.1.2 Apparatus and Materials

The six-a-side matches took place on an outdoor Astroturf playing area, measuring 40 x 20 metres, marked out by cones at each corner and at five metre intervals along each perimeter. Two regulation five-a-side goals were used in normal position. A digital camcorder (Panasonic NV-DS28) was situated in an elevated position behind one of the goals so that the whole of the playing area was visible. Prior to the start of play participants were informed of the nature of the task as per the instructions.

Awareness was assessed by means of a probe technique administered during suspensions of play, which can be seen as a domain adaptation reflecting the principles of the freeze technique utilised within Situation Awareness Global Assessment (SAGAT) (Endsley, 1988). The probe involved collecting information regarding participants' awareness of other players' locations on the pitch. PLATO liquid crystal occlusion spectacles (Milgram, 1987) were worn by one participant at a time to deprive them of visual information the moment play was suspended. A, scaled schematic representation of the playing area was provided to participants on A4 paper (Figure 4.1), to record their responses regarding player locations, and included information regarding their own location at the point of play freezing/being suspended.

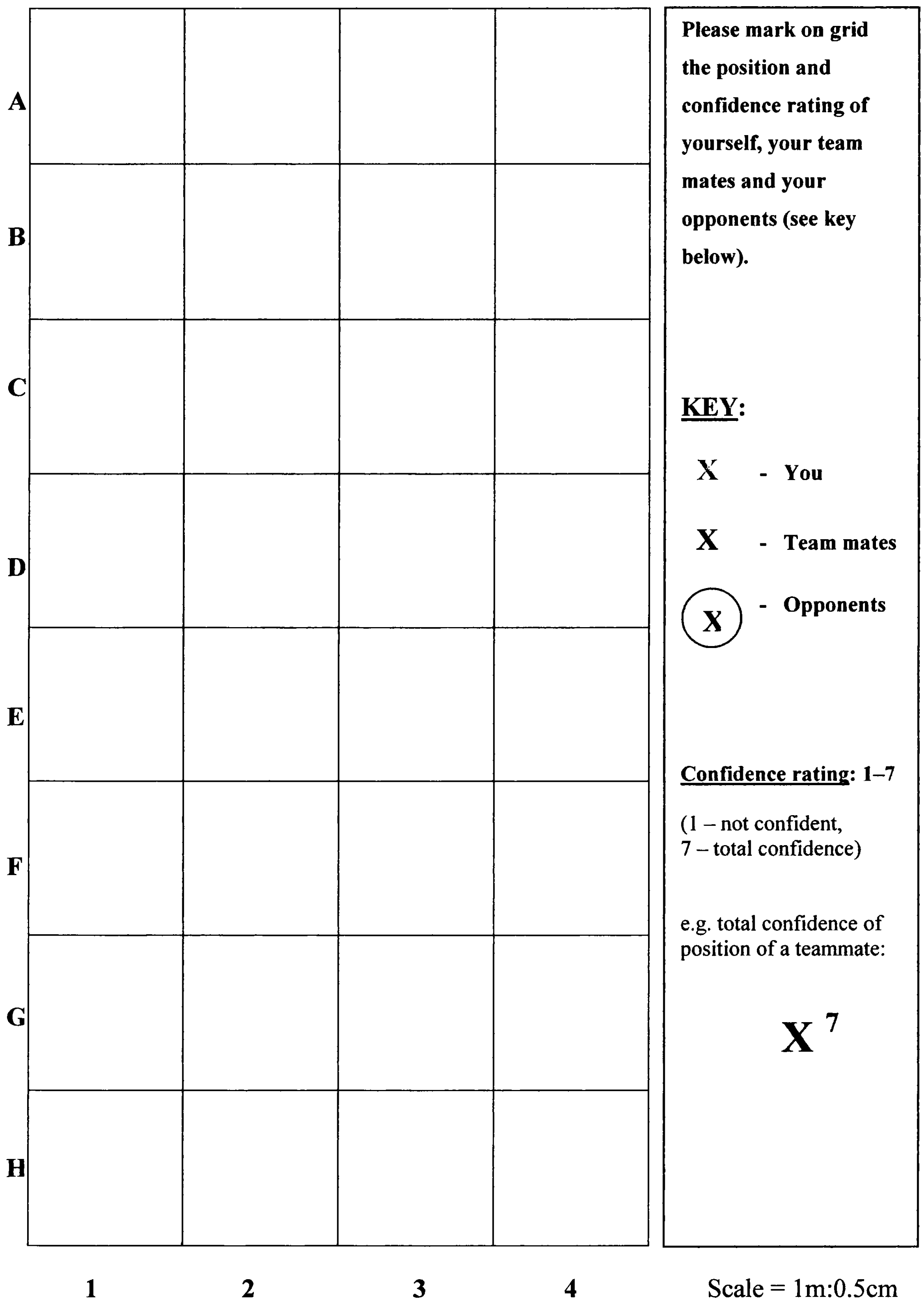


Figure 4.1: Schematic representation of the playing area

4.2.1.3 Design

The participants' SA was analysed through four categories of game situation that had been reduced from the seven regarded as highly reliable within study 2. These previous findings had suggested that a lack of awareness was a potential explanation for mistakes and consequently awareness was thought to be a critical determinant of performance. The seven original categories were amalgamated into four but still shared common task requirements for achieving SA (Table 4.1). This process involved a series of meetings involving the four experimenters and was thought necessary to enable the data collection to take place given the hypothesised frequency of occurrence of the four categories during competitive soccer.

Table 4.1: Definitions of New SA Categories

Category	Definition
New Category 1	Awareness of opponents behind, this involves the possibility of the participant being dispossessed by an opponent from behind in any situation. Play is thus suspended when the participant has possession of the ball and an opponent is behind them such that a challenge is possible.
Incorporating	Original Category 3 – 'Receiving pass, turning and being dispossessed by opponent behind' Original Category 4 – 'Receiving ball and being dispossessed by opponent chasing back' Original Category 5 – 'Receiving pass, controlling ball, avoiding one opponent and being dispossessed by a second opponent' Original Category 7 – 'Dribbling at speed and being dispossessed from behind by opponent chasing back
New Category 2	Awareness of team mates to pass to, this involves the possibility of the participant misplacing a pass in open play. Play is thus suspended when the participant has possession of the ball and is likely to attempt a pass.
Incorporating	Original Category 2 – 'Receiving pass and misplacing subsequent pass'
New Category 3	Awareness of opponents, the participant does not have possession of the ball but is the potential recipient of a pass which could be intercepted (from any direction) by an opponent. Play is suspended when the participant is in a position to receive a pass from a team mate.
Incorporating	Original Category 6 – 'Waiting to receive pass which is intercepted'
New Category 4	Awareness of opponents/team mates when defending, participant is in a defensive position without possession of the ball and the possibility exists that he is unaware of the location of important opponents and team mates possibly due to ball watching .Play is thus suspended when the participant is in a defensive situation without possession of the ball.
Incorporating	Original Category 9 – 'Failing to mark attackers in and around the penalty area'

4.2.1.4 Procedure

On arrival at the playing area all players completed consent forms for the study (Appendix 2). A senior researcher then explained the study instructions (Figure 4.2) before all players were given the opportunity to ask any questions that might need clarification. The players were split into two teams (each team wore different coloured bibs) of six and instructed to play as if in a normal game situation within a formation consisting of one goalkeeper, two defenders, two midfielders and one attacker, with each player taking up as familiar a position as possible.

