

Kyrre Fagereng

A Real Game Examination of Visual Perception in Soccer:

Testing the relationship between visual exploration frequency and performance in young and talented soccer players

Master thesis in Sport Sciences
Department of Coaching and Psychology
Norwegian School of Sport Sciences, 2010

Contents

Acknowledgements	2
Abstract.....	3
Introduction / theory.....	5
The dual task approach.....	5
Eye movement registration research.....	6
The ecological approach.....	9
Purpose of this study.....	12
Methods	14
Participants.....	14
Design/procedure.....	14
Measurements and analysis.....	16
Results	19
Descriptive results	19
Exploration frequency and performance.....	21
Opponent pressure and exploration frequency.....	22
Discussion.....	24
Visual exploration and performance.....	24
Exploration frequency and skill development.....	26
Exploration frequency and opponent pressure.....	26
General discussion / practical implications	28
Conclusions.....	30
References.....	32

Acknowledgements

First, thanks to Geir Jordet as my supervisor. He has showed an impressive patience with me. Geir has been "plagued" with my mails consisting promises of completion of the master thesis. It should be noted that his knowledgeable and motivating feedback has been vital in the attempt to reach the final end of this work. Furthermore, I would like to thank my family and especially my dear Mette, who has been a great support and help when I have been running away from our 3 children to work on this paper. Finally, thanks to Mathias Haugaasen, Lasse Møller, Martin Lund and Terje Kirsebom for good discussions and crucial help with data collection in Porsgrunn and around Oslo.

Abstract

The main purpose of this study was to test the relationship between visual exploratory activity and performance in real world soccer games by employing field analysis. In line with former research of adult expert soccer players, the hypothesis was that young and talented soccer players performance is better when they more extensively turn their head forward in the field before receiving the ball from a teammate positioned closer to their own goal. In accordance to former studies (Jordet, 2004) it was predicted that increased opponent pressure was followed by decreased visual exploration frequency.

To test participants at a high performance level in an evaluative and important game condition, 14 players were tested in a “representative game” at the election camp for the Norwegian national soccer team (U-16). In this setting the players had limited or no experience playing with their upcoming teammates and the team has no well-developed playing structure, which might enhance the objectivity of the visual exploration data. In line with the hypothesis the univariate logistic regression analyses of the representative game condition revealed that performance was significantly better in the high visual exploration frequency condition compared to the low exploration frequency condition. There was no significant difference in performance between situations where players showed low visual exploration frequency and intermediate visual exploration frequency.

Opposite to the predictions of highest exploratory activity frequencies in low opponent pressure, the players showed tendencies to engage in most frequent visual search activity when opponent pressure was intermediate. One possible explanation proposed was that the young players “suffers” from limited tactical knowledge, and therefore, compared to adult experts are weaker in knowing “where” and “when” to look, they do not take advantage of more time and space available for more extensive exploration activity.

To test the hypothesis in a more familiar game condition, 5 of the participants tested in representative games were recruited for additional testing in a club game. In this condition there were no significant differences in performance in relation to visual exploration frequency. A proposed explanation was that the club game had a smaller database consisting of fewer participants compared to the representative game. Also, since game conditions were more various here, uncontrolled variables may have affected the results. In club game the effect of opponent pressure on visual

exploration frequency was in line with the hypothesis. In this setting more incorporated play patterns and tactical guidelines might have compensated for the individual's lack of general tactical knowledge, helping them to engage in more extensive visual search activity when opponent pressure was low.

At last, because the talented players are at earlier stages in the development of perceptual skills compared to the passing experts and professionals, it was expected that they would display a lower visual exploration frequency. As predicted players showed a clearly lower exploration frequency compared to the expert passer in former studies, indicating that the young and talented players need to undergo extensive practice to become passing experts.

Introduction / theory

There is broad agreement that skilled perception is important for appropriate sports performance (Albernethy *et al.*, 1993, Williams *et al.*, 1999, Williams, 2000). This is definitely the case in team sports where performers have to make quick decisions based on knowledge of the position of other players and an understanding of how those players will change their position on the pitch. The experts' ability to "read the game" is mainly explained by their enhanced sport specific knowledge enabling them to pick up and interpret perceptual information more effectively than less skilled performers (Helsen & Starkes, 1999; Williams & Grant, 1999; Williams, 2000; Vaeyens, *et al.*, 2007). For optimal performance, before receiving the ball soccer midfielders have to pick up information from multiple sources like the ball, teammates and opponents. They must make rapid and appropriate performances with the ball, and their decisions are often made under pressure from opponents trying to limit both the time and space available to act (Williams, 2000). For example, when examined how soccer players moved in response to filmed offensive 3-on-3 situations, Williams and Davids (1998) reported that experienced players spent less time attending to the ball and more time on exploring other areas of the field compared to the less experienced soccer players. Williams (2000) stated that effective anticipation in soccer requires that players know "where" and "when" to look in a complex and constantly changing environment.

The dual task approach

Even if the less skilled players know "where" and "when" to look, they might because of limited skills related ball control be "forced" to keep focus on the ball. Parker's (1981) dual-task research of netball players was designed to closely mimic the demands of an actual game situation where players are required to perform basic skills of catching and throwing the ball while simultaneously monitoring the movements of teammates and opponents. As the primary task the players were supposed to complete as many passes to a designated target as possible in a 30-second period. The results showed that performance of the secondary task (detecting the illumination of lights in the periphery) was sensitive to skill level with the experts making significantly fewer detection errors than the less skilled players. In this case, the less skilled participants clearly knew that they were supposed to detect the

illuminations of lights in the periphery, but their low skills of controlling the ball, restricted their attention capacity.

The dual-task approach has also been employed when both tasks are equally weighted, emphasising participants' ability to switch attention between concurrent tasks. Smith and Chamberlin (1992) demonstrated that adding a cognitively demanding task during soccer dribbling caused higher decrement in performance for less skilled players compared to highly skilled players. According to Albernethy (2001) less skilled players allocate large amounts of attention capacity to performance of basic skills, and those are more likely to display "tunnel vision" during game situations. Highly skilled players need less attention capacity or resource to perform the primary task (e.g. handling the ball), enabling them to direct visual attention towards scanning the display for other important information (e.g. passing opportunities). Explained by cognitive models, experts perform their skills "automatically" requiring restricted conscious attentional demand. According to Williams (1999) this automaticity results when the performer, following extensive practice, moves from conscious to subconscious processing.

Eye movement registration research

"Visual search strategy" refers to the way in which performers continually move their eyes to focus on these important display features, thereby enabling them to base their decisions on relevant information only (Williams *et al.*, 1993). Studies that have examined performers' visual search strategy have mainly been conducted in laboratory settings, using eye-tracking systems to register eye movements related to video simulations of sport scenes (e.g., Janelle, Singer, & Williams, 1999; Williams & Davids, 1998; Murray & Janelle, 2003; Ward & Williams, 2003). According to Williams (2002) a common presumption is that the duration of each eye fixation represents the amount of cognitive processing and the point of gaze indicates the area of interest.

To test the validity of the eye movement registration technique, Williams and Davids (1997) examined the relationship between eye movements and concurrent verbal reports in 11 vs. 11 situations in soccer. They found no difference between the two methods in identifying the location of visual attention. In addition, both methods indicated that the less experienced group spent more time fixating on the ball/ball passer than the experienced group. This suggests that the experienced players were

more able to extract more information from other areas of the display such as movements and positions of players “off the ball”. Interestingly, in 3 vs. 3 situations there were no differences between the experienced and less experienced players in eye movements. However, in the verbal report condition the experienced soccer players reported distributing their attention between the ball/ball passer and information “off the ball”, indicating that experienced soccer players are more able to use the ball/ball passer as a central reference point while simultaneously scanning peripheral vision for the positions and movements of players (Williams & Davids, 1997).

Other empirical evidence suggests that experts fixate more on informative areas of the display, and their visual behaviour generally involves fewer fixations of longer duration on selected areas of the display compared to less skilled soccer players (see Helsen & Pauwels, 1993; Williams & Davids, 1998; Williams *et al.*, 1999). Helsen and Pawels (1993) examined differences in tactical decision-making between expert and novice soccer players. The participants watched offensive soccer simulations and were asked to respond quickly and accurately by pretend shooting, passing or dribbling a ball placed by their feet. In accordance with faster and more accurate responding, the experienced players employed fewer fixations of longer duration compared with the less skilled players. According to the researchers experts were more interested in any potentially areas of “free” space, while novices searched for information from less “sophisticated” sources like the ball and the goal.

This hypothesis that experts` visual behaviour generally involves fewer fixations of longer duration has not always been supported in the literature and by research. The inconsistency may arise because players change their search strategy as a function of the unique constraints presented by the task (Vaeyens *et al.*, 2007, Martell and Vickers, 2004). For example, players use different visual search strategies during offensive and defensive play (Williams, 2000), and visual search behaviour seems to be dependent of the number of players involved in different offensive and defensive plays. Vaeyens *et al.* (2007) analyzed whether differences in search behaviours exist across the various microstates of offensive play in soccer. The simulations were supposed to represent some of the typical situations that occur during real competitive games. In offensive simulations of 2 vs. 1 and 3 vs. 1 situations a relatively small number of fixations were employed. The players spent more than 80 % of the time fixating on the ball or the player in possession of the ball, which may reflect a greater role for information extraction via peripheral vision. As

the number of players and potential response alternatives increased (3 vs. 2, 4 vs. 3, 5 vs. 3 situations), players showed a higher search rate, fixating more on other areas than the ball or player in possession of the ball. Naturally, this increased search rate was explained by the need of extracting information from more disparate sources (Vaeyens *et al.*, 2007). For example, for defenders in 11 vs. 11 situations with the ball on the other half of the field, an extensive search strategy is required to make themselves aware of the positions and movement of the relatively large number of players located in the display, and the many passing opportunities presented to the player in possession of the ball (Williams, Davids, Burwitz, & Williams, 1994).

Conversely, in more time-constrained situations, such as 3 vs. 3 close to own goal, defensive players fixate gaze centrally on the ball or player in possession of the ball, and use peripheral vision to obtain information regarding passing opportunities from the movements of attacking players “off the ball” (Vaeyens *et al.*, 2007, Williams & Davids, 1998). In Williams & Davids’ (1998) experiment experts and novices did not differ in visual behaviour in 3 vs. 3 situations, but experts were better in anticipating the direction of passes. When masking information from areas other than the ball or ball passer, the effect was more detrimental for experts’ performance compared to novices. Further, when occluding the dribbler’s head and shoulders, hips and the lower leg and ball region in 1 vs. 1 situations experienced players performances were not affected more than that of the less experienced players. Williams and Davids (1998) concluded that experienced players spent less time attending to the ball or ball passer and more time on other areas of the display. Skilled players might focus on the hip of the ball passer because it is the most appropriate position to “anchor” foveal vision while using peripheral vision to extract task-specific information from the display (Williams, 2000).

Registration of eye movements is thought to reveal important information, and according to Moran, Byrne, & McGlade (2002) this method enables researchers to distinguish between “looking” (or visual fixation) and “seeing” (or paying attention). Knowler (1999) stated that when a sequence of images of target stimuli are maintained to the fovea (a central region of the retina which promotes high resolution for as long as required by the attentional system, visual “filtering” is achieved. However, as described above, different studies highlight the importance of peripheral vision to observe movements “off the ball”. Even if former studies using eye movement registration techniques have argued for the importance of peripheral vision

(eg. Williams & Davids, 1998, Vayens et al., 2007), and concurrent verbal reports has been employed to investigate the role of nonfoveal vision (e.g. Williams and Davids, 1998), the method has limitations since eye movements are only informative with respect to central vision (Albernethy, 2001). Abernethy (2001) argues that attention can be moved around the visual field without making eye movements, which points out that “looking” does not equate with “seeing”. Therefore, the statement that eye movement registration techniques enables researchers to distinguish between visual fixation) and paying attention (e.g. Moran, Byrne, & McGlade, 2002) is highly questionable. Nevertheless, as the research described above indicate more sophisticated equipments are developed. Researchers have become better in designing more realistic protocols and are more aware of the role of peripheral vision. Therefore, eye movement techniques have been effective in indicating differences in visual behavior between experts and novices, but it is still important for the reliability of these findings to conduct real world sport research.

The ecological approach

In a real soccer game, players are constantly surrounded by a total of 21 teammates and opponents, whose positions and movements have to be detected in order to act skillfully with the ball. For optimal performance, the soccer player has to detect information from the whole field. A movie screen only display information that is located in front of the participants, not reflecting the full amount of ambient information that in real world sports may be critical to detect (Jordet, 2004). Also, the recording devices in the laboratory are potentially disruptive to individuals’ normal allocation of attention and information pick-up (Albernethy, 2001). Even if larger video screens are developed and more complex and realistic soccer simulations have been employed by time (e.g. Williams & Davids, 1998, Vayens et al., 2007), more research on visual perception in real soccer games has to be conducted. Only by studying action in natural tasks settings the true and complete functional importance of attention may be revealed (Albernethy, 2001). Even if most ecological studies have been conducted in laboratory settings, Gibson (1979) suggests that the natural context is primary, and the unique relationships between environmental information and pick-up of this information consists of the most important variables in the study of perception. He claims that perception is not defined using the cognitive processes that are involved. Rather, it can be defined as *keeping in touch with the world*. Ecological

researchers admit the significance of cognitive component for learning, but it is not a priority to specify exactly what changes *in* the perceiver as a result of learning (e.g. Gibson and Pick (2000), in Jordet, 2004). Cognition and its development, has to be grounded in knowledge about the world, acquired through perceptual encounters with the world (Jordet, 2004). Therefore, according to the ecological approach, learning results from the improvements in the interdependent relationship between an individual and its environment.

In the ecological approach the construct of exploratory activity is described as movements that are initiated to gather information (Gibson, 1979). As Gibson postulated; "*We must perceive in order to move, but we must also move in order to perceive*". Gibson (1966) distinguished between three different levels visual exploratory activity. At the first level the body explores the environment by means of locomotion; at the second level through head turning; and at the third level compensatory saccadic eye movements. Eye movements in natural tasks depend on movements of head and body, and these movements have rarely been included in studies of visual behavior in sport (Jordet, 2004). One of few exceptions was Oudejans & Coolen (2001) investigating shooting performance of expert basketball players with vision occluded either before or after the ball and hand moved passed the line of sight. Vision was manipulated by using goggles that were controlled by the performer's movements. A personal computer used the data from registration of hand, heel, and head movements to shut or open the goggles in difference stages of the performance. This method is a promising in doing more ecological valid manipulations of performance. However, in team ball sports, like basketball and soccer, it is crucial to investigate visual perception and performance in open play situations involving more complex attention requirements. To make appropriate decisions with the ball in open game situations, the performer obviously take advantage of exploring the environment before receiving the ball.