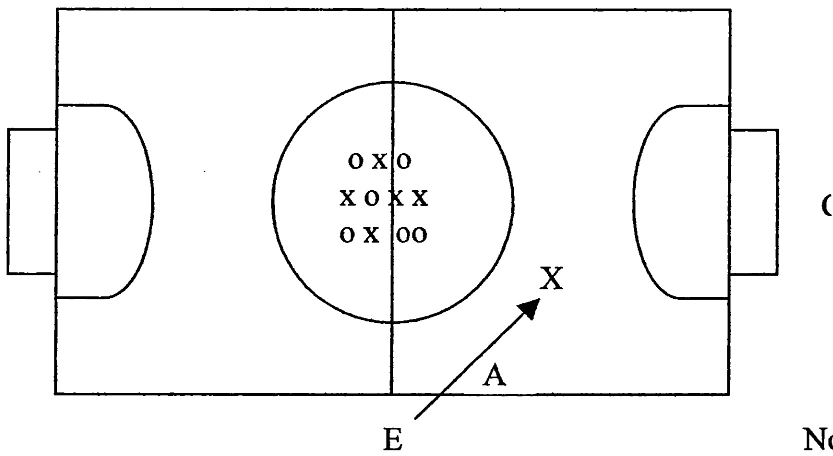
- The study has been developed in order to analyse certain aspects of a football player's behaviour in a match situation. The game will be played within the cones and normal football rules apply.
- We would like you all to play as if in a normal game situation with a formation consisting of 1 goalkeeper, 2 defenders, 2 midfielders and 1 attacker, each of you playing in as familiar a position as possible.
- Subject 1 has got the spectacles on which will be shut in conjunction with the whistle.
- Could you all remain still for 2-3 seconds when you hear the whistle and then move towards the centre circle.
- Also on the whistle could you all remain in silence until everyone is gathered in the centre circle.
- The player with the glasses on will then be presented with the attached sheet and asked to identify the location of as many team mates and opponents as possible at the moment the glasses were shut, using the key provided.
- As well as marking the positions of the other players, a confidence rating is also required for each player. Please indicate this confidence rating by writing a number between 1 and 7 (1 – not confident, 7 – total confidence) next to each of the corresponding markings.

Figure 4.2: Example of study instructions sheet provided to participants

The participants' coach led a brief warm up session and prior to play commencing. One player was then selected to wear the liquid crystal occlusion spectacles which were fitted by a researcher, and the blackout procedure demonstrated to the participant. This involved the spectacles being turned opaque via a remote control mechanism thus totally obscuring the participants' vision. The participant was allowed to ask any questions and an experimenter checked they were happy to continue play with the spectacles on. Play then started in a normal manner, on the instruction of an experimenter.

Play was suspended by an experimenter when it met the criteria for one of four category conditions. For example, when the participant was in a position to be the recipient of a pass from a team mate play could be suspended and category 3 analysed. This process involved the experimenter blowing a whistle while simultaneously lowering a raised arm to allow the point to be recorded on the overview video footage. On the sound of the whistle the liquid crystal occlusion spectacles were simultaneously blacked out by the experimenter via the remote control.

At the time play was suspended all players except the participant moved to the centre of the playing area. The participant, wearing the spectacles, stood standstill in the same location waiting for the experimenter to arrive (Figure 4.3). The experimenter moved hastily towards the participant in order to collect data (as indicated by arrow A in Figure 4.3). The spectacles were removed and the participant was presented with a grid representing the playing area (Figure 4.1) upon which the experimenter had estimated the participant's location at the point play was suspended (approximately the position in which they were currently standing). The participant was then instructed (Appendix 3) to mark on the grid estimates of the locations of all other players (team mates and opponents, excluding the two goalkeepers) that he could at the time play had been suspended. As well as this a confidence level was required, on a scale of 1-7 (1 = not at all confident, 7 = very confident) relating to each player location estimate. Once the participant was content with the markings made all players resumed their starting positions, the participant resumed wearing the spectacles and play recommenced on the instruction of the experimenter. This procedure was repeated for each participant until they had provided data for each of the four categories.



Not to scale

o = Opponents

x = Team mates

E = Experimenter

X = Participant

C = Position of Video Camera

Figure 4.3: Example of data collection procedure

4.2.1.5 Video Editing

A Panasonic NV-DS28 digital camcorder recorded the play from an elevated stationary position behind one of the goals which afforded a view of the whole of the playing area. The initial video footage was edited in Adobe Premiere v6.0 into segments that contained a few seconds before and after the time when play was suspended, highlighted by the point at which the experimenters arm was lowered. These clips were then exported to Commotion Pro v4.0 for a grid to be drawn over the playing area (using the 'AutoPaint' function) by joining up the cones situated at five metre intervals around the perimeter such that 32 five metre square grids were created (as seen in Figure 4.4). This grid was then used to aid the experimenter in measuring the location of each player at the time when play was suspended. The player location measurements were subsequently used as the basis for judging the accuracy of the participants' estimates of player location. Given the methods used to collect these estimates of player location it was recognised that both estimates (experimenter and participant) were subject to varying degrees of error depending on where on the pitch the player was located. Consequently assessment of this error was necessary.

Figure 4.4: Image of grid created in Commotion Pro v4.0

4.2.2 Determination of error associated with player location

The experimenter and participant derived player location estimates were subjected to error assessments appropriate to the different data collection methods.

4.2.2.1 Experimenter error

In order to test the accuracy of the experimenter in assessing player location a soccer player was instructed to move around the playing area used in the experiment (with cones in place) stopping at random locations with one hand in the air. At this point the x and y coordinates were directly measured by means of a tape measurement to the nearest side line (rounded to the nearest 0.1m). This measure was subsequently compared against the experimenter's assessment of each player location undertaken in the same way as during the actual experiment i.e. from the video with grid superimposed, as described in section 4.2.1.5. This process was repeated 128 times ensuring that all grids had been assessed four times so that mean errors for the experimenter in each five metre² section of the playing area could be calculated (Table 4.2). As expected errors tended to be greater when player location estimates were made in the grids furthest from the camera (row A) as the image view afforded the experimenter became progressively smaller. The errors, ranging from 0.15m in row A to 0.38m in row H, were subsequently used when calculating participant accuracy.

Table 4.2: Experimenter errors by grid position (metres)

Errors made in Rows/Grids	N	Minimum	Maximum	Mean	Std. Dev
A1	4	.10	.70	.36	.18
A2	4	.10	.80	.38	.21
A3	4	.20	.70	.33	.17
A4	4	.20	.60	.35	.14
B1	4	.20	.60	.34	.14
B2	4	.10	.70	.34	.19
B3	4	.10	.60	.33	.17
B4	4	.00	.70	.36	.20
C1	4	.10	.50	.28	.13
C2	4	.10	.60	.29	.16
C3	4	.10	.50	.26	.14
C4	4	.10	.70	.29	.20
D1	4	.10	.40	.26	.11
D2	4	.10	.60	.28	.15
D3	4	.10	.40	.23	.13
D4	4	.10	.60	.25	.16
E1	4	.10	.40	.25	.09
E2	4	.10	.40	.28	.09
E3	4	.10	.50	.25	.12
E4	4	.10	.50	.23	.14
F1	4	.10	.30	.23	.09
F2	4	.10	.40	.24	.11
F3	4	.10	.30	.21	.08
F4	4	.10	.40	.23	.10
G1	4	.00	.30	.19	.11
G2	4	.00	.30	.16	.11
G3	4	.00	.30	.18	.10
G4	4	.00	.30	.18	.10
H1	4	.00	.30	.18	.10
H2	4	.00	.30	.16	.12
H3	4	.00	.30	.15	.09
H4	4	.00	.30	.16	.12

4.2.2.2 Participant error

When participants made player location estimates they used a schematic of the pitch to record their estimations. This process was likely to introduce error in two ways. Firstly the experimenter had put a cross on the schematic to indicate where the participant was located. This was not a precise process and as such subject to error, referred to as participant location error. Secondly the task of indicating players' locations on a schematic is not a familiar one and as such the possibility exists of participants' knowledge of player location not being accurately reflected by their indications on the schematic, referred to as participant error.

Participant location error was determined by calculating the distance (using Pythagoras' theorem) between where the experimenter had put the cross on the schematic and the experimenter's assessment of the participant location using the grid superimposed on the video.

Participant error was calculated by having two soccer players stand in random areas of the pitch, one of them then used the schematic (as in Figure 4.1) to indicate where he thought the other player was located whilst his exact location was measured using a tape measure as previously. This was repeated so that all 32 grid positions were attempted four times from each grid (4096 measurements). Errors tended to be less than 0.5m (Table 4.3 gives the errors from grid D3 as an example).

Table 4.3: Participant errors from position D3 by grid position (metres)

Error made when marking from D3 to...	N	Minimum	Maximum	Mean	Std. Deviation
H1	4	.20	.50	.35	.13
H2	4	.30	.40	.35	.06
H3	4	.20	.40	.33	.10
H4	4	.20	.40	.28	.10
G1	4	.20	.40	.33	.10
G2	4	.20	.40	.30	.08
G3	4	.20	.40	.30	.08
G4	4	.20	.40	.28	.10
F1	4	.20	.40	.33	.10
F2	4	.20	.40	.28	.10
F3	4	.10	.30	.23	.10
F4	4	.20	.30	.23	.05
E1	4	.10	.30	.23	.10
E2	4	.10	.30	.20	.08
E3	4	.10	.30	.18	.10
E4	4	.10	.30	.20	.08
D1	4	.10	.20	.15	.06
D2	4	.00	.30	.15	.13
D3	4	.10	.20	.13	.05
D4	4	.00	.20	.13	.10
C1	4	.20	.20	.20	.00
C2	4	.10	.30	.18	.10
C3	4	.10	.20	.15	.06
C4	4	.10	.30	.20	.08
B1	4	.20	.40	.28	.10
B2	4	.20	.30	.25	.06
B3	4	.10	.30	.23	.10
B4	4	.20	.30	.25	.06
A1	4	.20	.40	.33	.10
A2	4	.20	.40	.30	.08
A3	4	.20	.30	.28	.05
A4	4	.20	.40	.28	.10

4.2.3 Data Extraction and Analysis

In order to calculate the participants' accuracy in locating players the two assessments for each player location (participant and experimenter) had to be compared taking into consideration the amount of error associated with each assessment. Consequently the distance (d_1) between the two estimates was initially calculated using Pythagoras' Theorem (as in Figure 4.5) before the participant and experimenter errors (each represented by the radius of the circle and dependant on the location of the participant and the player being located, as explained above) were subtracted. To simplify this process lookup tables were created in a Microsoft Excel spreadsheet so that the correct error values were used to correspond with the location of the participant and the player whose location was being estimated.

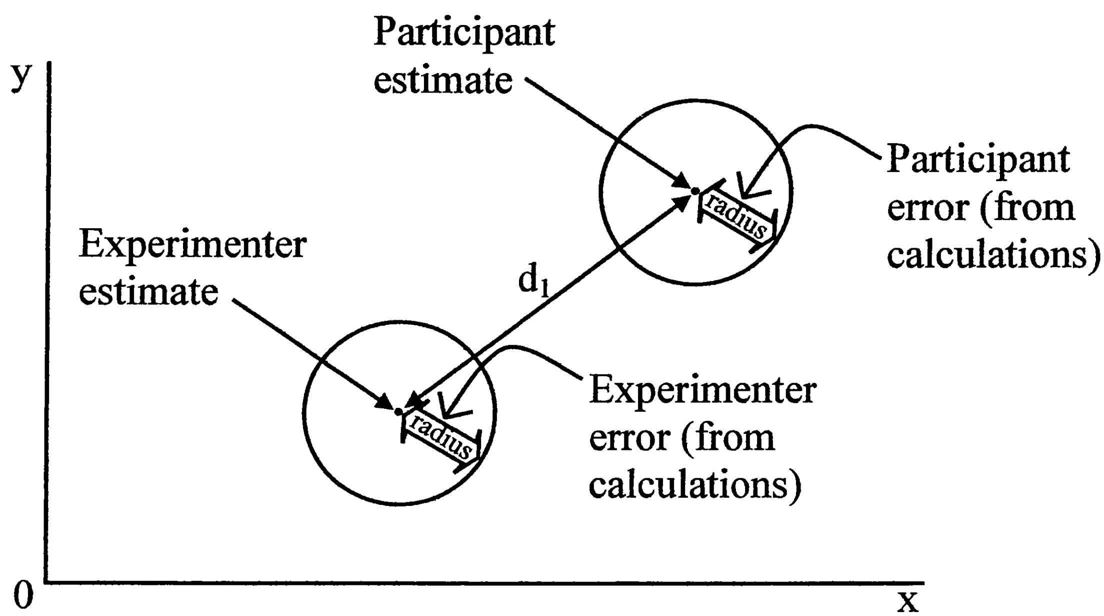


Figure 4.5: Schematic representation of participant and experimenter assessments of player location

Finally the participant location error was subtracted which resulted in the final accuracy score for that particular estimate of player location where the lower the value the more accurate the estimate. Accuracy scores could take negative values, when the combined error values were larger than the distance between the participant and experimenter estimates of player location. In this scenario the participant's estimate was taken to be very accurate.

4.3 Results

An independent samples t-test showed that the University and Academy players made similar numbers of player location estimations ($t = -0.61$, $df = 6$, $p = 0.56$) averaging 5.47 ($SD = 1.29$) estimations per trial, equating to 60.78% of the players on the pitch ($n=9$). Furthermore, these location estimations did not differ significantly in accuracy between the University and Academy players ($t = 0.18$, $df = 149.64$, $p = 0.86$) with an average error of 1.54m ($SD = 2.42$). Given these non-significant findings further analysis was undertaken on more fine grained measures related to individual players to assess any between group and between SA category differences.