Jordet (2004) developed a soccer specific method with the intention to remove both the lack of natural task specificity and absence of head and body movements in former laboratory research designs. In his analysis of real world macro visual behavior (head and body movements) micro level visual behavior (eye movements) identified in laboratory are not registered. However, according to Jordet (2004) it seems likely that these perceptual processes work in parallel, and therefore carried out within the confines of a macro level visual strategy. In real soccer game situations it is

impossible for the player to collect all relevant information only by using eye movements. Further, to avoid the “hidden” role of peripheral vision, it is important to study situations where performers take advantage of detecting critical information located outside the range of peripheral vision. More precisely, before a midfielder receives the ball from a teammate positioned nearer own goal, he will take advantage of turning one’s head and foveal vision away from the ball to direct the eyes to information forward in the field. The midfielder has to break free from defending opponents in order to receive the ball, openings and spaces must be detected and teammates in appropriate positions need to be located (Jordet, 2004). The frequency of exploratory activity is supposed to be sensitive to skill level. As the dual-task research indicated, highly skilled players hold less attention capacity on controlling the ball received by more subconscious processing, enabling them to direct visual attention to important areas away from the ball (Parker, 1981, Smith & Chamberlin, 1992, Williams, 1999). Therefore, experts are supposed to engage in more extensive visual exploration activity compared to novices.

Jordet’s (2004) case study of five expert midfielder passers indicated that they engaged in relatively high exploratory activity, but there was no clear relationship between exploration frequency and performance with ball. However, for the two highest ranked passers of the five participants, there was a modest positive relationship between exploration frequency and performance. Jordet (2004) emphasizes that the relationship is somewhat modified by the type of situation and when the exploratory activity is carried out. As mentioned, Vaeyens *et al.* (2007) demonstrated clear differences in search behaviours across various microstates of offensive play in soccer.

Jordet’s (2004) case study of expert passers had relatively few objects and has therefore limited generalization value. In terms of external validity more convincing results were found when Jordet *et al.* (2008) investigated the visual exploration in English Premier League players in the 2003-2004 season. 402 game situations with 54 midfielders were analyzed. In addition 27 amateur central midfield players from the top Dutch amateur league were recorded and analyzed in 114 situations. The results revealed a significant difference in exploration frequency between professionals (0.47 searches/second) and amateurs (0.39 searches/second). Further, they divided the professionals in “superstars” and regular professionals by the variable of player status (international awards). They found that “star players” employed significantly more

visual explorations (0.52 searches/second) compared to the regular professionals (0.45 searches/second). Interestingly, Chelsea and England national team “star player”, Frank Lampard was ranked as number 1 with an exploration frequency of 0.62 searches/second, with Steven Gerrard (Liverpool/England) ranked second with 0.61 searches/second. However, the ranking (skill level) of premier league midfielders is an indirect and somewhat inaccurate measurement of performance. Regarding visual exploration frequency it is possible that “superstars” benefit from playing on one of the most skilled teams. They cooperate with world-class teammates who deliver high quality passes. When their team is in possession of the ball they might be more patient and effective compared to weaker teams. The team movements are more precise and coordinated, and the pace of the game is generally higher compared to their weaker opponents. In sum, compared to lower rated players, the superstar might experience more optimal working conditions reinforcing high levels of exploration activity. Therefore, it is possible that the results to some degree are confounded by the different game conditions, and there is a need investigate the relationship between exploratory activity and performance in more equal game conditions.

To test the relation between visual exploration and performance on a more general level Jordet et al. (2008) measured performance by pass completion (possession of ball or not). Visual exploration frequency (searches/second) was positively correlated to pass completion. When players engaged in less than 0.26 searches/second, they completed by average 56% of their passes. When players employed more than 0.50 searches/second the mean pass completion was 75%. The results supported that high level of exploratory activity seems important for performance in soccer, and even if there are individual differences, expert midfielders seem to use their vision extensively to achieve prospective control of their actions.

Purpose of this study

This study will investigate the relationship between exploration frequency and performance further by testing 15 years old talent soccer players in real world soccer games by employing ecological field analysis. In accordance with former research (Jordet 2004; Jordet et al., 2008), it was expected to find a positive relationship between performance and exploratory activity among these young players. The hypothesis was that players` performance is better when more extensively turn their head forward in the field before receiving the ball from a teammate positioned closer

to own goal. More precisely, it was predicted that higher exploration frequency is linked with better performance. For example, Ward and Williams (2003) examined how visual perceptual, and cognitive skills contribute to the development of expert performance in soccer using film simulations. When observing offensive plays, as young as 9 years old elite players were better than their sub-elite counterparts at predicting key player involvement. This finding indicates that even very young expert soccer players effectively integrate contextual information with expectations stored in memory (Ward & Williams, 2003).

Anyway, it is expected that the talented players will display a lower visual exploration frequency compared to the passing experts and professionals, since they are at an earlier stage in the development of perceptual skills. Also, as mentioned the frequency of exploratory activity is supposed to be sensitive to the development of skill level. Compared to international elite players, the young soccer talent player has to attend more to controlling the ball receive, restricting visual exploration of important areas away from the ball.

Two different game conditions are investigated. In the “representative game” condition, fourteen talented soccer players attending an election camp were tested in one of two games at the same pitch at the same day. Because confounding and unpredictable variables could potentially interrupt the results, it was considered an advantage that a relatively high number of objects at same skill level were tested in more or less equal game conditions. Also, at this camp the players had limited or no experience playing with their upcoming teammates and the team has no well-developed playing structure, which might enhance the objectivity of the visual exploration data.

Further, five of the players attending election camp were tested in an additional club game to test the predictions in another game condition. Most teams have to a certain extent drilled playing structure that can control the choices and searches of the individuals. Other playing relations and patterns might have developed more “naturally”. For example, players who know each other well might pass the ball to each other in "blind". Nevertheless, still it will be essential that the teammates and opponents are detected by the participants, so even if the needs or requirements of the visual search behavior are different from the representative game condition, it was also in club game expected that high exploratory search frequency and good performance is positively related.

Finally, in accordance with Jordet's (2004) results, it was expected that more intense opponent pressure were followed by a decrease in exploration frequency. Jordet (2004) argues that in tight and pressured situations where failing to control the ball leads to loss of the ball, a more focused attention to the ball might be triggered. Therefore it was important to control for the variable of opponent pressure when investigating the relationship between exploration frequency and performance.

Methods

Participants

To test objects at a high performance level in an evaluative and important game condition, the election camp for the Norwegian national soccer team (U-16) was judged to be an appropriate research setting. From a total of 48 talented soccer players attending the camp, 14 participants (midfielders and strikers) were recruited for investigation. This group consisted of players having their sixteen birthdays during the year the data was collected (2004). Since participants' ages were relatively close, dates of birth were not considered as essential information to obtain.

In the year of 2004 almost 77 000 active soccer players between the age of 13 and 19 were registered in Norway (NFF, 2009) Based on these statistics approximately 10 000 active Norwegian soccer players were born within the year of 1988. The election camp held 48 of the highest rated individuals born this year, competing for selection to the national team. Therefore, the players were supposed to be among the most experienced and talented players at their age. Participants' playing position (midfielders and strikers) was of great importance for inclusion of the 14 individuals tested in this study (see measurements).

Based on geographic and practical availability, 5 of the participants tested in the representative game, were recruited for additional close –up filming in a game for their club team.

Design/procedure

Representative game. Because of the importance and attractiveness of being selected for the Norwegian national team, the games at the election camp were judged to hold elements of the performance pressure present in top-level soccer games. Further, at this camp the participants had little or no playing experience with their upcoming teammates. Therefore, in contrast to matches between more established teams, the competing teams at the election camp had no incorporated play patterns

and well-developed relationships that may affect the individuals visual search behavior. Also, because of the intention of testing the hypothesis on a more general level, it was important to get access to as many as possible research object competing at the same level in the same game conditions.

In advance of the camp, The Football Association of Norway (NFF) was approached and requested for permission to recruit participants for the investigation. At this camp both candidates for the Norwegian U-15 and U-16 team attended. NFF recognized the project and gave permission to test the more experienced U-16 players. In classrooms in the first day of the camp, all players were shortly informed about the study, but they did not get information of whose performance was going to be filmed close up. We assured the participants that the movies would only be used for research, and that no one outside the research group would have access to the results of individual players.

For the upcoming games the camp directors distributed the 48 participants in three teams. Two U-16 teams played against each other, while the third U-16 team played against a U-15 team. Information of starters and playing position in the upcoming camp games were first accessible short time before initiation of game (about 20 min.), which implicated a quick selection of subjects to include for the study. Midfielders and strikers were prioritized, and high-zoomed cameras followed each participant. When a player was replaced, the substitute was included in the study. In the two games, a total of 14 players were selected and filmed closed up for registration of visual perception

Club game. As mentioned, based on geographic and practical availability 5 players tested in the representative game were recruited for testing in a club game. Also, players that played in the same club, or players that competed in the same game were prioritized. We asked both the players and their coaches about permission, and assured the players confidentiality about individual results. A total of 3 different game conditions were investigated within 4 months after the camp. In the first game two players competing for the home team were filmed. In a second game, we observed one player competing for the home team and a second player competing for the away team. In a third game, one player at the home team was investigated. All three games were played at the highest junior soccer club level in the eastern region of Norway (*in Norwegian: "junior – interkrets, Østlandet"*). At this level players can compete

through the year they turn 19 years. Therefore, the participants in this part of the study competed with until 3 years older teammates and opponents.

Being a real-world study carried out without manipulation of independent variables, the external validity is strong and it is important as a foundation for more systematic and rigorous hypothesis testing. The problem is low precision of measurements and weak control of possible confounding variables. When testing players in more familiar game conditions, where potentially more incorporated play patterns might influence their visual search strategy, different results might occur. Maybe the participants will play more “blind” passes resulting in less exploratory activity. Otherwise, it is possible that the players explore more extensively by knowing where to direct their attention due to the incorporated play patterns. In this exploratory part of the study, testing a smaller number of objects, it is more likely that confounding and uncontrollable variables within each participant affect the results. Without investigating the underlying causes, this study will report individual differences in the relationship between visual exploratory activity and performance.

Measurements and analysis

Visual behavior was monitored by close up images of the player, provided by a high-zoomed video cameras staying on each participant throughout their entire performance. In addition, a low-zoomed video camera registered the ball and general game events. Pilot testing was not done, since the camera crew were considered to hold sufficient experience with the filming procedures. Each tape of individual close up images was synchronized and edited together with the tape of the general game events (see figure 1). This was done in Apple’s professional video editing program, Final Cut Pro 4.5 HD.

Based on the method developed by Jordet (2004), visual perception is measured by visual exploratory activity at the level of head movements. Disregarding frontally located information constrains the validity of these measurements. In order to alleviate some of these problems, only situations where participants receive a pass from a team mate located closer to their team’s own goal are included for further analysis. In these situations the participant would have information relevant for progressing in the field (towards the opponent’s goal) behind his back, To detect this information, the soccer player has to use movements of head and body (Jordet, 2004). Because midfielders and forwards more often than defenders are involved in

situations were the ball is received from a teammate closer to own goal, defenders are excluded from the study.



Figure 1. Snapshot of the synchronized individual close up- / general game events tapes.

The video analysis involved variables related to visual perception, environmental conditions and performance. As explained above, visual perception was measured by exploratory activity of head movements. Exploratory activity was coded when it occurred in a 5 or 3 second time interval before the participants received the ball from a teammate. The 5 seconds time interval was set when the ball potentially could arrive to the participant more than 5 seconds before actual ball contact. If the potential ball receipt started less than 5 seconds before actual ball contact, for example if the opponent team suddenly lost ball possession, the time interval was set to 3 seconds (a modification of Jordet's (2004) method).

An *exploratory search* was operationally defined as: “A body and/head movement in which the player's face is actively and temporarily directed away from the ball, seemingly with the intention of looking for teammates, opponents or other environmental object or events, relevant to perform a subsequent action with ball“ (Jordet, 2004, p.128). Dividing the number of searches with the time interval of the situation assessed *exploration frequency*. *Exploration – ball contact time interval* was defined as the time between end of last exploratory search before receiving the ball and the moment of ball contact. This time indicated to which extend the players were able to collect information from the surroundings even though the ball was approaching and even potentially being on its way (Jordet, 2004).

In addition, variables describing environmental conditions and performance were analyzed. *Opponent pressure* was operationally defined according to how close the opponents were when the participant received the ball; Within 1 - 2 meters (intense), 2 - 5 meters (intermediate), or 5 meters and more (light). *Performance with ball* was graded on a scale from 1 to 7. 1 - 3 was considered low performance, 4 was intermediate performance, and 5 – 7 good performance (Jordet, 2004). For example, if the performer failed to control the ball receive and lost the ball to the opponent, this was considered as low performance. In addition, if the ball was considered easy to receive in the form of a precise and non-bouncing pass, the performance was graded as “very low” (1). Further, if the upcoming pass in front of the ball loss was imprecise and the ball was bouncing, the performance was graded as “low” (3). A typical intermediate performance (4) was when the player after receiving the ball played a “neutral” support pass despite better opportunities of action. Further, examples of when performance was considered “very good” (7) was when the player received the ball and dribbled the opponent’s defenders and scored a goal, or passed the ball forward in the field leaving a teammate alone with the opponent’s goalkeeper.

In order to achieve stability in the measurements, the author analyzed each situation and all variables. In addition, in order to increase reliability in this process, an intra-subjectivity test was conducted approximately six months after the initial data analysis. The data from the representative games were analyzed a second time by the same researcher, on the variables of exploratory frequency and performance.

On the variable of performance the similarity of the intra-subjectivity test was 0.62 when performance were ranging from 1-7. At first glance, coding only 62 percents of the totally 121 performances similar in the two different occasions seems to provide a relatively low reliability value. However, this test did not take in to account the degree of difference in scores. For example, the difference between performance scores of 5 and 6 is small. Otherwise, if the same performance in the first analyze was rated as low (1) and in the second analyze rated as very good (7), this difference should ideally be given more gravity in the reliability test. However, when performance was split in two categories (low/good), the intra-subjectivity test showed a similarity of 0.91, providing high reliability. Therefore, only the “low/good” performance data were used for further statistical analysis. Ideally, to ensure stronger reliability in the assessment, an inter-subjectivity test should be conducted. Due to limited research resources this quality assurance was not prioritized. Even if the

scoring criteria of performance are made to guide raters to arrive at the same score, the judgment of performance is a largely a subjective evaluation. Certainly, it would be interesting to compare the qualified opinions of two experts. Anyway, since the author did all the assessments, the results were assumed to be trustful, especially when performance scores were simplified by divided in only two categories.

On the variable of exploratory activity frequency the test showed a similarity of 0.82, which means that the number of registered exploratory searches were the same in 82 percents of the game situations analyzed (n=121). Although we used high zoomed cameras, there were game situations where head movements were difficult to determine as clear enough to be defined as exploratory activity. With this in mind the result of the test were considered to be satisfactory to produce reliable results.