The video clips of all 32 trials were assessed by three independent raters who judged the importance of each player (team mates and opponents) at the time when play was suspended; this judgement was dependent on the SA category the trial belonged to as individual player importance varied as a function of category.

Clips were defined as SA category 1 when the participant had possession of the ball at the moment play was suspended and the possibility existed for him being dispossessed by an opponent located behind him. Players were ranked in terms of importance using the criteria in Table 4.4 but if they did not match any of the criteria they were not ranked.

Table 4.4: Criteria for categorisation of important players within SA category 1 – 'awareness of opponents behind'

Player	Ranking order and criteria
Team mates	1. Was able to receive a pass; ranked from most to least tactically sound
Opponents	1. Was in position to dispossess participant from behind; ranked from most to least threatening 2. Was in position to intercept an attempted pass by the participant; ranked from most to least likely to intercept the most tactically sound pass and then any other subsequent passes

SA category 2 clips again involved the participant being in possession of the ball as play was suspended but in this instance there was the possibility of misplacing a pass. Players were again ranked in terms of importance (Table 4.5) and not ranked if they did not match the criteria.

Table 4.5: Criteria for categorisation of important players within SA category 2 – 'awareness of team mates to pass to'

Player	Ranking order and criteria
Team mates	1. In position to receive a pass from the participant; ranked from most to least tactically sound
Opponents	1. Was in position to dispossess the participant; ranked from most to least threatening 2. Was in position to intercept an attempted pass by the participant; ranked from most to least likely to intercept the most tactically sound pass and then any other subsequent passes

Table 4.6 contains the ranking criteria for clips relating to SA category 3. These involved the participant not having possession of the ball as play was suspended, but at this point the participant was in position to be the likely recipient of a pass which an opponent could have intercepted.

Table 4.6: Criteria for categorisation of important players within SA category 3 – 'awareness of opponents'

Player	Ranking order and criteria
Team mates	1. In possession of the ball 2. Was also in position to receive a pass from the team mate in possession, ranked from most to least tactically sound
Opponents	1. Was in position to intercept an attempted pass aimed towards the participant, ranked from the most to least likely to intercept the pass

SA category 4 clips involved play being suspended when the participant was in a defensive position without possession of the ball. These situations were selected when the experimenter thought there was a possibility of the participant being unaware of the location of important opponents and/or team mates possibly as a consequence of ball watching. Players were again ranked in terms of importance (Table 4.7) and not ranked if they failed to match the criteria.

Table 4.7: Criteria for categorisation of important players within SA category 4 – 'awareness of opponents/team mates when defending'

Player	Ranking order and criteria
Team mates	1. Defending against opponents directly involved in the play; ranked from most affecting participant's role to not affecting participant's role
Opponents	1. Was in a tactically significant position; ranked from most (likely to contribute to a goal scoring situation) to least (supporting role and unlikely to threaten goal)

A rank order of importance for all players involved in each of the 32 trials was finalised after differences in the raters' opinions had been resolved through discussion. Since the raters deemed some players unimportant to the situation at the moment play was suspended it was necessary to assess whether the different SA categories had different task requirements i.e. the number of important players to be marked, as future between category differences may simply be a consequence of this differential. A one way ANOVA suggested this was not the case as there was no significant difference in the number of important players ($F = 2.52$, $df = 3, 28$, $p = 0.18$) between the four SA categories (Table 4.8).

Table 4.8: Number of players deemed important by raters within each category

	Category 1	Category 2	Category 3	Category 4	Sum
Mean	4.38	4.75	4.00	3.50	4.16
Std. Deviation	1.30	0.89	0.76	0.76	1.02

Participants' responses of player location were consequently assessed for frequency and accuracy in accordance with the raters' judgements of player importance. Consequently two separate analyses were conducted i.e. important and unimportant players (those not deemed important by the raters). Since the raters had identified slightly different numbers of important players between the four SA categories, both frequency counts for participant responses (important and unimportant players) were converted to proportions (of the total number of important or unimportant players for each SA category) to enable comparison between categories. All analyses were undertaken using three way ANOVA's (appendix 4) with playing standard (University and Academy) the between subjects variable and repeated measures on player type (team mates and opposition) and SA category (1 – 4).

4.3.1 Proportion of players marked according to raters' estimation of importance

4.3.1.1 Important players

There was no significant three–way interaction ($p = 0.60$) for the proportion of important players marked by participants (Table 4.9). Of the two way interactions only playing standard and category nearly reached significance ($F = 2.83$, $df = 3, 18$, $p = 0.07$). Simple main effects analysis suggested that the University and Academy players were most different in their ability to indicate important players on SA category 3 'awareness of opponents' although this was not significant ($F = 4.38$, $df = 1, 6$, $p = 0.08$). The main effects of playing standard ($F = 0.62$, $df = 1, 6$, $p = 0.46$), SA category ($F = 2.12$, $df = 3, 18$, $p = 0.13$) and player type ($F = 3.82$, $df = 1, 6$, $p = 0.10$) were also not significant.

Overall participants were aware of approximately three quarters (overall $M = 0.74$, $SD = 0.17$) of the other players who had been deemed important by the raters (overall $M = 4.16$ out of 9, $SD = 1.02$, Table 4.8) for all SA categories.

Table 4.9: Proportion of important players identified within each category by University and Academy players

			Cat 1	Cat 2	Cat 3	Cat 4
University	Team mate	mean	0.88	0.50	0.75	1.00
		SD	*0.25*	*0.00*	*0.29*	*0.00*
	Opposition	mean	0.92	0.71	0.61	0.79
		SD	*0.17*	*0.34*	*0.13*	*0.25*
Academy	Team mate	mean	0.67	0.88	1.00	1.00
		SD	*0.24*	*0.25*	*0.00*	*0.00*
	Opposition	mean	0.75	0.71	0.79	0.79
		SD	*0.32*	*0.34*	*0.25*	*0.25*

4.3.1.2 Unimportant players

The raters deemed 4.84 (SD = 1.02) players on average to be unimportant at the time play was suspended. There was no significant three–way interaction ($p = 0.94$) for the proportion of unimportant players marked by participants (Table 4.10). Of the two way interactions player type and category ($F = 1.78$, $df = 3, 18$, $p = 0.19$) and playing standard and player type ($F = 4.55$, $df = 1, 6$, $p = 0.08$) nearly reached significance. Simple main effects analysis suggested that the University and Academy players were most different in their ability to indicate unimportant opponents although this was not significant ($F = 5.38$, $df = 1, 6$, $p = 0.06$). A significant main effect for player type ($F = 9.76$, $df = 1, 6$, $p < 0.05$) was found where unimportant team mates were marked more (M = 0.55, SD = 0.31) than opponents (M = 0.38, SD = 0.27). Playing standard ($F = 1.00$, $df = 1, 6$, $p = 0.36$) and SA category ($F = 0.95$, $df = 3, 18$, $p = 0.44$) were not significant.

Table 4.10: Proportion of unimportant players identified within each category by University and Academy players

			Cat 1	Cat 2	Cat 3	Cat 4
University	Team mate	mean	0.63	0.58	0.46	0.59
		SD	*0.48*	*0.50*	*0.32*	*0.17*
	Opposition	mean	0.54	0.42	0.63	0.46
		SD	*0.32*	*0.29*	*0.29*	*0.16*
Academy	Team mate	mean	0.71	0.50	0.46	0.46
		SD	*0.34*	*0.41*	*0.09*	*0.09*
	Opposition	mean	0.33	0.17	0.33	0.17
		SD	*0.24*	*0.19*	*0.27*	*0.19*

4.3.2 Accuracy of players marked according to raters' estimation of importance

4.3.2.1 Important players

There was no significant three–way interaction ($p = 0.16$) for the error distances for important players marked by participants (Table 4.11). Of the two way interactions playing standard and player type ($F = 1.61$, $df = 1, 6$, $p = 0.25$) and SA category and player type ($F = 2.13$, $df = 3, 18$, $p = 0.13$) were approaching significance. The main effects of playing standard ($F = 0.09$, $df = 1, 6$, $p = 0.78$) and SA category ($F = 1.77$, $df = 3, 18$, $p = 0.19$) were not significant but player type was significantly different ($F = 8.78$, $df = 1, 6$, $p < 0.05$) with participants' mean error of 2.13m (SD = 2.62) when marking team mates compared to 0.94m (SD = 1.47) when marking opponents.

Simple main affects analysis for the SA category and player type interaction suggested the main reason for the significant main effect of player type was the significant difference in errors for team mates and opponents for SA category 1 ($F = 6.20$, $df = 1, 6$, $p < 0.05$; Table 4.11).

Table 4.11: Error distances for marking important players identified within each category by University and Academy players

			Cat 1	Cat 2	Cat 3	Cat 4
University	Team mate	mean	1.48	2.86	0.58	2.00
		SD	*0.85*	*3.48*	*1.16*	*1.03*
	Opposition	mean	1.08	0.73	1.21	1.18
		SD	*1.11*	*1.07*	*1.75*	*1.41*
Academy	Team mate	mean	4.00	2.69	0.25	3.20
		SD	*4.10*	*3.39*	*2.20*	*2.58*
	Opposition	mean	-0.10	1.76	0.17	1.49
		SD	*1.02*	*1.55*	*2.53*	*1.04*

4.3.2.2 Unimportant players

There was no significant three–way interaction (p = 0.38) for the error distances for unimportant players marked by participants (Table 4.12) and none of the two way interactions approached significance. The main effects of playing standard (F = 0.56, df = 1, 6, p = 0.48), SA category (F = 0.75, df = 3, 18, p = 0.54) and player type (F = 2.23, df = 1, 6, p = 0.19) were not significant. Overall this meant that the average error associated with marking unimportant team mates was 2.28m (SD = 1.95) compared to 1.46m (SD = 1.98) for opponents (Table 4.12).

Table 4.12: Error distances for marking unimportant players identified within each category by University and Academy players.

			Cat 1	Cat 2	Cat 3	Cat 4
University	Team mate	mean	3.88	1.81	1.46	2.12
		SD	*1.97*	*2.41*	*1.32*	*0.42*
	Opposition	mean	2.72	0.97	2.23	1.28
		SD	*3.20*	*1.36*	*3.14*	*1.30*
Academy	Team mate	mean	1.92	2.12	2.00	2.91
		SD	*2.76*	*0.20*	*3.42*	*1.67*
	Opposition	mean	1.17	1.24	-0.28	2.33
		SD	*1.52*	*1.49*	*1.74*	*0.88*

4.3.3 Confidence of the participants regarding the accuracy of player location estimates

4.3.3.1 Important players

There was no significant three–way interaction ($p = 0.42$) for the confidence ratings for marking important players by participants (Table 4.13). The two way interactions playing standard and player type ($F = 3.70$, $df = 1, 6$, $p = 0.10$), SA category and player type ($F = 2.14$, $df = 3, 18$, $p = 0.13$) and SA category and playing standard ($F = 1.75$, $df = 3, 18$, $p = 0.19$) were all close to significance. None of the main effects i.e. playing standard ($F = 0.36$, $df = 1, 6$, $p = 0.57$), SA category ($F = 0.95$, $df = 3, 18$, $p = 0.44$) and player type ($F = 2.52$, $df = 1, 6$, $p = 0.16$) were significantly different. On average participants rated their confidence as 5.12 on a 7 pt Likert scale ($SD = 1.54$) for the accuracy of their important player location estimates (Table 4.13).

Table 4.13: Confidence for marking important players identified within each category by University and Academy players

			Cat 1	Cat 2	Cat 3	Cat 4
University	Team mate	mean	4.92	3.00	5.50	3.75
		SD	*1.71*	*2.16*	*2.38*	*2.06*
	Opposition	mean	5.38	5.38	5.71	5.50
		SD	*0.48*	*1.70*	*1.53*	*1.22*
Academy	Team mate	mean	5.00	5.63	5.63	5.38
		SD	*1.83*	*1.25*	*1.11*	*1.18*
	Opposition	mean	4.42	5.38	5.38	6.00
		SD	*0.80*	*1.49*	*1.25*	*1.15*

4.3.3.2 Unimportant players

There was no significant three–way interaction (p = 0.25) for the confidence ratings for marking unimportant players by participants (Table 4.14) and none of the two way interactions approached significance. The main effects of playing standard (F = 2.89, df = 1, 6, p = 0.14), SA category (F = 1.59, df = 3, 18, p = 0.23) and player type (F = 2.76, df = 1, 6, p = 0.15) were not significant. Overall this meant that the confidence averaged 4.06 on a 7 pt Likert scale (SD = 1.12) for the accuracy of the participants' unimportant player location estimates (Table 4.14).

Table 4.14: Confidence for marking unimportant players identified within each category by University and Academy players

			Cat 1	Cat 2	Cat 3	Cat 4
University	Team mate	mean	2.39	4.17	3.00	3.88
		SD	*0.64*	*1.65*	*1.22*	*1.44*
	Opposition	mean	3.38	4.00	4.63	4.88
		SD	*1.11*	*0.82*	*1.25*	*1.31*
Academy	Team mate	mean	5.00	4.50	3.92	4.00
		SD	*2.31*	*0.71*	*0.83*	*1.83*
	Opposition	mean	3.88	4.50	4.00	5.50
		SD	*0.85*	*0.41*	*0.82*	*0.41*

4.3.4 Relationship between participants' confidence and accuracy for player location estimates

Correlation coefficients were calculated for important and unimportant players for each of the four SA categories. Coefficients ranged from -0.11 to 0.09 for important team mates and -0.32 to 0.23 for important opponents. Similarly coefficients ranged from -0.20 to 0.14 for unimportant team mates and -0.41 to 0.69 for unimportant opponents although these were based on smaller sample sizes.