A univariate logistic regression analysis was used to test the relationships between the independent variable “exploration frequency” and the dependent variable “performance”. Using statistical tools (SPSS) exploration frequency was split in three intervals (low/ intermediate / high) and as the dichotomous dependent variable performance was categorized as low or good. The influence of exploration frequency on the performance was assessed by looking at the odds-ratio, which is an index of how likely it is that soccer player performed either low or good given their exploration frequency before receiving the ball. An odds ratio of 1 would indicate that the players performance of low or good is equally to occur in the given exploration frequency condition.

A one-way between groups analysis of variance (ANOVA) was conducted to explore the impact of the three intensity categories of opponent pressure on exploration frequency. In the ANOVA Post hoc tests were conducted to provide which means of opponent pressure conditions that are significantly different from each other. In both analyses the alpha-level was set to 0.05 to indicate the reliability and to ensure statistical significance.

Results

Descriptive results

Based on the inclusion criteria, performance of 14 individuals was videotaped in the representative game condition. One participant was excluded for further investigation (not involved in ball contact situations satisfying the inclusion criteria). Therefore, 13 individuals were analyzed in a total of 121 ball contact situations (M=

9.3). Participants' playing time was varying from 31 to 82 minutes ($M=49$ min.), and individual ball contact situations approved for analysis varied from 6 to 22. They engaged in an exploration frequency ranging from 0.11 to 0.46 ($M=0.31$, $SD=0.24$) (See table 1 for values of the individual cases).

In the club game condition 5 players were tested in 75 game situations included for analysis ($M=15.00$). The players engaged in an exploratory activity frequency ranging from 0.22 to 0.39 ($M=0.32$, $SD=0.24$) (See table 2). Individual playing time varied from 45 to 84 minutes ($M=71$ min.). Individual cases and differences between the two game conditions are described in more details in the discussion part of this paper.

Table 1. Representative game; descriptive results for individuals mean exploration frequency, mean opponent pressure, mean performance, total of situations included for analysis, and playing time.

	Searches/ second	Opponent pressure (1 - 3)	Performance (1 - 7)	Analyzed situations	Playing time (minutes)
Player 1	0.16	3.00	4.67	6	31
Player 2	0.23	2.67	2.83	6	36
Player 3	0.17	2.78	4.67	9	36
Player 4	0.37	2.62	3.25	8	35
Player 5	0.46	2.44	3.89	9	75
Player 6	0.41	2.11	4.22	9	51
Player 7	0.11	2.06	3.82	17	82
Player 8	0.31	2.50	3.17	6	46
Player 9	0.35	2.27	4.36	22	82
Player 10	0.36	1.71	4.29	7	46
Player 11	0.23	2.50	4.50	6	47
Player 12	0.44	2.33	5.11	9	41
Player 13	0.33	2.29	3.71	7	41
Tot. mean	0.30	2.38	4.10	9.31	49
Std. Dev	0.24	0.72	1.36	-	-

Table 2. Club game; descriptive results for individuals mean exploration frequency, mean opponent pressure, mean performance, total of situations included for analysis, and playing time.

	Searches/second	Opponent pressure (1 - 3)	Performance (1 - 7)	Total analysed situations	Playing time
Player 1	0.24	2.57	5.14	14	79
Player 2	0.43	2.16	4.00	19	45
Player 3	0.22	2.75	4.33	12	84
Player 4	0.28	2.32	4.05	19	79
Player 5	0.39	2.55	2.91	11	66
Total mean	0.32	2.43	4.12	15.00	71
Std. Dev	0.24	0.70	1.35	-	-

In the analysis exploration was categorized in different types of exploratory searches (see table 3). When estimating what exploration types were engaged in most frequently in the representative game, most explorations were categorized as brief exploratory searches (79.3%), then 180 degree exploratory searches (14.2%), sequential searches (4.1 %), and least frequently long exploratory searches (2.4%). The variable of exploratory search type was omitted from further analysis because the frequency of exploratory searches in other categories than brief exploratory searches was considered too small (see table 3).

Table 3. Representative game; descriptive results of exploratory activity types (N = 121)

	Long exploratory activity	180 degree exploratory activity	Brief exploratory activity	Sequential exploratory activity
Mean/ situation	.03	.20	1.11	.06
Sum	4	24	134	7

Exploration frequency and performance

A univariate logistic regression analysis was used to test the relationships between exploration frequency and performance. Exploratory frequencies were split into three equal groups: low (0 – 0.19 searches/second), intermediate (0.20 – 0.39 searches/second) and high (0.40 + searches/second). Performance was split into two categories: low performance (1-3) and good performance (4-7).

In the representative game condition the players showed good performance in 65.3% (n = 79) of the analyzed game situations, and low performance in 34.7% (n = 42). Thus, the base OR = $65.3/34.7 = 1.88$. The univariate logistic regression analyses revealed that performance was significantly better in the high exploration condition (80.9% good performance) compared to the low exploration condition (56.3% good performance) (OR = 3.28, p = .021). There was no significant difference in performance between situations were players showed low exploration (56.3% good performance) and intermediate exploration (54.8% good performance) (OR = .94, p = .90; low exploration as reference category) (See table 4).

In the club game condition the players showed good performance in 68% (n = 51) of the analyzed game situations, and low performance in 32% (n = 24). Thus, the base OR = $68/32 = 2.13$. The univariate logistic regression analysis revealed no significant difference in performance between situations were players showed low exploration (62.5% good performance) and intermediate exploration (66.7% good

performance) (OR = 1.20, p = .79); low exploration as reference category). Likewise, performance was not significantly better in the high exploration condition (71.1% good performance) compared to the low exploration condition (62.5% good performance) (OR = 1.47, p = .54) (See table 5).

Table 4. Representative game; descriptive and univariate logistic regression analysis results for exploration frequency and its relation to performance.

Variable	N	Good performance	Low performance	% Good performance	OR	P
Exploratory frequency						
0 – 0.19 searches/second	32	18	14	56.3	1	(ref.)
0.20 – 0.39 searches/second	42	23	19	54.8	.94	.90
0.4 + searches/second	47	38	9	80.9	3.28	.021
Total	121	79	42	65.3	1.88	-

Table 5. Club game; descriptive and univariate logistic regression analysis results for exploration frequency and its relation to performance.

Variable	N	Good performance	Low performance	% Good performance	OR	P
Exploratory frequency						
0 – 0.19 searches/second	16	10	6	62.5	1	(ref.)
0.20 – 0.39 searches/second	21	14	7	66.7	1.20	.79
0.4 + searches/second	38	27	11	71.1	1.47	.54
Total	75	51	24	68.0	2.13	-

Opponent pressure and exploration frequency

A one-way between groups analysis of variance was conducted to explore the impact of opponent pressure on exploration frequency. There were three categories of opponent pressure level (light: 5 m +, intermediate: 2-5 m, intense 0-2 m).

In the representative game condition there were no significant differences in exploration frequency scores of the three groups (F(2, 118)=1.5, p=.23). Comparing the mean scores between the three groups, the largest difference in exploration frequency is between the intermediate opponent pressure condition (n=40, M=.35, SD=.24) and the intense opponent pressure condition (n=62, M=.27, SD=.24) (see graph 1). Exploration frequency mean in the light opponent pressure condition was .30 (n=19, SD=.27). Because of no significant main effect in the overall analysis of variance test, Post-hoc tests are not reported.