4.4 Discussion

Up until now it appears that the literature related to soccer performance has not assessed player's awareness of their team mates and opponents in a realistic match situation. Clearly this has been as a result of technological limitations. However this study developed a novel measurement technique to assess soccer players' awareness of other player's locations when play was suspended using liquid crystal occlusion spectacles to prevent vision. The timing of the cessation of play was based on a previous study (study 2) that had identified situations where player's awareness was thought to be problematical. Consequently all participant performances should be viewed as indicative of these situations and not necessarily representative of other situations. A six-a-side game on a reduced size playing area was used to simulate normal eleven-a-side conditions but clearly the condensed playing area and smaller number of players makes inferential statements regarding soccer player abilities during actual matches problematical. The participants, University and Academy players, were found to be similar in respect to the number of player location estimates they made (mean = 5.47, SD = 1.29) with no significant difference in the accuracy of these estimations. This suggested that these two groups of players were not too dissimilar in terms of ability and soccer knowledge and post-experiment enquiries revealed that the majority of players from both groups are now playing in the semi-professional Welsh Premier League. As such the performance of the participants should be viewed as indicative of sub-elite performance and clearly above novice. Furthermore whilst participants in this study were able to estimate 60.78% of the other players (n=9) on the pitch it should be noted that it is impossible to say how this translates to performance during a full game situation. Potentially this proportionate rate could be replicated i.e. 11.55 players (out of a possible 19) could be achievable but conversely the actual number of players reported in this study could be the limit for this standard of player. Clearly future research is needed to determine this.

In line with previous research more fine grained measures of participants' awareness were made. Firstly a critical feature of awareness, according to Patrick and James (2004), is how a quickly evolving situation, like soccer, means that the task requirements for achieving SA also change rapidly. Consequently analyses compared participants' performances between the four SA categories. However, even this demarcation is liable to problems as it was impossible to stop play in identical situations for all players. Indeed even if two situations were almost identical a matter of a second or perhaps less in the timing of the cessation of play could have made a big difference in the SA demands placed on the participant. Consequently within category differences were deemed to be highly likely and potentially problematical with regards to experimental findings.

A second consideration was the way in which players allocate attention with regards to importance. Helsen and Pauwels (1993) found that expert and novice soccer players could be differentiated by whether they tended to focus on opponents, attackers, areas of free space, the goal and the ball itself. Clearly this study suggested that expert players are able to distinguish between important and unimportant events better than novice players. A panel of three independent raters thus judged the importance of each player in all of the experimental scenarios to enable analyses of important and unimportant team mates and opponents. Participants were typically aware of approximately three quarters of the players the raters identified as being important with no significant difference between performances for each SA category. This is slightly better than the U17 elite and sub-elite players in Ward and Williams' (2003) study found. These participants were able to identify about 60% of key players in positions to receive a pass in a 11v11 film occlusion task although no information was given regarding how many key players were identified by the panel of expert coaches. The University and Academy players differed most on SA category 3 which was the situation when the participant was in the best position to receive a pass from a team mate and thought to be problematical for awareness of opponents. Overall the differences ranged from 50% of players estimated (University players' awareness of important team mates for SA category 2) to 100% (University and Academy players' awareness of important team mates for SA category 4 and Academy players' awareness of important team mates for SA category 3). Clearly SA category and whether the player was a team mate or opponent had an influence on participants' ability to estimate their location although these differences were not statistically significant. It would seem therefore that the participants were able to monitor the important players reasonably well, although less than 100% performance could have serious consequences, particularly close to goal.

Ward and Williams (2003) suggested that expert soccer players attach a probability hierarchy to key players by using their level of threat as an index of attention allocation. Level of threat in this context presumably relates to both team mates and opponents which supports the above findings. However no attempt has been made to discriminate between team mates and opponents. Could it be that players typically allocate more attention to opponents than team mates? Helsen and Pauwels (1993) found that elite level soccer players were able to derive information from the opposition sweepers' position unlike novices who fixated more on their team mates' positions, the goal and the ball. When the distance errors for important player location estimates were examined a significant difference was found between team mates 2.13m (SD = 2.62) and opponents 0.94m (SD = 1.47) suggesting that in the experimental situations participants did allocate more attention to opponents. A close look at the data suggests that the Academy players were more likely to exhibit this difference although the University players also did on SA categories 2 and 4. One explanation for this is that players become accustomed to where their team mates are located, given the propensity of players to adhere to their position within the team formation and the familiarisation between players that results from playing together over time, hence less attention is afforded them. However, in some situations it may be more important to be aware of the precise location of an opponent particularly when this player is in a position to intercept the ball or tackle the player. Clearly more research is needed to test these hypotheses.

Since soccer players can seemingly discriminate the importance of other players on the pitch the question arises as to whether awareness of unimportant players is required. Indeed if players are unimportant then why would awareness of them be necessary? One argument, concerning the rapidly changing dynamic nature of soccer, means that players who are unimportant in one moment could very easily become important in the next. Similarly an important player could very quickly become unimportant and it would be unlikely that memory of that player would suddenly cease just because the player became unimportant. In the Ward and Williams (2003) study participants had to identify players in terms of their perceived attacking importance and were thus considered incorrect if non-key players were identified. This form of assessment is very reliant on the raters agreeing on who is deemed important at the time the play was suspended. Indeed, if a consensus opinion had been formed then a participant could have identified a player that one of the 'expert' coaches had thought important but still be incorrect. When the independent raters in this study made judgements regarding importance there was certainly a great deal of debate and a decision was made that identifying a seemingly unimportant player was not deemed incorrect but it was hypothesised that fewer unimportant players would be identified because of the likely allocation of attention to important players previously mentioned. The three independent raters on average deemed 4.84 (SD = 1.02) players unimportant compared to 4.16 (SD = 1.02) important which signifies that participants had similar task demands in terms of important and unimportant players during all game situations. However participants indicated a lower proportionate number of unimportant players (M = 0.49, SD = 0.22) compared to important (M = 0.74, SD = 0.17) thus supporting the contention that participants were able to allocate attention according to player importance. The confidence ratings for these judgements were similar although slightly lower for unimportant players (M = 4.06 on a 7 pt Likert scale, SD = 1.12) compared to important ones (M = 5.12, SD = 1.54). Looking more closely at the unimportant players participants identified significantly more of the team mates (M = 0.55, SD = 0.31) than opponents (M = 0.38, SD = 0.27) but the average error associated with marking these unimportant opponents (M = 1.46m, SD = 1.98) was less, although not significantly, than for the team mates (M = 2.28m, SD = 1.95). This is quite an interesting finding as the lower error for the opponents is suggestive that more attention was allocated to the opponents compared to the team mates, as found for the important players, but a significantly greater number of team mates were located. One explanation for this is that team mate locations are well known even when attention is not directed at them as a consequence of the team's playing style and use of set player formations, which are well known to the players. Putting this into context it would seem that participants were able to allocate more attention to players deemed important than those who were unimportant but they also used any spare attentional capacity to possibly monitor unimportant opponents in favour of unimportant team mates whose locations could be approximated due to their playing position.