Neither in the club game condition any significant difference in exploration frequency scores of the three groups (F(2, 72)=1.8, p=.17) was found. Comparing the

VISUAL PERCEPTION IN SOCCER

mean scores between the three groups, exploration frequency in the light opponent pressure condition ($n=9$, $M=.44$, $SD=.16$) is relatively high compared to exploration frequency in the intermediate opponent pressure condition ($n=25$, $M=.33$, $SD=.27$) and to the intense opponent pressure condition ($n=41$, $M=.28$, $SD=.23$) (see graph 2). Because of the loss of significant main effect in the overall analysis of variance test, Post-hoc tests are not reported for the club game. However, the tendency of the results in the club game condition supported the expectations in that more intense opponent pressure was followed by a decrease in exploration frequency.

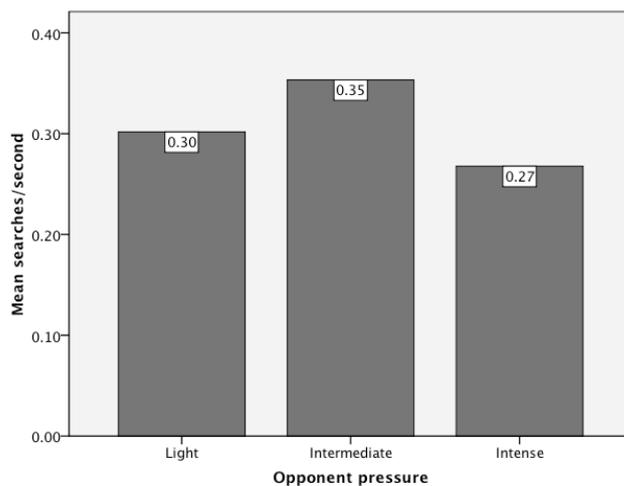


Figure 2. Representative game. Exploration frequency (exploratory searches/second) under different pressure conditions.

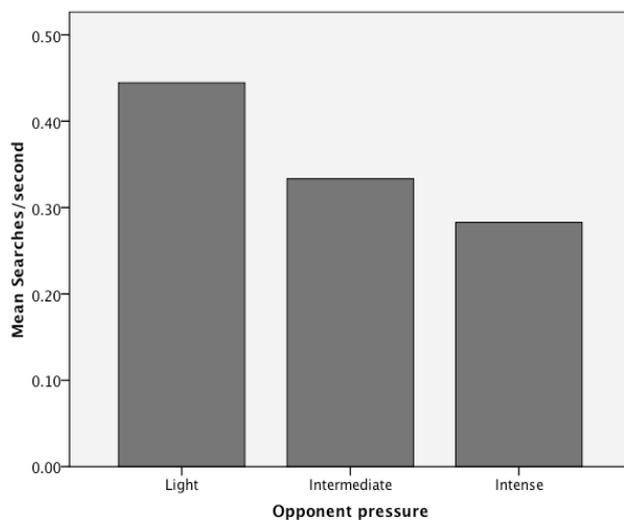


Figure 3. Club game. Exploration frequency (exploratory searches/second) under different pressure conditions.

Discussion

Visual exploration and performance

The main purpose of this study was to test the relationship between exploratory activity and performance in real world soccer games by employing field research methods grounded in the ecological approach. The hypothesis was that performance is better in situations where players turn their head forward in the field in front of ball reception. Complementing former findings from field research (Jordet et al., 2008; Jordet, 2004) the representative game condition showed a significant positive relationship between increased exploration frequency and performance.

However, in club game conditions the general relationship between increased exploration frequency and performance was weak and not significant (see table 5). A reasonable explanation of the difference is that the club game had a smaller database consisting of fewer participants compared to the representative game. Unfortunately few objects were tested in club games because of limited research resources. The method was time consuming, which made it difficult to test players in clubs far away from the research site. Also, since game conditions were more various in club games, uncontrolled variables like in-game emotions, game level, sun conditions, playing structure and position in team probably may have affected the results to a greater extend.

The mean values of exploration frequency, opponent pressure and performance were relatively similar when comparing the two game conditions. Anyway, in both game conditions there were clear individual variations in exploratory activity frequency (see table 1 / table 2), indicating different individual strategies and skills related to visual attention. For example, player 1 in club game had the lowest exploration frequency (0.24 searches/second), but highest performance (see table 2). This player might possess skills that compensate for low developed perceptual skills, like quick and smart movements away from opponents in relation to ball-receive. In this case, the player might show “tunnel vision” but has still prospective control of his actions because he is confident getting past his opponent with the ball in control. Therefore, even if researchers proposes that expert soccer players in general engage in more visual search activity because of larger attentional resources or capacity (see Vaeyens *et al.*, 2007), individual differences in this study indicates that some talented players might perform well even if they are “ball watching”.

The mean of analyzed situations per individual is higher in the club game (M=15.00) compared to the representative game (M=9.31), which reinforces the potential effect of individual factors on the results in the club game condition. The presence of individuals influencing the result is also present in the representative game. For example, player 7 reveals the lowest exploration frequency (0.11) and is analyzed in as much as 17 game situations (see table 1), which impacts the results by reducing the mean exploration frequency for the group from 0.32 to 0.30 searches/second.

Further, as the laboratory research of Vaeyens *et al.* (2007) revealed, as the number of players and potential response alternatives increased, players showed a higher search rate to extract information from more disparate sources. In this research number of passing opportunities was not analysed, which is an idea to implement in future research. Another example of possible improvement is to discriminate how the ball approaches the ball receiver. Smith and Chamberlin (1992) demonstrated that adding a cognitively demanding task during soccer dribbling caused decrement in performance of soccer players, leading to “tunnel vision” during game situations (Albernethy, 2001). Supported by cognitive theories, players need less attention capacity to prospectively control the receive of a ball “floating” on the ground towards them compared to a bouncing and imprecise pass from a teammate. In these situations experts are supposed to engage in more search activity than novices, due to larger attentional resources and capacity. Even if this study and the findings of Jordet *et al.* (2008) revealed a positive correlation between visual exploratory activity and performance, it would be interesting to investigate differences in visual behaviour according to these situational constraints.

To generalize the results it important to minimize the influence of individual properties by testing as many different objects as possible in the same game condition. The representative game condition, with 121 analyzed situations based on 13 different objects in two almost similar games, was an important contribution in revealing a correlation between exploration frequency and performance at a general level. Anyway, to increase validity future investigation should involve more objects in as similar as possible game conditions.

Exploration frequency and skill development

The young and talented players showed a mean exploration frequency of 0.30 searches/seconds in study 1 and 0.32 searches/second in study 2, indicating that the two game conditions were relatively similar in the requirements regarding visual perception. For comparison, the expert passer in Jordet's (2004) study engaged in a mean exploratory activity frequency of 0.53, and the "star players" showed 0.52 searches/second. The clear difference indicates that the young and talented players need to undergo extensive practice to become passing experts. Explained cognitively, the young players might have restricted tactical knowledge and therefore they do not engage in more visual search activity. Conversely, experts are thought to have an enhanced ability to recognize meaningful associations between players' positions, resulting in more rapid identification of playing patterns (Williams and Davids, 1995). Another explanation based on the dual task paradigm (e.g. Smith & Chamberlin, 1992; Parker, 1981) is that when the talented players develop their basic skills further (e.g. handling the ball), more visual attention can be directed towards scanning the display for other important information (e.g. passing opportunities).

Anyway, even if the mean exploration frequency seems relatively low in this study, Ward & Williams (2003) found that even very young elite soccer players were better than their sub-elite counterparts at predicting key player involvement. Since the participants of this investigation consisted of the highest rated soccer players at their age in Norway, the mean exploration frequency of the group is probably high compared to novices at their age. This should be investigated further.