In conclusion it seems that this study has allowed an assessment of a soccer player's awareness (SA) in a realistic setting. The findings suggest that players are able, at least at higher levels of skill, to allocate attention to certain players and not others based on sophisticated game related knowledge. In particular, a player's attentional focus is mainly allocated to the most important players irrespective of whether they are team mates or opponents although some bias toward attending to important opponents over important team mates was evident based on the marking error. Soccer players are also likely to-be aware of some unimportant players; with significantly more team mates identified than opponents although tentative evidence regarding marking error again suggested more attention being allocated to the opponents. This is only feasible if team formation and familiarisation between players on the same side allows players to have a general awareness of their team mates and thus allow them to attend to opponents more closely. The relative importance of opponents' and team mates' positions may therefore not be the sole determination of attention allocation. This in not too surprising if one considers soccer as a rapidly changing environment where players move in and out of importance rapidly. Some caution is required regarding the above conclusions given that only four situations were sampled and therefore only a small snapshot of the awareness capabilities of a soccer player has been tested. The situations used in this study were hand picked as being likely for SA to be poor and so these results may be indicative of relatively low awareness although since play was suspended before a mistake could be made it is not possible to ascertain this. This caveat concurs with Patrick and James' (2004) warning that SA should be studied from a task-orientated approach encompassing the diversity of the soccer environment since the constantly changing situation will affect a person's means of achieving SA. Future studies need to address this by sampling a wider range of situations.

Chapter 5: General Discussion

Since there has been little mention in the sports psychology literature relating SA to sport, especially soccer, this thesis aimed to utilise novel techniques in order to discover whether this concept could be seen as a cause of errors made by soccer players. Video clip examples of nine different game situations were assessed by a panel of expert raters and agreement was sought that player error was due to SA deficiencies. This was found for seven of the nine game situations, which in terms of positive practical applications now gives soccer coaches and players at least seven areas within which they know performance may possibly be affected by deficiencies in awareness. Consequently, their training and strategy may have to be altered from time to time. Although it was also important to point out that these situations were not exhaustive of all areas where SA may be a problem in soccer. One goal for future research, therefore, is to investigate further situations within competitive soccer, and other sports for that matter, that may pose particular problems to players regarding SA.

Having identified some situations where soccer players' SA was problematical it was then necessary to attempt to measure SA in these situations. It was first realised that the seven categories needed to be merged into four new novel ones to facilitate the data collection phase. This simply meant that it was more likely that a particular category would occur during a match because the category descriptors were not so precise. The categories were defined by their common task requirements necessary to achieve good SA as suggested by Patrick and James (2004). However, in any rapidly changing environment, such as soccer, the task requirements for achieving SA also change rapidly. Therefore, this demarcation is liable to problems as it is impractical to expect play to be suspended in indistinguishable situations for all players. Consequently some within category differences in the SA demands placed on participants was inevitable. However the main weakness of this is the difficulty in attributing between category differences which at this stage of the research is not critical.

The measurement technique used to measure players' SA was novel but based around the Situation Awareness Global Assessment Technique (SAGAT) developed by Endsley (1988). This pioneering approach was possible through the use of liquid crystal occlusion spectacles (Milgram, 1987) worn by the participant during simulated matches and a pitch schematic to record awareness measures. A detailed error analysis was conducted on all awareness measure calculations prior to final analysis. In future locating the camera directly above the pitch would alleviate some of the problems although this is difficult in most settings. Soccer players of a semi-professional level were assessed when play was suspended during six-a-side matches played on a 40 x 20 metre Astroturf pitch. Awareness measures were the accuracy, frequency and confidence of the location of team mates and opponents. This technique retained a high level of ecological validity as soccer players are very used to playing in this format as a training scenario and therefore it did assess there performance in as normal an environment as possible. Not only this, the time constraints of the technique are not drastic and therefore analysis of a soccer players SA can easily be incorporated into a team training session. The drawback to this manipulation is that the smaller playing area and reduced number of players compared to normal conditions makes inferential statements regarding the abilities of soccer players during actual matches problematical. Therefore, it is suggested that future research is needed utilising simulated eleven-a-side matches on full size pitches.

Soccer players in this study were able to relatively accurately (to within a few metres) locate 60.78% of the other players on the pitch. This is quite interesting from the point of view that no other research has attempted to measure this before although it is impossible to speculate whether this is the upper limit of these players' ability. Thus if these players were tested during full size matches would they still on average locate 5.47 (SD = 1.29) players or would their ability increase with the number of players on the pitch? Some form of discrimination in their attention allocation was also evident as more of the important players (about 74%), as rated by a panel of experimenters, were located than the unimportant ones (about 45%). Some bias was also found toward attending to opponents above team mates. This was based on the fact the error associated with opponent location estimations were lower than for team mates although only significantly for important players. The most plausible explanation for this is that these players have developed a sixth sense regarding their team mates locations derived from familiarity of team positions. It would be useful to test this hypothesis by having players play in unfamiliar teams and in different positions. Relating these findings to Endsley's model (1995a) proves interesting; as the participants were discovered to be aware of 60.78% of all other players on the pitch it is fair to say that they had achieved level 1 SA. This involved them perceiving the status, attributes and dynamics of relevant elements in their environment, this study required them to perform this for the other players on the pitch and in general they were aware of the majority of them. It is extremely unrealistic to expect any soccer player to be aware of the location of every other player on the pitch, even if it were possible, as attention would be better focussed on the elements which they may influence at that point in the game rather than players on the other side of the pitch who may have no immediate influence whatsoever. To achieve level 2 SA a soccer player's perception of elements needs to include an understanding of the implications of those elements in reference to related goals. A mental image of the environment must be formed which comprehends the importance of every object. The results of this study do indicate that soccer players are capable of achieving level 2 SA in the situations analysed, as proved by the attention allocation skills used in identifying the location of a higher percentage of the designated important players compared to unimportant. However, the methods used in the study make it impractical to rate the participants in terms of achieving level 3 SA. This involves the ability to forecast future events and dynamics within the environment but the game simulation used was suspended before this was possible. What can be said is that as the participants were able to achieve level 2 SA and therefore understand the relevance of certain players in their environment they had put themselves in a good position to predict future events and achieve level 3 SA. However, as it is not feasible to ascertain this, discovering the extent to which soccer players can successfully achieve level 3 SA should be an aim for future research. On the whole the extent to which the findings of this study translate to players of different abilities and experience is also worthy of examination. Clearly future studies need to adopt the classical expert novice paradigm to assess skill based differences and if differences are discovered as hypothesised then further research can be aimed at developing and testing training methods for soccer players SA.

Through the use of novel methodologies this thesis has discovered an awareness issue in soccer and highlighted the fact that sub-elite soccer players are capable of being aware of the majority of important players within certain game situations but they are not always aware of them all. The situations used in this study were hand picked as being likely for SA to be poor and so these results may be indicative of relatively low awareness. However since play was suspended before a mistake could be made it is not possible to ascertain this. Certainly this study did not capture the diversity of the soccer environment as suggested by James and Patrick (2004) as necessary for predictive validity and therefore future studies need to broaden the situations tested. In a worst case scenario, poor SA could lead to the loss of a match and it would therefore seem sensible for future research to investigate methods for improving SA in soccer players. However, it is important to highlight the positive impact the findings of this thesis can have, even if initially only the link between good SA and successful performance in soccer is highlighted to coaches and players. Eventually, SA has the potential to play a critical part in a coaches thinking toward training techniques and be an important attribute in the make-up of a successful soccer player.