Exploration frequency and opponent pressure

In former studies of expert passers there was a clear tendency that increased opponent pressure was associated with lower exploration frequency (Jordet, 2004, Jordet et al., 2008). The results from the representative game condition indicated no such relation. Instead, it appeared that the players searched most frequently when the pressure was intermediate, and that players searched almost as little when the pressure was light as when it was intense (see figure 1). Neither in club game conditions any significant result was discovered, but in line with the expectations it was a tendency of lower search frequency when opponent pressure increased (see figure 2). When opponent pressure was light, the mean exploration frequency in representative game was 0.30 searches/second and in club game 0.44 searches/second. The variable of

light pressure in club game contained of only 9 play situations, and the results must therefore be interpreted with caution. However, the difference in mean exploration frequency between the two settings is clear, and it is the result from the representative game based on 19 play situations of light opponent pressure is contrary to previous research findings (e.g. Jordet, 2004, Jordet et al., 2008).

An explanation for the weak relationship between exploration frequency and opponent pressure in both game conditions might be that the young players have not fully developed perceptual skills, implying a less refined visual search pattern. Active and effective visual exploration requires that soccer players know “where” and “when” to look (Williams, 2000). It is possible that the young players “suffers” from limited tactical knowledge, and that this limitation provides the greatest impact in representative game situations with light opponent pressure. In this condition, despite having time and space to implement extensive exploratory activity, the absence of well-developed play patterns and tactical guidelines might limit the individual’s perceptual skills and exploratory activity. Opposite, in club game more incorporated play patterns and tactical guidelines might, to some degree, compensate for the individual’s lack of general tactical knowledge and therefore spend more time looking for his teammates.

The relationship between types of explorations and opponent pressure was reported, but not analyzed in this study (small sample size in other categories than brief explorations). Anyway, it is likely that more time consuming search activity (e.g. long explorations) is conducted to a greater extent than brief explorations when opponent pressure is light, since then the player has time and space to explore the environment more extensively. When estimating what visual search types expert passers engaged in, Jordet (2004) reported a frequency of 53.3% brief exploratory searches, which means that the remaining 46.7% of the searches were of more extensive and time consuming nature (25.9% 180 degree exploratory searches, 15.9% sequential exploratory searches, and 4.9% long exploratory searches). Based on the results from the representative game, 20.7% of the young players’ exploratory searches can be categorized as more extensive and time consuming (14.2% 180 degree exploratory searches, 4.1 % sequential searches, and 2.4% long exploratory searches). The clear difference indicates that experts are more analytic in their exploration of the environment compared to the young players, supporting that statement that skilled performers’ ability to “read the game” is mainly explained by

their enhanced sport specific knowledge enabling them to pick up and interpret perceptual information (Vaeyens, *et al.*, 2007). Compared to the talented players in this study, more experienced players seem to know more of “where” and “when” to look.

General discussion / practical implications

Findings from this study are in line with former research proposing that soccer players will increase visual exploration activity with experience and skill development. Former studies from laboratory show that different playing situations put different demands according to visual attention, and that experts are more effective in exploring their environment compared to novices. Ecological and cognitive approaches to visual perception might send conflicting signals to coaches and players engaged in soccer. For novices the practice of dribble the ball between cones can indirectly affect visual perception by developing ball control skills necessary to discover new opportunities in the environment (the dual task paradigm). For other players it might be more effective to practice perceptual skill more directly. One option based on cognitive research can be visual training programs using video simulations representing the real world task as closely as possible. But as the varying results presented in the theory part of this paper illustrate, the most secure way to practice visual attention skills seems to practice skills as realistic as possible.

The principal difference between ecological and cognitive perspectives is that for ecological researchers the locus of explanation is relational, and not within a person’s head (Jordet, 2004). According to the ecological approach, learning results from the improvements in the relationship between an individual and its environment, and therefore the midfielder should practice in realistic situations challenging his/her prospective control. The results from this study indicating that even 15 years old soccer players take advantage of high level of visual exploration frequency can inspire young players to be more active visual perceivers. It is obviously their tactical knowledge is limited compared to adult experts with extensive experience of the “real game”. If soccer coaches and players are informed of how the best players act to achieve prospective control in real game situations (e.g. Frank Lampard, in Jordet *et al.* 2008), this might be an inspiration and help for more effective practice.

Further, by observing and investigating how soccer superstars act and move on the pitch to optimize their visual attention and prospective control fruitful learning

can emerge. For example, young players might observe that skilled defenders run more backwards after losing the ball close to opponent's goal compared to less "tactical" skilled players. In that way the player can run back in defence and at the same time keep track on the ball and movements of opponent and teammates. This example is speculative, but the principle of affording players such concrete real world based information can help them optimize their learning potential by extracting more relevant information from their surroundings.

Practical implications based on the dual task paradigm can be understood like the talents have to practice technical skills until their skills require restricted conscious attentional demands. In this way they achieve the ability to rapidly shift attention between concurrent tasks (see Williams, 1999). Literally, this can be interpreted as if the soccer player practice more isolated skills, like dribbling the ball between cones, the skills will at a final stage become "automatic". Then the player can engage in more visual searches, since more resources of the memory are available for other tasks. A distinction between technical and tactical capabilities might exist, but these properties are closely connected, and may not be necessary to distinguish from each other.

A brain/body dualism might result in practitioners emphasizing too much on training of isolated technical and tactical skills. For example, if a teams midfielder have difficulties making good decisions of where to pass the ball when attacking, it can be tempting to assume that this player has to develop his/hers tactical knowledge. The coach might give the player a tactical lecture of where to play the ball to improve the individuals' task specific knowledge. Certainly, this is not the intention of research from the cognitive approach, but when laboratory researches exclude important characteristics of the real game and the focus is to explain differences inside the head, practitioners might be misled. It is important that research has practical value, and training visual-perceptual skills without the corresponding sport specific movements may be ineffective given the linkage between perception and action (see Gibson 1979). As stated by Williams and Grant (1999) *"the enhanced knowledge base which underlies experts' perceptual skills appears to be primarily developed as a result of sport-specific experience acquired through being actively involved in playing and practicing the sport as opposed to via observation."*

It is crucial that interventions focus on perceptual skills in the true dynamic and complex nature of the real soccer game involving individual's visual behavior of eyes, head and body.

As Dzewaltowski (1997) stated *“The science and practice of sport psychology will merge when ecologically informed “psychological skills” training programs are set up. The basic assumption of a model of this type is that regulation of behavior is based upon the skilled individual's attunement to the affordances that the sport and exercise environment provides”* (p. 271). One example can be how the psychological skill of concentration can be developed by knowledge of visual attention in soccer. Most players have heard their coaches shouting: *“Improve yourself! Be more concentrated!”* Many players may in such circumstances have no idea of what they are supposed to focus on, and often they can feel those comments as disturbing or even stressful. Based on results from ecological science, a way to improve in-game concentration could be to show individuals how the best soccer players in world engage in extensive visual search behavior, not only when involved with the ball but also in relatively “inactive” periods of their performance (see Jordet 2008). Then individuals can be exposed for training sessions that “force” them to use their head and body to search for essential information in the field. In this way players can improve their prospective control of actions, which is undoubtedly an essential part of concentration. However, even if it is advantageous to engage in extensive exploratory activity, it is as Jordet (2004) stated most important that the explorations are adapted to the constraints of the situations and implemented at the right times. This underlines the importance that even young soccer players are given much experience in realistic game situations.

Conclusions

Former studies from the cognitive approach have revealed interesting information about the relationship between visual perception and performance. When comparing these findings with results from ecological field based research, useful knowledge for practitioners is developed. Complementary to former ecologically grounded research employing similar methods (Jordet, 2004; Jordet et al., 2008) this field research was valuable by indicating that increased exploration frequency in real soccer games is related to better performance. The results are comparable with findings from more cognitive based research indicating that expert soccer players are

less inclined to “ball watch” and are more aware of positions and movements of players “off the ball” (e.g. Williams et al., 1994, Williams & Davids, 1998, Vaeyens et al. 2007).

To develop knowledge that is useful in practice, it is important to take the individual sport seriously through researching its nature more directly. The results from the earlier laboratory research are interesting and knowledgeable, but it is crucial to investigate what happens in the real world sports. This study has some limitations; relatively few participants involved; time consuming procedures; reliance on correlational analysis; and weak control of variables influencing the results. Clearly, an inter-subjectivity test should be conducted to prove stronger reliability.

Future ecological research of visual perception in soccer should develop more valid research protocols without compromising the nature of the real game. Testing players in more or less structured playing situations on the real soccer field might prove higher validity since fewer unpredictable variables will influence the results. Further, to reveal information of the development of perceptual skills, players at different ages and levels should be tested. For example, it would be interesting to investigate if young and successful players showing high exploratory frequencies in the soccer field also perform well in laboratory experiments recording eye movements (e.g. dual task- and video simulation designs). However, still it is important to dig deeper into what is happening in the real soccer field. Combining video analysis with interviews of research objects might reveal crucial information about “where” and “what” the best players are attending to. When field based research describing how players in different stages of development act skillfully are compared and combined with cognitive based research and theory, powerful knowledge can be developed and used in practice by players and coaches. In this way findings and theories from cognitive and ecological approaches can complement each other and provide valuable practical use.

References

- Abernethy, B. (1987). Selective attention in fast ball sports II: Expert-novice differences. *Australian Journal of Science and Medicine in Sport*, 19(4), 7-16.
- Abernethy, B. (1991). Visual search strategies and decision-making in sport. *International Journal of Sport Psychology*, 22, 189-210.
- Abernethy, B. (2001). Attention. In R.N. Singer, H.A. Hausenblas, & C.M. Janelle, (Eds.), *Handbook of sport psychology* (2nd ed., pp. 174-203). New York: John Wiley & Sons.
- Abernethy, B., Thomas, K.T., & Thomas, J.R. (1993). Strategies for improving understanding of motor expertise (or mistakes we have made and things we have learned!). In J.L. Starkes & F. Allard (Eds.), *Cognitive issues in motor expertise* (pp. 317-358). Amsterdam: Elsevier.
- Dzewaltowski, D. A. (1997). The Ecology of Physical Activity and Sport: Merging Science and Practice. *Journal of Applied Sport Psychology* 9, 254-276.
- Gibson, J.J. (1966). *The senses considered as perceptual systems*. Boston: Houghton Mifflin.
- Gibson, J.J. (1979). *An ecological approach to visual perception*. Boston: Houghton Mifflin.
- Helsen, W.F., & Pawels, J.M. (1993). The relationship between expertise and visual information processing in sport. In *Cognitive Issues in Motor Expertise* (edited by J.L. Starkes and F. Allard), pp. 109-134. Amsterdam: Elsevier.
- Helsen, W.F., & Starkes, J.L. (1999). A multidimensional approach to skilled perception and performance in sport. *Applied Cognitive Psychology*, 13, 1-17.
- Janelle, Singer, & Williams (1999). External distractions and attentional narrowing: Visual search evidence. *Journal of Sport & Exercise Psychology*, 21, 70-91.
- Jordet, G. (2004) *Perceptual expertise in dynamic and complex competitive team contexts. An investigation of elite football midfield players*. Dissertation from the Norwegian University of Sport and Physical Education.
- Jordet, G., Bloomfield, J., Heijmerikx, J., & Leidekker, H. (2008). *Visual exploration in Premier League footballers*. Unpublished presentation ECSS, July 11, 2008.

- Knowler, E. (1999). Eye movements and visual attention. In *The MIT Encyclopedia of the Cognitive Sciences* (edited by R.A. Wilson and F.C. Keil), pp.306-309, Cambridge, MA: MIT Books.
- Martell, S.G., & Vickers, J.N. (2004). Gaze characteristics of elite and near-elite athletes in ice hockey defensive tactics. *Human Movement Science*, 22, 689-712.
- Moran, A., Byrne, A., & McGlade, N. (2002). The effects of anxiety and strategic planning on visual search behavior. *Journal of Sport Sciences*, 20, 225-236.
- Murray, N.P., & Janelle, C.M. (2003). Anxiety and Performance: A Visual Search Examination of the Processing Efficiency Theory. *Journal of Sport & Exercise Psychology*, 25, Iss. 2.
- Oudejans, R.R.D., & Coolen, B.H. (2003). Human kinematics and event control: on-line movement registration as a means for experimental manipulations. *Journal of Sport Sciences*, 21, 567-576.
- Parker, H. (1981). Visual detection in netball, in M. Corckerill and W.W. MacGillivray (eds) *Vision and Sport*, Cheltenham: Stanley Thornes.
- Smith, M.D. & Chamberlin, C.J. (1992). Effects of adding cognitively demanding tasks on soccer skill performance. *Perceptual and Motor Skills* 75: 955-61
- The football Association of Norway (NFF) (2009). Statistikk breddefotball,2009 [Soccer Stats, 2009]. Downloaded 11. October 2010 from http://www.fotball.no/Documents/PDF/2010/Barne-og-ungdomsfotball/Statistikk_Bredde_2009.pdf.
- Vaeyens, R., Lenoir, M., Williams, A.M., Mazyn, L., & Philippaerts, R.M. (2007). The effects of task constraints on visual search behavior and decision-making skill in youth soccer players. *Journal of Sport & Exercise Psychology*, 29, 147-169. Human Kinetics
- Ward, P. & Williams, M.W. (2003) Perceptual and Cognitive Skill Development in Soccer: The Multidimensional Nature of Expert Performance. *Journal of Sport & Exercise Psychology*, 25, 93-111.
- Williams, A.M. (2000). Perceptual skill in soccer: Implications for talent identification and development. *Journal of Sport Sciences*, 18(9), 737-750.
- Williams, A.M. (2002). Visual search behaviour in sport. *Journal of Sports Sciences*, 20, 169-170.

- Williams, A.M., & Davids, K. (1997) Assessing cue usage in performance contexts: a comparison between eye movements and verbal report methods. *Behavioral Research methods, Instruments, and Computers* 29: 364-75.
- Williams, A.M., & Davids, K. (1998). Visual search strategy, selective attention, and expertise in soccer. *Research Quarterly of Exercise and Sport*, **69**(2), 111-128
- Williams A.M., & Grant, A. (1999) Training perceptual skill in sport. *International journal of Sport Psychology*, 30, 194-220.
- Williams, A.M., Davids, K., Burwitz, L., & Williams J.G. (1992). Perception and action in sport. *Journal of Human Movements Studies*, 22, 147-205
- Williams, A.M., Davids, K., Burwitz, L., & Williams J.G. (1993). Visual search and sports performance. *Australian Journal of Science and Medicine in Sport*, 25(2), 55-65.
- Williams, A.M., Davids, K., Burwitz, L., & Williams J.G. (1994). Visual search strategies of experienced and inexperienced soccer players. *Research Quarterly for Exercise and Sport*, 65, 127-135.
- Williams, A.M., Davids, D., & Williams, J.G. (1999). *Visual Perception & Action in Sport*. London: E & FN Spon.