Chapter 6: References

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Appendix 1: Study 1 results of Average Deviation test

	Rating	Dif		
	2	0.125		
	3	1.125		
	1	0.875		
	3	1.125		
	2	0.125		
	1	0.875		
	1	0.875		
	2	0.125	sig	
			practically	statistically
mean	1.875	0.65625	1	1
no of subjects	N	8		
no of categories	C	7		
Critical value		0.97	statistically	
Cutoff value		1.17	practically	

		sig		Av. Dev
	value	**practically**	**statistically**	**p value**
Clip1A	0.5625	1	1	0.0021
Clip1B	1.3125	0	0	0.2402
Clip2A	0.21875	1	1	0.0000
Clip2B	0.46875	1	1	0.0006
Clip3A	0.5625	1	1	0.0013
Clip3B	0.25	1	1	0.0001
Clip3C	0.5	1	1	0.0013
Clip4A	0.65625	1	1	0.0041
Clip4B	0.21875	1	1	0.0000
Clip4C	0.5	1	1	0.0007
Clip5A	0.4375	1	1	0.0001
Clip5B	0.4375	1	1	0.0003
Clip5C	0.8125	1	1	0.0159
Clip6A	0.625	1	1	0.0031
Clip6B	1.96875	0	0	0.8406
Clip6C	0.5	1	1	0.0013
Clip7A	1.625	0	0	0.5594
Clip7B	0.46875	1	1	0.0006
Clip7C	0.5625	1	1	0.0013
Clip9A	0.25	1	1	0.0001
Clip9C	0.65625	1	1	0.005

Appendix 2: Participant consent form

University of Wales Swansea Department of Sports Science

Participant Consent

I understand that my participation in this study will involve completing a brief questionnaire regarding awareness of other players, during a six-a-side soccer game, and that this information will be collected during a suspension of play. I am aware that the game will be recorded on video.

I understand that participation in this study is entirely voluntary and that I can withdraw from the study at any time without giving a reason.

I confirm that I have read the instruction sheet relating to this study and understand that I am free to ask any questions at any time. If for any reason I experience discomfort during participation in this study, I am free to withdraw or discuss my concerns with Dr. Nic James.

I also understand that at the end of the study I will be provided with additional information and feedback.

I, ____(Name) consent to participate in the study conducted by Paul Jones, Department of Sports Science, University of Wales Swansea with the supervision of Dr. Nic James.

Signed: Date:

Appendix 3: Verbal Instructions to the Participants

- Before the experiment starts the participants will be instructed as a group on what will occur, these instructions will not deviate from what is said on the sheet which they receive prior to play starting.
- Once the spectacles are closed, the position of the participants will be marked on the grid and the experimenter will say the following to them 'You are here, could you mark down on the grid the position of as many teammates and opponents as possible along with a level of confidence for each of their positions at the time the glasses were shut.' This will be recorded with a digital camcorder.
- Once they have completed their markings the sheet will be taken away and they will be asked 'Think back to literally just before the glasses were shut, please can you just talk through what you were thinking at that time.' This will be recorded with a digital camcorder and Dictaphone.

Appendix 4: Example of 3-way anova's conducted throughout results of study 2

General Linear Model – Proportion of important players marked by participants (Section 5.3.3.1)

Within-Subjects Factors

Measure: MEASURE_1

CATS	TMOP	Dependent Variable
1	1	CT1PRPTM
	2	CT1PRPOP
2	1	CT2PRPTM
	2	CT2PRPOP
3	1	CT3PRPTM
	2	CT3PRPOP
4	1	CT4PRPTM
	2	CT4PRPOP

Between-Subjects Factors

		Value Label	N
STANDARD	1.00	University	4
	2.00	Academy	4

Mauchly's Test of Sphericity

Within Subjects Effect	Mauchly's W	Approx. Chi-Square	df	Sig.	Epsilon(a)		
					Greenhouse-Geisser	Huynh-Feldt	Lower-bound
CATS	.781	1.167	5	.949	.864	1.000	.333
TMOP	1.000	.000	0	.	1.000	1.000	1.000
CATS * TMOP	.182	8.051	5	.161	.497	.735	.333

Measure: MEASURE_1

Tests the null hypothesis that the error covariance matrix of the orthonormalized transformed dependent variables is proportional to an identity matrix.

a May be used to adjust the degrees of freedom for the averaged tests of significance. Corrected tests are displayed in the Tests of Within-Subjects Effects table.

b Design: Intercept+STANDARD Within Subjects Design: CATS+TMOP+CATS*TMOP

Tests of Within-Subjects Effects

Measure: MEASURE_1

Source		Type III Sum of Squares	df	Mean Square	F	Sig.
CATEGORIES	Sphericity Assumed	.318	3	.106	2.122	.133
	Greenhouse-Geisser	.318	2.593	.123	2.122	.144
	Huynh-Feldt	.318	3.000	.106	2.122	.133
	Lower-bound	.318	1.000	.318	2.122	.195
CATEGORIES * PLAYING STANDARD	Sphericity Assumed	.425	3	.142	2.834	.067
	Greenhouse-Geisser	.425	2.593	.164	2.834	.078
	Huynh-Feldt	.425	3.000	.142	2.834	.067
	Lower-bound	.425	1.000	.425	2.834	.143
Error(CATEGORIES)	Sphericity Assumed	.899	18	.050		
	Greenhouse-Geisser	.899	15.558	.058		
	Huynh-Feldt	.899	18.000	.050		
	Lower-bound	.899	6.000	.150		
PLAYER TYPE	Sphericity Assumed	.091	1	.091	3.818	.099
	Greenhouse-Geisser	.091	1.000	.091	3.818	.099
	Huynh-Feldt	.091	1.000	.091	3.818	.099
	Lower-bound	.091	1.000	.091	3.818	.099
PLAYER TYPE * PLAYING STANDARD	Sphericity Assumed	.040	1	.040	1.662	.245
	Greenhouse-Geisser	.040	1.000	.040	1.662	.245
	Huynh-Feldt	.040	1.000	.040	1.662	.245
	Lower-bound	.040	1.000	.040	1.662	.245
Error(PLAYER TYPE)	Sphericity Assumed	.143	6	.024		
	Greenhouse-Geisser	.143	6.000	.024		
	Huynh-Feldt	.143	6.000	.024		
	Lower-bound	.143	6.000	.024		
CATEGORIES * PLAYER TYPE	Sphericity Assumed	.223	3	.074	1.339	.293
	Greenhouse-Geisser	.223	1.492	.149	1.339	.298
	Huynh-Feldt	.223	2.205	.101	1.339	.298
	Lower-bound	.223	1.000	.223	1.339	.291
CATEGORIES * PLAYER TYPE* PLAYING STANDARD	Sphericity Assumed	.107	3	.036	.640	.599
	Greenhouse-Geisser	.107	1.492	.071	.640	.506
	Huynh-Feldt	.107	2.205	.048	.640	.557
	Lower-bound	.107	1.000	.107	.640	.454
Error(CATEGORIES* PLAYER TYPE)	Sphericity Assumed	.999	18	.056		
	Greenhouse-Geisser	.999	8.954	.112		
	Huynh-Feldt	.999	13.229	.076		
	Lower-bound	.999	6.000	.167		

Tests of Between-Subjects Effects

Measure: MEASURE_1

Transformed Variable: Average

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Intercept	40.529	1	40.529	528.243	.000
STANDARD	.048	1	.048	.624	.460
Error	.460	6	.077		